Final Report

Critical Evaluation of State-of-the-Art In Situ Thermal Treatment Technologies for DNAPL Source Zone Treatment

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Environmental Security Technology Certification Program
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  - Gorm Heron (Terra Therm)
  - John LaChance (TerraTherm)
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  - Ralph Baker (TerraTherm)

- **Steam Enhanced Extraction**
  - Gorm Heron (TerraTherm)
  - Gregory Crisp (TerraTherm)

- **Hot Air/Steam Injection Using Large Diameter Auger (LDA) In-Situ Mixing**
  - Phil La Mori (BEM Systems, FECC Corporation)
  - Elgin Kirkland (FECC Corporation)
Executive Summary

In-situ thermal soil and aquifer remediation technologies (e.g., electrical resistance heating, conductive heating, steam-based heating, etc.) have undergone rapid development and application in recent years. These technologies offer the promise of more rapid and thorough treatment of non-aqueous phase liquid (NAPL) source zones; however, their field-scale application has not been well-documented in the technical literature.

In this project, the performance of thermal technologies for DNAPL source zone remediation was assessed with particular emphasis on post-treatment groundwater quality and mass discharge (sometimes referred to as “mass flux”). This critical evaluation involved an empirical analysis of available design and operating information and performance results from pilot- and full-scale applications to see what experiences to-date have been. This was supplemented with post-treatment field sampling at selected sites to fill data gaps. This project was complementary to, and made use of knowledge gained from other ESTCP and SERDP projects that were looking at relationships between DNAPL architecture, treatment effectiveness, and groundwater mass discharge (flux).

Documents from 182 applications were collected and reviewed, which included 87 electrical resistance heating, 46 steam-based heating, 26 conductive heating, and 23 other heating technology applications conducted between 1988 and 2007. Approximately 90% of the 182 applications were implemented after 1995 and about half since 2000. More specifically, this review identified the geologic settings in which these technologies were applied, chemicals treated, design parameters, operating conditions, and performance metrics. The results of this study are summarized in a set of summary tables (spreadsheet-based tables) linking this information to five generalized geologic scenarios. The Summary Tables can be used by practitioners, regulators, and site owners to anticipate the likely performance of thermal-based DNAPL treatment technologies at their sites. The tables provide a tool where performance experience and theoretical bounds on performance expectations are linked to a small number of generalized geologic scenario site descriptors. The user can choose the generalized scenario that most closely resembles their site and can quickly assess:

a) how the technology has been applied to date in that type of setting,
b) the designs employed,
c) the operating conditions,
d) the performance monitoring that results are based on,
e) the performance observed,
f) indicators of success at other sites, and
g) reasonable bounds on expected performance.

The two summary tables are the Overall Data Summary Table and the Site-Specific Summary Table. The Overall Data Summary table provides a summary of the thermal application since 2000, while the Site-Specific Summary Table provides all the background information acquired for each site for a detailed summation of any site of interest to the user.
Additional data for these Summary Tables were gained by performing post-treatment groundwater sampling at sites where a full-scale thermal application was applied aggressively. By aggressively, we mean attaining temperatures greater that 90°C and maintaining that for at least three days. The post-treatment groundwater sampling was performed after the groundwater was allowed to cool to pre-treatment temperatures and move through the treated zone to see what residual contamination may have been left after treatment. These groundwater impacts were quantified by dissolved concentrations and mass flux (discharge) into the aquifer which were obtained through high spatial density sampling at five thermal treatment sites. The range of concentration and mass flux reductions ranged from about <10X to 1000X, and was strongly linked to how well the source zone was delineated prior to treatment.

Another product of this work is the document *State-of-the-Practice Overview of the Use of In Situ Thermal Technologies for NAPL Source Zone Cleanup*. It is intended to be a useful tool and primer for program managers considering the use of thermal technologies at their sites. It contains the results of this work, but in a more condensed format prepared for the program manager audience.
# Table of Contents

1.0 INTRODUCTION .............................................................................................................. 1
  1.1 BACKGROUND .................................................................................................... 1
  1.2 OBJECTIVE OF THE DEMONSTRATION ......................................................... 1
  1.3 REGULATORY DRIVERS ................................................................................... 2

2.0 TECHNOLOGY ................................................................................................................. 3
  2.1 TECHNOLOGY DESCRIPTION .......................................................................... 3
  2.2 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY ...................... 4

3.0 PERFORMANCE OBJECTIVES ...................................................................................... 5

4.0 SITE DESCRIPTION ......................................................................................................... 9
  4.1 SITE SELECTION ................................................................................................. 9
  4.2 SITE LOCATION AND HISTORY ....................................................................... 9
  4.3 SITE GEOLOGY/HYDROGEOLOGY .................................................................... 12
  4.4 CONTAMINANT DISTRIBUTION.................................................................... 13

5.0 TEST DESIGN ................................................................................................................ . 15
  5.1 CONCEPTUAL EXPERIMENTAL DESIGN..................................................... 15
  5.2 BASELINE CHARACTERIZATION ..................................................................... 15
  5.3 TREATABILITY OR LABORATORY STUDY RESULTS ...................................... 16
  5.4 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS ...................... 16
  5.5 FIELD TESTING .................................................................................................. 16
  5.6 SAMPLING AND ANALYTICAL METHODS ................................................. 17
  5.7 SAMPLING RESULTS........................................................................................ 20

6.0 PERFORMANCE ASSESSMENT .................................................................................. 23
  6.1 EMPIRICAL DATA COLLECTION AND SYNTHESIS WITH
      EMPHASIS ON SETTING, DESIGN, AND OPERATING
      CONDITIONS ...................................................................................................... 23
  6.2 EMPIRICAL DATA COLLECTION AND SYNTHESIS WITH
      EMPHASIS ON PERFORMANCE (GROUNDWATER QUALITY
      AND MASS DISCHARGE CHANGES).................................................................... 23
  6.3 SUMMARY OF KEY OBSERVATIONS ........................................................... 33

7.0 IMPLEMENTATION ISSUES ........................................................................................ 36

8.0 REFERENCES .................................................................................................................37

9.0 APPENDICES ................................................................................................................. . 38
  APPENDIX A  Points of Contact
  APPENDIX B  State-of-the-Art Technology Descriptions
  APPENDIX C  Data Logs
  APPENDIX D  Supplemental Site Investigation Reports Site Specific Demo Plan and
                 Data Analysis Reports
  APPENDIX E  Quality Assurance Project Plan
  APPENDIX F  Uncertainty Analysis for Mass Discharge Calculations
List of Figures

Figure 1. Sample of Overall Data Summary Table ................................................................. 8
Figure 2. Sample of Site-Specific Summary Table ................................................................. 9
Figure 3. Site Locations for Supplemental Investigations ...................................................... 13
Figure 4. Generalized Geologic Scenarios ........................................................................... 27

List of Tables

Table 1. Performance Objectives ......................................................................................... 6
Table 2. Site Geology, Hydrogeology, and Treatment Area Information ............................ 14
Table 3. Sampling Transect Widths at the Supplemental Field Sites .................................. 15
Table 4. Sampling Methods ................................................................................................ 19
Table 5. Groundwater Sample Collection Procedures ....................................................... 19
Table 6. Mass Discharge Sampling Transect Details for Supplemental Site Investigations ... 21
Table 7. Total Number and Types of Samples Collected ..................................................... 21
Table 8. Range of Permanent Monitoring Well Pre- and Post-Treatment Concentration Data (ug/L) ........................................................................................................... 22
Table 9. Summary of Mass Discharge (Mass Flux) Calculations at Field Investigation Sites ... 23
Table 10. Summary of Technology Applications by Technology Type ............................... 26
Table 11. Characterization of the Data Available from the 182 Applications Reviewed ....... 28
Table 12. Basic Design Information Compiled for all Sites Reviewed .................................. 28
Table 13. Basic Operating Conditions Summary for all Applications Reviewed ................. 29
Table 14. Summary of Key Information Gathered from Reviewed Applications Conducted Since 2000 ...................................................................................................... 31
Table 15. Summary of Source Zone Dissolved Groundwater Concentration and Mass Discharge Reductions Achieved at Sites with Sufficient Data to Perform this Analysis ........................................................................................................... 33
Table 16. Summary of Mass Discharge Estimates for Sites with Sufficient Data ............... 34
# List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AFP4</td>
<td>Air Force Plant 4</td>
</tr>
<tr>
<td>ASU</td>
<td>Arizona State University</td>
</tr>
<tr>
<td>bls</td>
<td>Below land surface</td>
</tr>
<tr>
<td>bgs</td>
<td>Below ground surface</td>
</tr>
<tr>
<td>BTEX</td>
<td>Benzene, toluene, ethylbenzene, xylene</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celsius</td>
</tr>
<tr>
<td>CAH</td>
<td>Chlorinated aliphatic hydrocarbon</td>
</tr>
<tr>
<td>DELCD</td>
<td>Dry electrolytic conductivity detector</td>
</tr>
<tr>
<td>DNAPL</td>
<td>Dense non-aqueous phase liquid</td>
</tr>
<tr>
<td>DO</td>
<td>Dissolved oxygen</td>
</tr>
<tr>
<td>DoD</td>
<td>Department of Defense</td>
</tr>
<tr>
<td>DRMO</td>
<td>Defense Re-utilization Marketing Office</td>
</tr>
<tr>
<td>EGDY</td>
<td>East Gate Disposal Yard</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>ERH</td>
<td>Electrical resistance heating</td>
</tr>
<tr>
<td>ESTCP</td>
<td>Environmental Security Technology Certification Program</td>
</tr>
<tr>
<td>FID</td>
<td>Flame-ionization detector</td>
</tr>
<tr>
<td>ft</td>
<td>Feet/foot</td>
</tr>
<tr>
<td>g / gm</td>
<td>Gram</td>
</tr>
<tr>
<td>HAAF</td>
<td>Hunter Army Airfield</td>
</tr>
<tr>
<td>HASP</td>
<td>Health and Safety Plan</td>
</tr>
<tr>
<td>HCl</td>
<td>Hydrochloric acid</td>
</tr>
<tr>
<td>in</td>
<td>inch</td>
</tr>
<tr>
<td>ISTD</td>
<td>In situ thermal desorption</td>
</tr>
<tr>
<td>L</td>
<td>Liter</td>
</tr>
<tr>
<td>LNAPL</td>
<td>Light non-aqueous phase liquid</td>
</tr>
<tr>
<td>M</td>
<td>Meter</td>
</tr>
<tr>
<td>MCB</td>
<td>Marine Corps Base</td>
</tr>
<tr>
<td>mg</td>
<td>Milligram</td>
</tr>
<tr>
<td>ml</td>
<td>Milliliter</td>
</tr>
<tr>
<td>NAPL</td>
<td>Non-aqueous phase liquid</td>
</tr>
<tr>
<td>NAS</td>
<td>Naval Air Station</td>
</tr>
<tr>
<td>NRC</td>
<td>National Research Council</td>
</tr>
<tr>
<td>ORP</td>
<td>Oxidation reduction potential</td>
</tr>
<tr>
<td>PAH</td>
<td>Poly-nuclear aromatic hydrocarbons</td>
</tr>
<tr>
<td>PID</td>
<td>Photo-ionization detector</td>
</tr>
<tr>
<td>QA</td>
<td>Quality assurance</td>
</tr>
<tr>
<td>QC</td>
<td>Quality control</td>
</tr>
<tr>
<td>RFH</td>
<td>Radio frequency heating</td>
</tr>
<tr>
<td>SEE</td>
<td>Steam enhanced extraction</td>
</tr>
<tr>
<td>SERDP</td>
<td>Strategic Environmental Research and Development Program</td>
</tr>
<tr>
<td>TCE</td>
<td>Trichloroethylene</td>
</tr>
<tr>
<td>ug</td>
<td>Microgram</td>
</tr>
<tr>
<td>ul</td>
<td>Microliter</td>
</tr>
</tbody>
</table>
USEPA  United States Environmental Protection Agency
VOA   Volatile organic analysis
VOC   Volatile organic compound
1.0 INTRODUCTION

1.1 BACKGROUND

Dense nonaqueous-phase liquid (DNAPL) source zone treatment is one of the most significant remediation challenges facing the Department of Defense (DoD) and the private sector. As a result, the number of in situ cleanup technologies developed and tested at DNAPL sites has increased in recent years. Approaches that employ increased temperature, chemical oxidation, surfactant flushing, and biological degradation processes have been developed and applied with varying degrees of success.

More recent critical review of the data from many of these sites has revealed that even with the most recent advancements in application of these treatment technologies, complete DNAPL source removal is unlikely. Hence, residual DNAPL after aggressive technologies have achieved their effective endpoints are expected to continue to have an impact on groundwater quality.

This project is focused on thermal-based technologies (e.g., resistive heating, conductive heating, steam-based heating) for DNAPL source treatment and a critical assessment of the potential performance of these technologies as measured by conventional and mass flux metrics. Thermal technologies are of interest because of their rapid development in recent years and because of vendor claims that they offer unique advantages over competing technologies. In particular, it is claimed that thermal technology performance is less hindered by geologic stratification and other sources of mass-transfer resistances than other flow-based technologies applied to DNAPL source zones (such as surfactant flushing, chemical oxidation, and in situ sparging).

This project is complementary to other ESTCP and SERDP projects that are looking at relationships between DNAPL architecture, treatment effectiveness, and groundwater mass discharge (flux). It is unique from the other projects in that the final report will tie together a combination of results from empirical analyses of available field data and project-specific field sampling at target sites.

It is important to note that this project is unlike other ESTCP projects in that it does not involve the field demonstration of a particular technology nor is it linked to any specific site(s). This document, therefore, is non-site-specific, and while it does focus on thermal-based DNAPL treatment technologies, it is non-technology specific.

1.2 OBJECTIVE OF THE DEMONSTRATION

In this project, the performance of thermal technologies for DNAPL source zone remediation was assessed through compilation and critical review of data available from pilot- and full-scale applications. Particular emphasis was placed on gaining a better understanding of settings in which thermal technologies have been applied, the design and operating conditions that were used, and the performance of the systems. With respect to the latter, particular emphasis was placed on post-treatment groundwater quality and source zone residual mass discharge to the aquifer (commonly referred to as “mass flux”). This critical evaluation was supplemented with
post-treatment field sampling at selected sites to fill data gaps. This project was complementary to and made use of knowledge gained from other ESTCP and SERDP projects that were looking at relationships between DNAPL architecture, treatment effectiveness, and groundwater mass discharge (flux).

Included with this report are Summary Tables (spreadsheet-based tables) that can be used by practitioners, regulators, and site owners to anticipate the likely performance of thermal-based DNAPL treatment technologies at their sites. Each table is a tool where application and performance experience are linked to a small number of generalized geologic scenario site descriptors. The user can choose the generalized scenario that most closely resembles their site and can quickly assess:

- a) how the technology has been applied to date in that type of setting,
- b) the designs employed,
- c) the operating conditions,
- d) the performance monitoring that results are based on, and
- e) the performance observed.

1.3 REGULATORY DRIVERS

Regulatory agencies at the federal, state, and local levels generally have groundwater quality concentration-based metrics that necessitate treatment or containment of DNAPL source zones. Thermal treatment technologies, which have undergone significant development in the past decade, present innovative options for source zone treatment.
2.0 TECHNOLOGY

This project does not involve the demonstration of a developing technology, as is common for most ESTCP projects. Rather, it seeks to supplement our understanding of existing thermal treatment technologies through the development of a practicable tool in which performance experience and theoretical bounds on performance expectations are linked to a small number of generalized scenario site descriptors. This section describes in situ thermal technology development and use.

2.1 TECHNOLOGY DESCRIPTION

The history of in situ thermal technology development and use is summarized in the United States Environmental Protection Agency (USEPA), March 2004 report, *In Situ Thermal Treatment of Chlorinated Solvents: Fundamentals and Field Applications*. In brief, most in situ thermal cleanup technologies originate from thermal heating technologies developed for enhanced oil recovery applications. In the past two decades, the understanding of in situ heating and fluid recovery gained from enhanced oil recovery applications has been applied to hazardous waste site cleanups.

The in situ thermal technologies which are most commonly used and for which data were available include steam-based heating (sometimes referred to as steam-enhanced extraction), conductive heating (sometimes referred to as in situ thermal desorption), electrical resistance heating (sometimes referred to as six- or three-phase heating), radio-frequency heating, and in-situ soil mixing with large diameter augers combined with steam and hot air injection. Each of these technologies relies on heat to enhance the removal and treatment of contaminant vapors and liquids from the subsurface. Depending on operating temperatures, heating may decrease contaminant liquid viscosity, decrease interfacial tension, increase biodegradation rates, increase solubility, and/or increase volatility. What differentiates one technology from the next is the method of heating or energy delivery, for example: steam injection, resistive heating by passing a current through the soil between electrodes, conductive heating accomplished by heat conduction away from in situ heating elements, and radio frequency heating from radio waves. Detailed descriptions of these technologies along with vendor supplied state-of-the-practice reports (with the exception of radio-frequency heating which has had limited application) are provided in Appendix B and can also be found in greater detail in Triplett Kingston (2008).

The approach used in this study to summarize data on the application and performance of in-situ heating technologies (i.e., performance experience and theoretical bounds on performance expectations linked to a small number of generalized scenario site descriptors) was similar to that employed in the NRC 2004 report *Contaminants in the Subsurface: Source Zone Assessment and Remediation*. The approach, as it pertained to this project, was to identify sites where thermal technologies had been applied and to collect and compile site characterization and in situ thermal design, operation, and treatment data from each. Although 180 in situ thermal applications were identified, acquisition of detailed application and performance data was difficult and of varying quantity and quality.
For each in situ thermal application studied, data collection focused on:

- Setting (geology, depth to groundwater, source zone boundaries, chemicals present, etc.),
- System design parameters (number of energy delivery points, area and depth of the treatment zone, etc.),
- Operating conditions (temperature achieved, duration of treatment, duration of monitoring, etc.), and,
- Performance data (emphasizing improvement in groundwater quality and reduction in mass discharge of contaminant to the aquifer).

To streamline data collection and maintain consistency of the data collected from each site, data logs were used. Data logs are shown in Appendix C.

Data reduction involved interpretation and the use of professional judgment, especially when comparing pre- and post-treatment groundwater impacts. To simplify data reduction and remain consistent with the typical quality and quantity of available data, performance data were quantified only in terms of order-of-magnitude reductions in groundwater concentrations and source zone mass discharges.

Results were compiled in tables in a manner thought to be useful to practitioners that might be interested in evaluating thermal treatment options for their sites and who would benefit from this empirical compilation of historical data.

2.2 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

Thermal technologies are attractive because of potentially shorter treatment times (weeks or months, rather than years for many other technologies) and lower total operations and maintenance costs. Only energy, and in some cases water and air, are added to the subsurface, rather than chemicals or bio-amendments.

In situ thermal technologies are thought to have advantages relative to other remedial options, including: (1) shorter operation times, (2) many chemicals can be treated at once, and (3) some thermal technologies, ERH and conductive heating in particular, are less sensitive to subsurface heterogeneities across a site.

The potential drawbacks of use of in situ thermal technologies include the following: (1) they are difficult to apply near occupied/active sites; (2) they require more sophisticated design and operation; (3) they may enhance the potential for contaminant to migrate to previously non-impacted areas; and (4) post-treatment soil temperatures may remain elevated for prolonged periods of time (months to years).

In addition, poor documentation and a lack of quantitative post-treatment performance data has made it difficult to confidently define practicable performance expectations for thermal technologies.
3.0 PERFORMANCE OBJECTIVES

The performance objectives for this project are captured below in Table 1.

Table 1. Performance Objectives

<table>
<thead>
<tr>
<th>Performance Objective</th>
<th>Data Requirements</th>
<th>Success Criteria</th>
<th>Results</th>
</tr>
</thead>
</table>
| Quantitative Performance Objectives | Collect data on in-situ thermal applications | Data on hydrogeologic setting, type and method of application, temperature data, and estimate of contaminant reduction | • Ability to obtain documentation  
• Data exists in documentation                                                                 | Summary table of relevant data.                                                                      |
| Qualitative Performance Objectives | Assess Groundwater Quality and Mass Discharge | Groundwater concentration data and groundwater velocity | Ability to obtain accurate concentration data and velocity data | Summary tables of concentration and mass discharge data. |

Developing the Preliminary Assessment Tool involved the following tasks:

- Task 1 - Data collection, review, and compilation of historical performance data: Using professional judgment, application and performance data were reduced, linked to idealized geologic conceptual models, and summarized in user-friendly performance summary tables.
- Task 2 - Supplemental post-treatment field investigations performed at sites identified in Task 1: Sites were chosen to best augment the information compiled in Task 1.

More detailed discussions of the technical approach for each task are given below.

**Task 1 - Data Compilation, Interpretation, and Capture in Tables:** The objective of this task was to compile and review DNAPL source zone treatment/characterization experiences at existing field sites by mining historic data from sites where a thermal treatment had been applied. Data requirements needed to support the review of thermal treatment applications and to develop and classify the sites into the idealized conceptual models included:

- subsurface and hydrogeologic characteristics (generalized geologic descriptions, groundwater flow direction, hydraulic conductivity),
- pre-treatment characterization data (chemical concentrations and distribution, source area, DNAPL mass estimates, etc.),
- technology implementation,
- DNAPL removed and measurement methods,
- DNAPL mass and/or distribution remaining after treatment,
- dissolved contaminant concentrations in and down gradient of the source zones (preferably over a period of time sufficient to evaluate rebound),
- remedial action objectives,
• post-treatment status of the source-zones/sites (e.g., monitored natural attenuation with long-term monitoring, pump-and-treat with institutional controls, closure), and
• treatment costs incurred.

Efforts during this project focused on identifying sites where thermal technologies had been applied and collecting as much of the available data listed above for those sites. It was found that thermal technologies have been applied at numerous sites but obtaining detailed site characterization and treatment/performance data for the thermal application was difficult as it was either not collected or not reported for many sites. Through considerable effort, data of varying quantity and quality was obtained for 182 thermal sites.

A preliminary review of the data revealed that database compilation would require more professional judgment and interpretation of the data than initially anticipated. Also, the construction of the database needed to be an iterative process that resulted in a final database structure reflective of the type of information contained in the reports. Because of these issues, it was critical that all key project personnel were engaged in this activity on an on-going basis.

Sample Summary Tables are shown below in Figures 1 and 2.

**Task 2 - Supplemental Field Investigations at Thermal Treatment Sites:** This task involved the collection of field data from sites that had undergone thermal treatment and for which sufficient time had elapsed to allow the subsurface environment to return to pre-treatment conditions. Supplemental data collection focused on assessing groundwater impacts as quantified by dissolved concentrations and source zone discharge (mass flux) to the aquifer following an in situ thermal treatment for NAPL removal. Site selection was based on available data and priorities for data augmentation in the summary tables, idealized conceptual models (that all results were tied to), the frequency of occurrence of site type in the broader database population of sites, and supplemental data needs identified from the database analysis.

Once the sites were selected, approvals were sought for site access, demonstration plans were prepared for each site, site investigations were performed, and field data reports were issued.
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Technology</th>
<th># of Sites</th>
<th># of Pilot Tests</th>
<th>Name(s) of Best Studied Site(s)</th>
<th>Peak Temperature Achieved in Target Treatment Zone</th>
<th>Duration of Treatment at Peak Temperature</th>
<th>Duration of Post-Treatment Monitoring</th>
<th>Estimated Post-Treatment Mass Discharge</th>
<th>Estimated Reduction in Mass Discharge</th>
<th>Criteria Used to Assess Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generalized Scenario A: relatively homogeneous and permeable unconsolidated sediments (mixtures of sands, gravel and silts, etc.)</td>
<td>Steam Heating</td>
<td></td>
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<td></td>
<td>Resistance Heating</td>
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<td>Generalized Scenario B: relative homogeneous and relatively impermeable unconsolidated sediments (days, silty days, etc.)</td>
<td>Steam Heating</td>
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<td>Resistance Heating</td>
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<tr>
<td>Generalized Scenario C: largely permeable sediments with interbedded lenses of low permeable material</td>
<td>Steam Heating</td>
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<td></td>
<td>Resistance Heating</td>
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<tr>
<td>Generalized Scenario D: largely impermeable sediments with interbedded layers of higher permeable material</td>
<td>Steam Heating</td>
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<td>Resistance Heating</td>
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<td>Generalized Scenario E: competent, but fractured bedrock</td>
<td>Steam Heating</td>
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<td>Generalized Scenario F: weathered bedrock</td>
<td>Steam Heating</td>
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<tr>
<td>Generalized Scenario G:</td>
<td>Steam Heating</td>
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<td>Resistance Heating</td>
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</table>

Footnotes:
1. Concentration reduction in existing monitoring well network
2. Asymptotic performance limit of treatment system
3. Mass discharge reduction
4. Mass removal criteria

Figure 1. Sample of Overall Data Summary Table
## Figure 2. Sample of Site-Specific Summary Table

<table>
<thead>
<tr>
<th>Technology</th>
<th>Site Name</th>
<th>Geology at This Site is Most Like Scenario</th>
<th>Year(s) Applied</th>
<th>Pilot Test?</th>
<th>Full-Scale System?</th>
<th># of Energy Delivery Points (wells or electrodes)</th>
<th>Size of Target Treatment Area</th>
<th>Thickness of Target Treatment Interval</th>
<th>Depth to Top of Treatment Zone</th>
<th>Thickness of Treatment Zone Below Ground Water Table</th>
<th>Peak Temperature in Target Treatment Zone</th>
<th>Duration of Treatment at Peak Temperature</th>
<th>Number of Ground Water Monitoring Wells Used for Post-Treatment Monitoring</th>
<th>Duration of Post-Treatment Monitoring</th>
<th>Estimated Post-Treatment Mass Discharge</th>
<th>Estimated Reduction in Mass Discharge</th>
<th>Criteria Used to Assess Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Injection</td>
<td>Site #1</td>
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<td>Site #2</td>
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<td>Site #3</td>
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<tr>
<td>Electrical Resistance Heating</td>
<td>Site #4</td>
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<td>Site #5</td>
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<tr>
<td>Other Thermal Treatments</td>
<td>Site #6</td>
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<td>Site #7</td>
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</tr>
<tr>
<td>Scenario Descriptors for the target treatment zone:</td>
<td>A - relatively homogeneous and permeable unconsolidated sediments (sands, etc.)</td>
<td>B - relatively homogeneous and relatively impermeable unconsolidated sediments (clays)</td>
<td>C - largely permeable sediments with interbedded lenses of low permeable materials</td>
<td>D - largely impermeable sediments with interbedded layers of higher permeable materials</td>
<td>E - Competent, but Fractured Bedrock</td>
<td>F - Weathered Bedrock</td>
<td>G - Poorly consolidated sediments and muds</td>
<td>H - Poorly consolidated sediments and muds</td>
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</tbody>
</table>

Footnotes: Success Criteria:
1. Concentration reduction in existing monitoring well network
2. Asymptotic performance limit of treatment system
3. Mass discharge reduction
4. Mass removal criteria
4.0 SITE DESCRIPTION

As indicated previously, this ESTCP project does not involve the demonstration of a developing technology. Rather, it seeks to supplement our understanding of existing thermal treatment technologies. This was accomplished in two tasks: Task 1) Data Compilation, Interpretation, and Capture in Tables; and Task 2) Supplemental Field Investigations at Thermal Treatment Sites. The former involved an empirical analysis of existing data and is therefore not relevant to this section; the latter involved field data collection and is therefore the focus below.

4.1 SITE SELECTION

The following were considerations when selecting candidate sites for supplemental field investigations:

- Sufficient post-treatment time had elapsed for subsurface temperatures to return to pre-treatment conditions;
- Priorities for augmenting performance summary tables and supplemental data needs identified from the database analysis from data collection and the empirical analysis of sites; and,
- Conceptual model types and the frequency of occurrence of each type of site in the broader database population of sites.

In addition, it was preferable that sites had the following characteristics:

- The hydrogeology of the site was reasonably well-characterized (flow direction, depth to groundwater, hydraulic properties and changes with depth are known semi-quantitatively, etc.);
- The aerial extent of the source zone was reasonably defined prior to treatment;
- The depth to groundwater was less than 20 ft;
- The total depth to impacted groundwater was less than 40 ft;
- There was access immediately down-gradient of the treatment zone for drilling and additional site investigation;
- Direct-push technology could be used for drilling/sampling purposes; and,
- Local site personnel were present to facilitate the logistics associated with the sampling events.

Brief descriptions of all the sites are provided below. For more detailed information, Appendix D provides full descriptions of each site.

4.2 SITE LOCATION AND HISTORY

Four sites were selected for supplemental data collection and investigation of post-treatment groundwater quality. These sites and a brief history for each are shown below while Figure 3 shows the location for each on a map of the continental United States:
1) Site 89, Camp LeJeune, Jacksonville, North Carolina:

   **History:** Site 89 at the Camp Geiger portion of Marine Corps Base (MCB) Camp LeJeune was used primarily as a storage yard for the Defense Re-utilization Marketing Office (DRMO) until June 2000.

   **Treatment History:** Electrical resistive heating (ERH) was selected as the technology to remove DNAPL. The system consisted of 43 deep heating electrodes installed to a depth of 26 ft below ground surface (bgs) and 48 shallow heating electrodes installed to a depth of 19 ft bgs. The system was operated from September 2003 until the beginning of May 2004. The remedial system performance was continuously monitored during operation, and an estimated 48,000 pounds of volatile organic compound (VOC) contamination were removed in recovered volatile vapors and 428 pounds of chlorinated compounds were recovered from the groundwater during the application. After the shutdown of the system, the monitoring well network was monitored for one year.

2) Building 5, Site 5-1, Naval Air Station (NAS) Alameda, Alameda, California:

   **History:** Building 5 housed specialty shops for aircraft component repair and maintenance from 1942 until the base was closed in April 1997. Chemical contaminants from the various industrial processes inside Building 5 are believed to have been released directly to the subsurface beneath certain operational areas.

   **Treatment History:** A pilot scale electrical resistive heating (ERH) application was performed in June of 2002. Based on the results of the pilot, a full-scale system was installed and operated. The system consisted of 7 electrodes installed to a depth of 19 ft bgs and 28 electrodes installed to a depth of 14 ft bgs and 1 electrode installed to 15 ft bgs. The full-scale system was operated from July 2004 until November 2004. The remedial system performance was continuously monitored during operation, and an estimated 3,000 pounds of volatile organic compound (VOC) contamination were removed in recovered volatile vapors and groundwater. After the shutdown of the system, the monitoring well network was monitored for four months.

3) Building 181, Air Force Plant 4 (AFP4), Ft. Worth, Texas

   **History:** Building 181 is part of a mile long structure designed for aircraft production. The primary contaminant at Building 181 is trichloroethylene (TCE). The TCE source is believed to be degreaser tanks in Building 181, which have since been removed. Several subsequent investigations found that releases of TCE had migrated through cracks in the concrete building floor resulting in contamination in the saturated and unsaturated zone.

   **Treatment History:** A pilot scale six-phase electrical resistance heating (ERH) application was performed completed in the winter of 2001. Based on the results of the pilot, a full-scale three-phase electrical resistance application was performed in Building 181 in 2002. The full-scale system consisted of 73 electrodes installed to a depth of 32 ft bgs, including 7 electrodes from the pilot-scale test and 2 electrodes installed during operation to enhance heat generation in target areas. The full-scale system was operated from May 2002 until December 2002. The remedial system
performance was continuously monitored during operation, and an estimated 1,417 pounds of TCE was removed via steam and vapor extraction systems. The treatment area has been monitored semi-annually since the system was shut down in 2002.

4) Former Pumphouse No. 2, Hunter Army Airfield (HAAF), Savannah, Georgia

**History:** Former Pumphouse No. 2 at Hunter Army Airfield (HAAF) was an aviation-gas fuel island that was used from 1953 until the early 1970s. During previous investigations, petroleum contaminants were identified in the soil and groundwater, including benzene, toluene, ethylbenzene, and xylenes (BTEX), as well as polynuclear aromatic hydrocarbon (PAH) constituents in the form of free product light non-aqueous phase liquid (LNAPL). The LNAPL source area was determined to be approximately 11,500 square feet (ft²) by the time the ERH application was performed.

**Treatment History:** During the previous investigations, free product was identified. It was recommended that electrical resistance heating (ERH) be implemented to remove the free product. The system consisted of 111 electrodes installed to a depth of 16 ft below ground surface (bgs) with the conductive interval set from 8 to 16 ft bgs. A full-scale ERH system was operated from March 2002 until July 2002. After shutdown, the piezometers installed for the ERH application were left in place and are still being sampled semi-annually.

Supplemental data collection was also performed at a fifth site, Ft. Lewis East Gate Disposal Yard Area 3, Ft. Lewis, Washington. Data collection differed at the Ft. Lewis East Gate Disposal Yard since it was a real-time evaluation of a thermal treatment to evaluate the concurrent and post-treatment groundwater response. A brief summary of Ft. Lewis East Gate Disposal Yard shown below and Figure 3 shows its location:

5) Ft. Lewis East Gate Disposal Yard Area 3, Ft. Lewis, Washington

**History:** Ft. Lewis was initially developed as a Logistics Center in April 1942, but was transferred to ordnance jurisdiction in August 1942. It operated as an ordnance depot until 1963 when the area was turned back over to the Logistics Center to serve as the primary non-aircraft maintenance facility for Ft. Lewis. The main degreasing agent used at this facility until the mid-1970s was Trichloroethylene (TCE) when it was replaced with 1,1,1-trichloroethane (1,1,1-TCA). The waste TCE was disposed of with waste oils at several locations including the East Gate Disposal Yard (EGDY). The EGDY was used between 1946 and the mid-1970s as a waste disposal site storing barrels and vats in trenches around the yard.

**Treatment History:** The remedial investigations identified free product interspersed throughout the soil matrix mainly in the form of ganglia and globules. It was recommended that electrical resistance heating (ERH) be implemented to remove the free-phase product and optimize the existing groundwater pump-and-treat system. The system consisted of 93 electrodes installed to a depth of 30 ft below ground surface (bgs) with the conductive interval set from 0 to 30 ft bgs. The third full-scale ERH system at the EGDY was operated from October 2006 until January 2007. After shutdown, the monitoring wells installed for the ERH
application were left in place and are still being sampled throughout the cool-down process and then will continue to monitored quarterly.

Figure 3. Site Locations for Supplemental Investigations

4.3 SITE GEOLOGY/HYDROGEOLOGY

Table 2 below provides pertinent information regarding the site geology/hydrogeology for each supplemental data collection site. In addition, the table includes information regarding the thermal treatment applied at each.
### Table 2. Site Geology, Hydrogeology, and Treatment Area Information.

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Technology</th>
<th>Geology at This Site is Most Like This Conceptual Scenario¹</th>
<th>Number of Permanent Monitoring Wells</th>
<th>Type of Chemicals Treated (C-chlorinated solvents, P-petroleum hydrocarbons, W-Wood-treating, O-other)</th>
<th>Size of Target Treatment Area [ft²]</th>
<th>Thickness of Target Treatment Interval [ft]</th>
<th>Depth to Water [ft]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter Army Airfield Former Pumphouse #2</td>
<td>ERH</td>
<td>A</td>
<td>12</td>
<td>P, O</td>
<td>30,000</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Air Force Plant 4 Bldg. 181</td>
<td>ERH</td>
<td>B</td>
<td>21</td>
<td>C</td>
<td>21,780</td>
<td>37</td>
<td>30</td>
</tr>
<tr>
<td>NAS Alameda Building 5, Site 5-1</td>
<td>ERH</td>
<td>C</td>
<td>15</td>
<td>C</td>
<td>14,520</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>Ft. Lewis EDGY Area 3</td>
<td>ERH</td>
<td>C</td>
<td>17</td>
<td>C, P</td>
<td>18,200</td>
<td>30</td>
<td>N/A</td>
</tr>
<tr>
<td>Camp LeJeune Site 89</td>
<td>ERH</td>
<td>C</td>
<td>26</td>
<td>C</td>
<td>15,873</td>
<td>21</td>
<td>5</td>
</tr>
</tbody>
</table>

¹Scenario Descriptors (for the target treatment zone)
- A - relatively homogeneous and permeable unconsolidated sediments (sands, etc.)
- B - largely impermeable sediments with interbedded layers of higher permeable material
- C - largely permeable sediments with interbedded lenses of low permeable material
- D - Competent, but fractured bedrock
- E - Weathered Bedrock
- ERH - Electrical resistance heating
- N/A - Not Available

### 4.4 CONTAMINANT DISTRIBUTION

Field investigations associated with this project focused on post-treatment groundwater sampling across a transect perpendicular to groundwater flow and immediately down-gradient of the treatment zone at each site. The lateral and vertical distributions of contaminants in groundwater were determined at each site by on-site chemical analyses conducted as samples were collected. The width of each transect is given in Table 3 below.
Table 3. Sampling Transect Widths at the Supplemental Field Sites.

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Treatment Zone Width Perpendicular to GW Flow (ft)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter Army Airfield Former Pumphouse #2</td>
<td>400</td>
<td>Documentation indicated quasi radial groundwater flow from the source zone, likely the result of drainage to a doglegged drainage ditch adjacent to the site.</td>
</tr>
<tr>
<td>Air Force Plant 4 Bldg 181</td>
<td>170</td>
<td>Flow direction based on groundwater contour maps and contaminant distribution from site documentation.</td>
</tr>
<tr>
<td>NAS Alameda Building 5, Site 5-1</td>
<td>115</td>
<td>Flow direction based on groundwater contour maps and site documentation.</td>
</tr>
<tr>
<td>Ft. Lewis EGDY Area 3*</td>
<td>110</td>
<td>Flow direction based on groundwater contour maps and site documentation.</td>
</tr>
<tr>
<td>Camp LeJeune Site 89</td>
<td>255</td>
<td>Flow direction based on groundwater contour maps. However, site constraints would require a transect with an approximate 30 degree angle, the apex of which was directly downgradient of source zone.</td>
</tr>
</tbody>
</table>
5.0 TEST DESIGN

As in Section 4.0, this section focuses on the supplemental field investigation component of this project.

5.1 CONCEPTUAL EXPERIMENTAL DESIGN

The goal of the supplemental field investigations was to collect sufficient groundwater and aquifer characterization data to assess post-treatment groundwater quality and mass discharge immediately down-gradient of source zone areas where an in situ thermal remediation had been applied. Data determined necessary for a competent evaluation of the site included the following: 1) depth-specific groundwater quality data and aquifer characterization data along a transect down-gradient of the source zone and perpendicular to the groundwater flow direction; 2) groundwater quality data and aquifer characterization data from monitoring wells in and adjacent to the source/treatment zone; 3) soil core collection to confirm geologic conceptual model; and 4) depth to water measurements for flow direction and gradient.

To accomplish the goal described above, the following field activities were undertaken:

- Groundwater sampling and aquifer characterization at depth-discrete sampling points along a transect down-gradient of the treatment zone and perpendicular to the direction of groundwater flow,
- Groundwater sampling and aquifer characterization at select monitoring wells in or adjacent to the treatment zone, and
- Analysis of water samples for general chemistry and hydrocarbon concentrations.

Aquifer characterization involved the following activities:

- Aquifer specific-capacity tests or slug tests of both depth-discrete sampling points along transects and permanent monitoring wells,
- Depth to water measurements, and
- Soil core collection.

These activities were conducted at Hunter Army Airfield, Air Force Plant 4, NAS Alameda Bldg. 5, and Camp LeJeune Site 89. The Ft. Lewis EGDY site supplemental data collection involved analysis of groundwater samples collected from permanent monitoring wells (shipped to ASU by Army Corps of Engineers personnel). Samples were collected during 16 sampling events over a 1.5 year time frame, and included pre-, concurrent-, and post-treatment sampling events.

5.2 BASELINE CHARACTERIZATION

Baseline characterization data for each supplemental characterization site were obtained from existing reports. The field studies associated with this project focused on post-treatment
groundwater quality and mass flux assessment from completed thermal remediation sites, and therefore, baseline pre-treatment data had to be obtained from site reports.

5.3 TREATABILITY OR LABORATORY STUDY RESULTS

No treatability or laboratory studies were conducted as part of this project as the focus was on critical assessment of thermal technologies already being applied at the pilot- and full-scale.

5.4 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS

No system design was conducted in this project as the focus was on critical assessment of thermal technologies being applied at the pilot- and full-scale. The designs of the thermal remediation systems implemented at sites selected for the supplemental post-treatment assessment work are summarized along with all other thermal system designs reviewed in this work in the tables presented in Chapter 6.

5.5 FIELD TESTING

Field testing for this project differed from other ESTCP projects since no demonstration was performed. Field investigations at four of five demonstration sites focused on the assessment of post-treatment groundwater quality and mass flux of contaminant from the treatment zone. Field investigations at these sites included groundwater sampling for analysis of general water quality parameters and hydrocarbon concentrations, aquifer characterization, soil core collection for verification of geology, and depth to water measurements for groundwater flow direction and gradient. Field investigations at the fifth site focused on groundwater quality response during and following an active thermal treatment.

5.6 SAMPLING AND ANALYTICAL METHODS

To accomplish the goals described above, the following field activities were undertaken:

- A sampling transect down-gradient of the treatment zone and perpendicular to the direction of groundwater flow was identified. Each transect encompassed the width of the original source zone and down-gradient dissolved plume, unless portions were inaccessible. Ideally, transects would have at least 10 sampling locations, each of which would have at least five sampling depths. Actual sampling locations and depths were dictated by site-specific factors/costs,
- At each sampling location, depth-discrete groundwater samples and aquifer characterization data were collected using direct push technology.
- Groundwater sampling and aquifer characterization was also performed at select monitoring wells in and adjacent to the treatment zone.
- Water samples were analyzed onsite for general chemistry (pH, electrical conductivity, temperature, dissolved oxygen, and oxidation reduction potential) and hydrocarbon concentrations (chlorinated solvent or petroleum hydrocarbon). Hydrocarbon concentrations were analyzed using gas chromatography and were performed on-site to
help guide selection of the sampling locations and provide a basis for any in-the-field revisions to the sampling plan.

Aquifer characterization involved the following activities:

- **Aquifer specific-capacity tests**: Aquifer specific capacity tests were conducted in permanent monitoring well locations of interest when slug testing was not possible and at all depth-discrete groundwater sample locations where depth to water did not exceed the capabilities of a peristaltic pump. Depth-discrete tests were conducted using a direct-push rod equipped with a groundwater sampler. Specific capacity tests involved the measurement of the steady flow rate achieved with a fixed drawdown; ideally, all tests were conducted with the same fixed drawdown (usually 0.3 – 1.0 feet), but that was variable depending on the rate of groundwater production at each interval.

- **Slug testing**: Slug tests were conducted in selected monitoring wells within and directly adjacent to the treatment zone. At one site where depths-to-water were too great (Air Force Plant 4), pneumatic slug testing was used at all depth-discrete groundwater sampling locations.

- **Depth-to-water measurements**: Depth-to-water was measured in all monitoring wells in and adjacent to the treatment zone. Using survey data from site records, measurements were converted water level elevations to determine groundwater flow direction and gradient at the time of sampling.

- **Soil core collection**: One to three direct-push soil cores were collected from each site. Continuous soil cores were collected along the downgradient edge of the treatment zone and extended from about 2 ft above the current groundwater elevation down to the deepest known depth of groundwater impact. Soil cores were used to confirm the site geologic conceptual model and, as needed, were subdivided in the lab into sections with visually distinct geologies for permeameter testing.

Sampling and analytical methods are summarized in Table 4.

Depth-discrete groundwater samples were collected using direct-push groundwater samplers (e.g. Geoprobe screen point sampler or groundwater profiler) and peristaltic pumps with dedicated polyethylene tubing. As possible, each sample depth was purged for at least one probe rod volume (typically about 1-L) and until a portable YSI DO meter inserted in a flow-through cell indicated stable DO and temperature readings. When purging was complete, zero-headspace groundwater samples were collected in two 40 ml volatile organic analysis (VOA) vials for analysis on site.

Groundwater sample collection from permanent monitoring wells and/or piezometers was facilitated by peristaltic pump, disposable bailers, or submersible electric pump.
Table 4. Sampling Methods.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Description of Analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field water quality measurements</td>
<td>Analysis of pH, electrical conductivity (EC), temperature, dissolved oxygen (DO), and oxidation reduction potential (ORP) using an Horiba U-22 with flow through cell. In certain circumstances, only dissolved oxygen was measured using a YSI 550A DO meter with flow through cell. Meters were calibrated as per manufacturer instructions at least once per day.</td>
</tr>
<tr>
<td>Hydrocarbons Chemicals of interest in groundwater (inclusive of Ft. Lewis EGDY samples)</td>
<td>Sample collection: Samples were collected with zero-headspace in 40 mL VOA vials and placed on ice until analyzed. Sample analysis: Heated headspace method with on-column injection. 30-ml sample warmed in 40-ml VOA vial to 35°C followed by 0.5 ml on-column injection of headspace on the GC. Separation by capillary column and analysis by PID, FID, and/or DELCD.</td>
</tr>
<tr>
<td>Specific Capacity</td>
<td>Specific capacity tests were conducted using an electronic water level indicator, a volumetric cylinder, a peristaltic pump, and a stop watch. After driving a direct-push rod to the desired depth, the water level was measured in the rod until stable. Then the polyethylene tubing inlet was lowered 1 ft below the stable water level and the peristaltic pump was run at a high speed that draws the water down to that level (this is apparent by slugs of air coming up in the tubing). At this point, the flow was measured by recording the time to collect 1-L of water, or under low flow conditions, how much water was collected in a ten-minute interval. Successive analyses were conducted to ensure that the yield had reached a stable value.</td>
</tr>
<tr>
<td>Slug Tests</td>
<td>Slug tests were conducted in conventional wells using a data-logging pressure transducer and a slug capable of displacing about 2 ft of water. The slug was either lowered into, or pulled out of the well, and the water level response was monitored until it stabilized at the pre-test level. The data was then analyzed by standard slug-test analysis methods.</td>
</tr>
</tbody>
</table>

At the time of sample collection, sample vials were labeled with the location ID and sampling depth. Sample collection followed procedures defined in Table 5. Since samples collected at the four field sites were analyzed within 24 hours of collection (and typically within 4 hours), samples were only preserved on ice. Since Ft. Lewis EGDY samples were shipped, they included hydrochloric acid (HCl) preserve.

Table 5. Groundwater Sample Collection Procedures.

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Analyte</th>
<th>Container</th>
<th>Preservative</th>
<th>Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>Chlorinated and Petroleum Hydrocarbons</td>
<td>40 ml VOA</td>
<td>Ice*</td>
<td>&lt;24 hours (on site)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 ml VOA</td>
<td>HCl, Ice (Fort Lewis EGDY site only)</td>
<td>&lt;7 days (shipped to ASU)</td>
</tr>
</tbody>
</table>
All hydrocarbon analyses including the Ft. Lewis EGDY analyses were conducted using a heated headspace (35°C) method on dedicated SRI Model 8610C gas chromatographs equipped with FID, PID, and DELCD detectors and a DB-1 type capillary column. The instruments were calibrated each day against at least three different concentrations spanning the concentration range of interest (e.g. 10, 100, 1000 µg/L for dissolved concentrations). In addition, calibration samples were analyzed on a regular basis throughout each day to detect instrument drift. Reporting levels of 1 ug/L were established based on the calibration results.

Quality assurance (QA) samples were collected at a frequency of not less than one in ten samples. QA samples included both duplicate (split) sample collection and analysis and replicate sample analysis.

All sampling locations were recorded. For temporary sampling or transect locations, exact location was based on measurement from at least two known surveyed locations (i.e., existing wells). These measurements were then used for plotting purposes and northings/eastings could be back-calculated from known survey points. Sample locations for Ft. Lewis EGDY were surveyed.

All sampling activities were recorded in site dedicated field books. More specifically, all project, field personal maintained a continuous record of site activities their own dedicated field book.

Appendix E provides additional detail on the calibration of analytical equipment, quality assurance sampling, decontamination procedures, and sample documentation.

5.7 SAMPLING RESULTS

Specifics of the supplemental site investigation are summarized below. More detailed individual field summary reports are provided in Appendix D. Table 6 summarizes details of the sampling transects (transect length, number of sampling locations, depth intervals, etc.). Table 7 provides the number of locations where groundwater samples were collected and aquifer characterization tests were performed. Tables 8 and 9 provide an overview of pre- and post-treatment groundwater concentrations and calculated mass discharge for each site, respectively. Table 9 also provides the calculated mass discharge normalized to the width of the treatment zone perpendicular to the flow direction [mass discharge per linear distance]. The mass discharge calculations were performed using the ESTCP-sponsored Mass Flux Toolkit software provided by GSI, Inc. Mass discharge calculations for each of the constituents can be found in the field reports in Appendix D.
Table 6. Mass Discharge Sampling Transect Details for Supplemental Site Investigations.

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Number of Transect Sampling Locations</th>
<th>Transect Length (ft)</th>
<th>Vertical Sampling Interval (ft bgs)</th>
<th>Number of Depth-Specific GW Samples</th>
<th>Number of Aquifer Specific-Capacity Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter Army Airfield Former Pumphouse #2</td>
<td>10</td>
<td>400</td>
<td>12 - 22</td>
<td>48</td>
<td>47</td>
</tr>
<tr>
<td>Air Force Plant 4 Bldg 181</td>
<td>10</td>
<td>170</td>
<td>29 - 35</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>NAS Alameda Site 5-1, Bldg. 5</td>
<td>7</td>
<td>115</td>
<td>6.5 - 21</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>Camp LeJeune Site 89</td>
<td>7</td>
<td>255</td>
<td>3 - 40</td>
<td>78</td>
<td>62</td>
</tr>
<tr>
<td>Ft. Lewis EGDY Area 3*</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

ft - Feet  
bgs – Below ground surface  
N/A – Not applicable to this site  
Note: All analysis were performed via groundwater samples from permanent monitoring wells collected by the Corp of Engineers and were sent directly to ASU for analysis. Analyses were performed pre-, during, and post-treatment to gauge how contaminant flux changed while treatment was occurring.

Table 7. Total Number and Types of Samples Collected.¹

<table>
<thead>
<tr>
<th>Site</th>
<th>Sampling Location</th>
<th>Number of GW Sample Locations</th>
<th>Number of Aquifer Characterization Test Locations</th>
<th>Analytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter Army Airfield, Former Pumphouse 2</td>
<td>Permanent Monitoring Wells</td>
<td>12</td>
<td>11</td>
<td>Petroleum Hydrocarbons</td>
</tr>
<tr>
<td></td>
<td>Transect/Discrete-depth Locations</td>
<td>10</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Air Force Plant 4 Bldg. 181</td>
<td>Permanent Monitoring Wells</td>
<td>18</td>
<td>15</td>
<td>Chlorinated Solvents</td>
</tr>
<tr>
<td></td>
<td>Transect/Discrete-depth Locations</td>
<td>11</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>NAS Alameda Site 5-1,Bldg. 5</td>
<td>Permanent Monitoring Wells</td>
<td>11</td>
<td>11</td>
<td>Chlorinated Solvents</td>
</tr>
<tr>
<td></td>
<td>Transect/Discrete-depth Locations</td>
<td>7</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Camp LeJeune Site 89</td>
<td>Permanent Monitoring Wells</td>
<td>26</td>
<td>23</td>
<td>Chlorinated Solvents</td>
</tr>
<tr>
<td></td>
<td>Transect/Discrete-depth Locations</td>
<td>7</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Ft. Lewis EGDY Area 3</td>
<td>Permanent Monitoring Wells</td>
<td>17 (16 sampling events)</td>
<td>0* (16 sampling events)</td>
<td>Chlorinated Solvents</td>
</tr>
</tbody>
</table>

¹ Exact information on total number of samples collected can be found in Appendix D which contains the Field Reports for each site.  
* Aquifer characterization data for the wells used were obtained from site reports for the Fort Lewis EGDY site.
<table>
<thead>
<tr>
<th>Site</th>
<th>Contaminant</th>
<th>Pre-treatment Concentration Ranges From Site Documentation (ug/L)</th>
<th>Post-treatment Concentration Ranges from Supplemental Field Investigations Performed Under This Study (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Hunter Army Airfield, Former Pumphouse 2</strong></td>
<td>Benzene</td>
<td>1,670</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>Toluene</td>
<td>3,630</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>Ethylbenzene</td>
<td>9,470</td>
<td>426</td>
</tr>
<tr>
<td></td>
<td>Xylenes</td>
<td>40,500</td>
<td>594</td>
</tr>
<tr>
<td></td>
<td>Naphthalene</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Air Force Plant 4, Bldg 181</strong></td>
<td>1,1-Dichloroethene</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Trans-1,2-Dichloroethene</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethane</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Cis-1,2-Dichloroethene</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>1,2-Dichloroethane</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>1,1,1-Trichloroethane</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>285,000</td>
<td>5,960</td>
</tr>
<tr>
<td></td>
<td>1,1,2-Trichloroethane</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>NAS Alameda, Site 5-1, Bldg. 5</strong></td>
<td>Vinyl Chloride</td>
<td>8,140</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethene</td>
<td>15,100</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td></td>
<td>Trans-1,2-Dichloroethene</td>
<td>300</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethane</td>
<td>48,800</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Cis-1,2-Dichloroethene</td>
<td>13,700</td>
<td>ND&lt;1.3</td>
</tr>
<tr>
<td></td>
<td>1,2-Dichloroethane</td>
<td>ND&lt;250</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td></td>
<td>1,1,1-Trichloroethane</td>
<td>42,000</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>1,600</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td></td>
<td>1,1,2-Trichloroethane</td>
<td>ND&lt;250</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>54</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td><strong>Camp LeJeune, Site 89</strong></td>
<td>Vinyl Chloride</td>
<td>1,400</td>
<td>ND&lt;1</td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethene</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Trans-1,2-Dichloroethene</td>
<td>49,800</td>
<td>ND&lt;2</td>
</tr>
<tr>
<td></td>
<td>Cis-1,2-Dichloroethene</td>
<td>224,000</td>
<td>ND&lt;2</td>
</tr>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>541,000</td>
<td>ND&lt;2</td>
</tr>
<tr>
<td></td>
<td>1,1,2-Trichloroethane</td>
<td>18,600</td>
<td>ND&lt;2</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>3,720</td>
<td>ND&lt;2</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-Tetrachloroethane</td>
<td>2,240,000</td>
<td>ND&lt;2</td>
</tr>
<tr>
<td><strong>Ft. Lewis EGDY Area 3</strong></td>
<td>Vinyl Chloride</td>
<td>5,800</td>
<td>ND&lt;1</td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethene</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Trans-1,2-Dichloroethene</td>
<td>480</td>
<td>ND&lt;1</td>
</tr>
<tr>
<td></td>
<td>Cis-1,2-Dichloroethene</td>
<td>30,000</td>
<td>ND&lt;1</td>
</tr>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>17,000</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>9</td>
<td>ND&lt;1</td>
</tr>
<tr>
<td></td>
<td>1,3,5-Trimethylbenzene</td>
<td>88</td>
<td>ND&lt;1</td>
</tr>
<tr>
<td></td>
<td>1,2,4-Trimethylbenzene</td>
<td>22</td>
<td>ND&lt;1</td>
</tr>
</tbody>
</table>

Note: * NAPL was found in a well; ND<X denotes non-detection at X ug/L detection level

<table>
<thead>
<tr>
<th>Site</th>
<th>Contaminant</th>
<th>Pre-treatment Discharge (kg/yr)</th>
<th>Post-treatment Mass Discharge (kg/yr)</th>
<th>Post-treatment Mass Discharge per Linear Foot (kg/yr/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter Army Airfield Former Pumphouse 2*</td>
<td>Total Contaminant Flux</td>
<td>5.2 x 10^1</td>
<td>1.9 x 10^-1</td>
<td>1.1 x 10^-3</td>
</tr>
<tr>
<td>Air Force Plant 4 Bldg 181**</td>
<td></td>
<td>6.0 x 10^1</td>
<td>2.1 x 10^1</td>
<td>1.4 x 10^1</td>
</tr>
<tr>
<td>NAS Alameda Site 5-1, Bldg. 5*</td>
<td></td>
<td>4.9 x 10^1</td>
<td>1.3 x 10^-1</td>
<td>9.6 x 10^-4</td>
</tr>
<tr>
<td>Camp LeJeune Site 89*</td>
<td></td>
<td>6.8 x 10^2</td>
<td>8.2 x 10^1</td>
<td>5.5 x 10^-1</td>
</tr>
<tr>
<td>Ft. Lewis EGDY Area 3***</td>
<td></td>
<td>3.2 x 10^1</td>
<td>2.1</td>
<td>1.9 x 10^-2</td>
</tr>
</tbody>
</table>

Notes:
1 Mass discharge calculations were based on monitoring well data from the documentation.
2 Mass discharge calculations were based on discrete-depth sampling data, or a combination of discrete-depth sampling data and monitoring well data.
* Mass discharge calculations were base on discrete-depth sampling data only.
** Mass discharge calculations were performed for discrete-depth sampling data only and discrete-depth sampling data with monitoring well data.
*** Mass discharge calculations were based on monitoring well data analyzed by ASU personnel.
6.0 PERFORMANCE ASSESSMENT

The performance objectives of this demonstration included:

- Collecting application data (design, setting, operating conditions, performance) from in situ thermal applications and then compile and synthesize that information in a way that would assist others to anticipate the applicability and performance of in situ thermal technologies at their sites.

- Assess changes in groundwater quality and contaminant mass discharge from source zones treated with in situ thermal technologies.

The results from each are discussed below. Section 6.1 focuses on the former, while Section 6.2 focuses on the latter.

6.1 EMPIRICAL DATA COLLECTION AND SYNTHESIS WITH EMPHASIS ON SETTING, DESIGN, AND OPERATING CONDITIONS

The in situ thermal treatment application data collected in this study were obtained from a variety of sources including: (1) site reports, (2) published literature, (3) Environmental Protection Agency (EPA) cost and performance reports, (4) discussions with project managers, vendors, and consultants, and (5) unpublished data and observations. Sites for which data were collected encompassed in situ thermal technology applications world-wide and included electrical resistance heating (ERH), steam-based heating with and without hot water injection, conductive heating, and other methods (radio-frequency heating (RFH), hot air injection, and in situ soil large diameter auger mixing with steam and/or hot air injection).

For each technology application studied, emphasis was placed on identifying:

- the setting (geology, depth to groundwater, source zone boundaries, chemicals present, etc.),
- system design parameters (number of energy delivery points, area and depth of the treatment zone, etc.),
- operating conditions (temperature achieved, duration of treatment, duration of monitoring, etc.), and,
- performance data (emphasizing improvement in groundwater quality and reduction in mass discharge of contaminant to the aquifer).

Capture of this data involved data interpretation and the use of professional judgment, especially when comparing pre- and post-treatment groundwater impacts. To simplify data reduction and remain consistent with the typical quality and quantity of available data, performance was quantified only in terms of order-of-magnitude reductions in groundwater concentrations and source zone mass discharges.
Each technology application reviewed was assigned to one of five idealized geologic scenarios, much in the same way that the NRC (2004) used generic conceptual models to summarize knowledge about treatment technologies in general. The idealized scenarios were as follows:

- **Scenario A**: relatively homogeneous and permeable unconsolidated sediments (mixtures of sands, gravels, silts, etc.)
- **Scenario B**: largely impermeable sediments with inter-beded layers of higher permeability sediments
- **Scenario C**: largely permeable sediments with inter-beded lenses of low permeability sediments
- **Scenario D**: competent, but fractured bedrock (i.e. crystalline rock)
- **Scenario E**: weathered bedrock (limestone, sandstone, etc.)

A category for homogeneous and impermeable settings was not created, as this setting rarely occurs and most low permeability sites have layers, albeit thin, of higher conductivity materials (Scenario B). A generic diagram of each geologic setting can be found in Figure 4.

Finally, the results were compiled and synthesized in tables in a manner thought to be useful to practitioners interested in evaluating thermal treatment options for their sites. The structure of these tables is discussed in more detail below.

After a rigorous review of the data, compiled information was sent to each respective site contact for their review and to see if additional information could be obtained.

A total of 182 in situ thermal treatment technology applications at 163 different sites were identified in this study. Table 10 presents the number of in-situ thermal applications by technology. It also indicates how many were full-scale vs. pilot-scale applications and how many occurred since 2000. As can be seen, about half of all applications (98 of 182) were implemented at full-scale, with roughly half of those (56 of the 98) being ERH systems. Table 10 also shows that 84 of 182 applications (46%) have been implemented since 2000, over half (57%) of which were ERH systems. ERH applications outnumber all other applications since 2000 by about a factor of three, and there also seems to be a recent trend in the increasing use of conductive heating and decreasing use of steam heating.

Since the quantity and quality of information available for each application varied, a scale of 0 to 4 was used to characterize data availability for each site. Table 11 defines this scale and also summarizes the number of applications falling into each category. The following are of note:

- Sufficient data were available to identify the target chemicals of concern at 159 of 182 sites (87%).
- Sufficient data were available to identify the treatment area for 62 of 182 sites (34%) and the density of energy delivery points at 57 of 182 sites (31%); these are basic system design parameters that were compiled in this study.
• Sufficient data were available to identify the peak temperature at 49 of 182 sites (27%) and the duration of heating at 59 of 182 sites (32%); these are basic operational parameters that were compiled in this study.

• Post-treatment groundwater monitoring data were available for only 14 of 182 sites (8%); these are the basic performance data that were compiled in this study.

Thus, while there have been a large number of thermal treatment applications (at least 182), data collected for this project indicated that many have been poorly documented. This study, therefore, can provide insight to the range of settings to which thermal technologies have been applied, the designs that have been applied, and the operating conditions. However, it cannot provide much information on the actual performance of these technologies since the long-term effect on groundwater quality improvements and source zone discharge reductions appear to be poorly documented and/or not monitored at many thermal treatment sites.

Table 10. Summary of Technology Applications by Technology Type.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Number of Applications</th>
<th>Pilot-Scale*</th>
<th>Full-Scale*</th>
<th>Number Since Year 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam-Based Heating</td>
<td>46</td>
<td>26</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Electrical Resistance Heating</td>
<td>87</td>
<td>23</td>
<td>56</td>
<td>48</td>
</tr>
<tr>
<td>Conductive Heating</td>
<td>26</td>
<td>12</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Other (including Mixing/Heating)</td>
<td>23</td>
<td>14</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>182</td>
<td>75</td>
<td>98</td>
<td>84</td>
</tr>
</tbody>
</table>

* Some sites have an unknown application size and thus are not included in the Pilot- and Full-scale count.
Figure 4. Generalized Geologic Scenarios. (a) Generalized scenario A - Relatively homogeneous and permeable unconsolidated sediments (mixtures of sands, gravels and silts, etc.); (b) Generalized scenario B - Largely impermeable sediments with inter-bedded lenses of higher permeability material; (c) Generalized scenario C - Largely permeable sediments with inter-bedded lenses of low permeability material; (d) Generalized scenario D - Competent, but fractured bedrock; (e) Generalized scenario E – Weathered bedrock.
Table 12 summarizes the aggregate design information for all applications reviewed. As can be seen, 117 of 121 applications for which data were available involved treating areas $<4 \times 10^4 \text{ ft}^2$ ($<3716 \text{ m}^2$, or about one acre) and roughly two-thirds of those involved treatment zones smaller than $10^4 \text{ ft}^2$ ($<929 \text{ m}^2$, or about a quarter-acre). Table 12 also indicates that the distribution was similar for all of the technologies.

Table 11. Characterization of the Data Available from the 182 Applications Reviewed.

<table>
<thead>
<tr>
<th>Level of Data Quantity</th>
<th>Description</th>
<th>Number of Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Application in progress</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>No documentation available at the time of this study</td>
<td>26</td>
</tr>
<tr>
<td>1</td>
<td>Insufficient data to assess performance of technology, but some design information</td>
<td>78</td>
</tr>
<tr>
<td>2</td>
<td>Limited performance data; some soils and/or groundwater concentration data and some operating data (e.g., temperature information)</td>
<td>37</td>
</tr>
<tr>
<td>3</td>
<td>Good performance data record, but insufficient for estimating differences between pre- and post mass discharge from source zone</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>Data sufficient for full assessment of performance (groundwater concentrations and mass discharge)</td>
<td>14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>182</strong></td>
</tr>
</tbody>
</table>

Table 12. Basic Design Information Compiled for all Sites Reviewed.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Number of Sites With Target Treatment Zones With Sizes In This Range [ft²]</th>
<th>Number of Sites With Density of Energy Delivery Points (electrodes or wells) In this Range [# per 100 ft²]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;10⁴</td>
<td>10⁴ - 4x10⁴</td>
</tr>
<tr>
<td>Steam-Based Heating</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Resistance Heating</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>Conductive Heating</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>Other (including Mixing/Heating)</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>

* For the three steam auger sites, the density is one energy point per cell. This does not fit into the number calculation so it is classified as $<0.5.$
With respect to the area density of energy delivery points (i.e., steam injection wells, electrodes, and in situ heaters), there were clear differences between the technologies. Table 12 categorizes the number of energy delivery points per 100 ft\(^2\) (~ per 10 m\(^2\)), and indicates that most steam-based heating designs (20 of 26 with sufficient information) had densities of less than one energy delivery point per 400 ft\(^2\) (~ one per 40 m\(^2\), or greater than 20-ft (6-m) spacings), while most conductive heating applications involved densities greater than one energy delivery point per 200 ft\(^2\) (~ one per 20 m\(^2\), or less than 14 ft (4.2 m) spacings). Electrical resistance heating applications spanned the range of density categories, but were weighted more towards higher densities and electrode spacings less than 20 ft (6 m).

Table 13 summarizes the basic operating conditions for all of the applications reviewed. Of the 95 applications for which temperature data were available, 63 were operated at temperatures in the 80-110°C range in the target treatment zone. With respect to technology, most (37 of 46, or 80%) of the electrical resistance heating applications were operated within that 80-110°C range, while one-third (7 of 21) of the steam-based heating applications were operated at temperatures less than 80°C and about half of the conductive heating applications were operated at temperatures greater than 110°C.

Of note in Table 13 are the durations of application. For the applications for which data were available, 81 of 84 were operated for less than six months, and this pattern is true for all thermal technologies. It should be noted that there was little documentation as to the criteria or rationale used to determine the duration of operation; in many cases, it appeared that the duration was determined prior to start-up or may have been linked to some time-temperature criterion (i.e., operate for 2 months once a target temperature is reached). There was little indication that the duration of operation was linked to mass removal-, groundwater quality-, or soil concentration-based criteria.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Number of Sites With Temperatures in Target Treatment Zone in These Ranges [°C]</th>
<th>Number of Sites With Active Heating Durations in These Ranges [y]</th>
<th>Number of Sites With Post-Treatment Monitoring in These Ranges [y]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>80</td>
<td>80 - 110</td>
<td>&gt;110</td>
</tr>
<tr>
<td>Steam-Based Heating</td>
<td>7</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Resistance Heating</td>
<td>9</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>Conductive Heating</td>
<td>0</td>
<td>11*</td>
<td>12*</td>
</tr>
<tr>
<td>Other (including Mixing/Heating)</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

* One site had two different temperature values. The 80-110°C temperature was for the saturated zone and the >110°C temperature for the vadose zone.
One might argue that applications conducted in recent years are more representative of the current state-of-the-practice. For that reason, the Overall Data Summary Table (Table 14) was prepared using only data from the 84 applications conducted since 2000 that were reviewed in this study. This table was formatted to flow from left to right, beginning with the five “generalized conceptual scenarios”. The thought behind its structure was that practitioners interested in assessing the potential applicability of thermal technologies to their site would first choose the generalized conceptual scenario that best matches their site conditions. Then, by viewing from left to right across the table, they would be able to quickly review the experience base for each technology as applied to that generalized conceptual scenario.

The major columns found to the right of the generalized conceptual scenarios and each thermal technology include the total number and types of applications (pilot- vs. full-scale), chemicals treated, basic design parameters, basic operating parameters, and performance measures. Columns found under each of these main headings represent categories (i.e., pilot-scale vs. full-scale under “# of sites” heading) or distributions of specific numerical values as in the case of the “Design Parameters” heading (e.g., three options for temperature in the treatment zone are presented: <80°C, 80 – 110°C, and >110°C). The numerical entry in each box of this table represents the number of sites matching that combination of conditions caused by the intersection of the row and column. For example, there are four applications of resistance heating in generalized conceptual scenario C with treatment areas <10^4 ft^2 (~ 1000 m^2 or one-quarter acre). Note that the number of applications totaled in each column may not total 84 due to the fact that the information might not be available for all 84 applications. In general, there is a trend towards having less information as one moves through the columns from left to right across Table 14.

Table 14 shows that majority of the thermal applications were conducted in generalized scenarios B and C. Scenario B (low permeability with high permeability lenses) accounts for 43% (36 of 84) of thermal treatments, two-thirds of which are ERH applications. Of interest was that most conductive applications occur in scenario B (10 of 17), as do ERH applications (24 of 48). Scenario C (high permeability with low permeability lenses) settings account for roughly another one-third (29%) of all applications. The majority of applications in scenario C settings are ERH, although steam-heating had most of its applications (6 of 15, or 40%) within this geologic setting.

Few applications in generalized scenarios A, D, and E were identified in this study (7, 4, and 1 of 84 total documented applications, respectively). This may reflect the low frequency of occurrence of homogeneous settings in nature (scenario A) as well as the difficulty and risks in dealing with complex fractured and bedrock settings.

Table 14 also summarizes information available on the chemicals present at 83 of 84 sites. Of those 83 sites, chlorinated solvents were treated at 63 (75%) of the sites. Petroleum hydrocarbons were the other main contaminant category treated by thermal applications and represent about 36% (30 of 84) of sites in this study. Wood-treating and other chemicals accounted for about 13% of sites (11 of 84).

<table>
<thead>
<tr>
<th>Generalized Conceptual Scenario</th>
<th>Technology</th>
<th>Design Parameters</th>
<th>Operating Parameters</th>
<th>Performance Measures</th>
<th>Name(s) of Example Well-Studied Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Generalized Scenario A</strong>:</td>
<td>SEE</td>
<td></td>
<td></td>
<td></td>
<td>Gualupay</td>
</tr>
<tr>
<td></td>
<td>ERH</td>
<td></td>
<td></td>
<td></td>
<td>Hunter Army Airfield</td>
</tr>
<tr>
<td></td>
<td>ISTD</td>
<td></td>
<td></td>
<td></td>
<td>Alhambra Pole Yard</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td>Cape Canaveral Air Force Station</td>
</tr>
<tr>
<td><strong>Generalized Scenario B</strong>:</td>
<td>SEE</td>
<td></td>
<td></td>
<td></td>
<td>Edwards Air Force Base, Lansing Air Force Base</td>
</tr>
<tr>
<td></td>
<td>ERH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ISTD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Generalized Scenario C</strong>:</td>
<td>SEE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ERH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ISTD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Generalized Scenario D</strong>:</td>
<td>SEE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ERH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ISTD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Generalized Scenario E</strong>:</td>
<td>SEE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ERH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ISTD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- 84 sites with systems have been installed since 2000, but only 72 of these sites have known geologic settings.
- Data may total more than the total number of sites because some sites treated more than one type of contaminant during an application.
- SEE – Steam Enhanced Extraction (Steam-based Heating)
- ERH – Electrical Resistance Heating
- ISTD – In Situ Thermal Desorption (Conductive Heating)
- Other – Other Heating Methods (i.e. Radio-Frequency Heating or In Situ Soil Mixing combined with Heating)
Design and operating parameter information is discussed above for all sites and the data in Table 14 reflect that discussion. Of note is the absence of information for applications conducted in generalized scenarios D and E except for steam heating in scenario D.

This study collected and documented a large amount of information on thermal applications, which has been summarized above in Table 14. An additional summary table, Site-Specific Summary Table (Plate 1 – see electronic attachment Site Specific Summary Table) contains detailed site-specific information for all thermal applications identified in this study.

6.2 EMPIRICAL DATA COLLECTION AND SYNTHESIS WITH EMPHASIS ON PERFORMANCE (GROUNDWATER QUALITY AND MASS DISCHARGE CHANGES)

As discussed above, there was sufficient documentation to assess changes in groundwater quality and source zone mass discharge for only 14 of the 182 applications identified in this study. Two of the 14 were described as pilot treatments; however, the treatment zone appeared to completely encompass the source zone at those sites so a mass discharge analysis was performed. Table 15 presents the estimated order-of-magnitude concentration and mass discharge percent reductions for those 14 sites and reflects data from site reports and from the supplemental post-treatment assessment field work conducted during this project. In 9 of 14 sites (64%), the dissolved groundwater concentration reduction was about one order-of-magnitude (10X) or less and four sites had concentration reductions equal to or greater than two orders-of-magnitude (100X). Because mass flux or discharge calculations involve spatially variable hydraulic conductivity data, the mass discharge reduction can differ from the overall concentration reduction. For example, at sites with a 10X concentration reduction or less, the estimated mass discharge reduction varied from <10X to 1000X. Nine sites had mass discharge reductions of about 10X or less and almost one-half of the sites (6 of 14, or 43%) had at least a 100X reduction in mass discharge (please note that Site #6 is counted in both the less than or equal to 10X reduction and greater than or equal to 100X because the mass discharge values were calculated for two different vertical intervals).
Table 15. Summary of Source Zone Dissolved Groundwater Concentration and Mass Discharge Reductions Achieved at Sites with Sufficient Data to Perform this Analysis

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Heating Technology</th>
<th>Generalized Scenario/Site</th>
<th>Dissolved Groundwater Concentration Reduction</th>
<th>Mass Discharge Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;10x</td>
<td>10x</td>
</tr>
<tr>
<td>1</td>
<td>ERH</td>
<td>Generalized Scenario A (SDC)</td>
<td>10x</td>
<td>x</td>
</tr>
<tr>
<td>2</td>
<td>ERH</td>
<td>Generalized Scenario B (SDC)</td>
<td>&lt;10x</td>
<td>x x</td>
</tr>
<tr>
<td>3</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td>10x</td>
<td>x</td>
</tr>
<tr>
<td>4</td>
<td>ERH</td>
<td>Generalized Scenario C* (SDC)</td>
<td>&gt;10x to &lt;100x</td>
<td>x</td>
</tr>
<tr>
<td>5</td>
<td>ERH</td>
<td>Generalized Scenario C*</td>
<td>&lt;10x</td>
<td>x</td>
</tr>
<tr>
<td>6</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td>&lt;10x</td>
<td>x x</td>
</tr>
<tr>
<td>7</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td>&lt;10x</td>
<td>x</td>
</tr>
<tr>
<td>8</td>
<td>ERH</td>
<td>Generalized Scenario C (SDC)</td>
<td>10x</td>
<td>x</td>
</tr>
<tr>
<td>9</td>
<td>ERH</td>
<td>Generalized Scenario C (SDC)</td>
<td>100x</td>
<td>x</td>
</tr>
<tr>
<td>10</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td>1000x</td>
<td>x</td>
</tr>
<tr>
<td>11</td>
<td>SEE</td>
<td>Generalized Scenario C</td>
<td>100x</td>
<td>x</td>
</tr>
<tr>
<td>12</td>
<td>SEE</td>
<td>Generalized Scenario C</td>
<td>10x</td>
<td>x</td>
</tr>
<tr>
<td>13</td>
<td>SEE</td>
<td>Generalized Scenario C</td>
<td>10000x</td>
<td>x x</td>
</tr>
<tr>
<td>14</td>
<td>SEE</td>
<td>Generalized Scenario D*</td>
<td>&lt;10x</td>
<td>x</td>
</tr>
</tbody>
</table>

* Pilot application appeared to encompass the entire source zone based on documentation reviewed.
+ Mass discharge assessment involved two calculations using first only the post-treatment field investigation data and then the post-treatment field investigation data supplemented with data from a set of monitoring wells that were directly in line with the field investigation transect.
^ Site used two different vertical intervals to calculate mass discharge: 1) Only shallow geology and 2) shallow and deep geology.
SDC – supplemental data collection site for this project

Table 16 provides the calculated mass discharge rates for the sites summarized in Table 15. Again, the table entries reflect data gathered from reports as well as data collected during the supplemental data collection phase of this project.

Mass discharge calculations were performed using the ESTCP-sponsored Mass Flux Toolkit software by GSI, Inc. In addition to the mass flux calculation, this software allows for an uncertainty analysis of calculations and presents a statistical breakdown of the contribution each sampling location makes to the total mass discharge. An uncertainty analysis was performed for the main contaminant of concern at each field site.

Uncertainty analyses for each site indicated that most locations contributed fairly equally to the total mass discharged. However, at each site there were one or two locations where groundwater concentrations and/or hydraulic conductivity resulted in contributions of greater than +/- 25% to the total mass discharge. Appendix F presents the uncertainty analyses for each of the five field sites.
Table 16. Summary of Mass Discharge Estimates for Sites with Sufficient Data

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Heating Technology</th>
<th>Site</th>
<th>Contaminant</th>
<th>Pre-treatment Discharge (kg/yr)¹</th>
<th>Post-treatment Discharge (kg/yr)²</th>
<th>Post-treatment Discharge per Linear Foot (kg/yr/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ERH</td>
<td>Generalized Scenario A * (SDC)</td>
<td></td>
<td>5.2 x 10¹</td>
<td>1.9 x 10¹</td>
<td>1.1 x 10⁻³</td>
</tr>
<tr>
<td>2</td>
<td>ERH</td>
<td>Generalized Scenario B ** (SDC)</td>
<td></td>
<td>6.0 x 10¹</td>
<td>2.1 x 10¹</td>
<td>1.4 x 10⁻¹</td>
</tr>
<tr>
<td>3</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td></td>
<td>4.0 x 10⁻¹</td>
<td>3.1 x 10⁻²</td>
<td>1.5 x 10⁻²</td>
</tr>
<tr>
<td>4</td>
<td>ERH</td>
<td>Generalized Scenario C * (SDC)</td>
<td></td>
<td>6.8 x 10⁻²</td>
<td>8.2 x 10⁻²</td>
<td>5.5 x 10⁻³</td>
</tr>
<tr>
<td>5</td>
<td>ERH</td>
<td>Generalized Scenario C ^^</td>
<td></td>
<td>1.7</td>
<td>6.0 x 10⁻¹</td>
<td>4.0 x 10⁻³</td>
</tr>
<tr>
<td>6</td>
<td>ERH</td>
<td>Generalized Scenario C ^^</td>
<td></td>
<td>2.4</td>
<td>9.7 x 10⁻¹</td>
<td>6.5 x 10⁻³</td>
</tr>
<tr>
<td>7</td>
<td>ERH</td>
<td>Generalized Scenario C ^^</td>
<td></td>
<td>9.4</td>
<td>2.7 x 10⁻²</td>
<td>1.4 x 10⁻⁴</td>
</tr>
<tr>
<td>8</td>
<td>ERH</td>
<td>Generalized Scenario C *** (SDC)</td>
<td></td>
<td>4.9</td>
<td>1.6</td>
<td>8.7 x 10⁻³</td>
</tr>
<tr>
<td>9</td>
<td>ERH</td>
<td>Generalized Scenario C * (SDC)</td>
<td></td>
<td>9.3</td>
<td>1.7 x 10⁻²</td>
<td>6.3 x 10⁻⁵</td>
</tr>
<tr>
<td>10</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td></td>
<td>7.4</td>
<td>1.6 x 10⁻²</td>
<td>6.0 x 10⁻⁵</td>
</tr>
<tr>
<td>11</td>
<td>SEE</td>
<td>Generalized Scenario C</td>
<td></td>
<td>3.2 x 10⁻¹</td>
<td>2.1</td>
<td>1.9 x 10⁻²</td>
</tr>
<tr>
<td>12</td>
<td>SEE</td>
<td>Generalized Scenario C</td>
<td></td>
<td>4.9 x 10⁻¹</td>
<td>1.3 x 10⁻¹</td>
<td>9.6 x 10⁻⁴</td>
</tr>
<tr>
<td>13</td>
<td>SEE</td>
<td>Generalized Scenario C</td>
<td></td>
<td>1.2</td>
<td>5.4 x 10⁻⁴</td>
<td>1.6 x 10⁻⁴</td>
</tr>
<tr>
<td>14</td>
<td>SEE</td>
<td>Generalized Scenario D</td>
<td></td>
<td>4.6</td>
<td>7.3 x 10⁻⁴</td>
<td>3.4 x 10⁻⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.3</td>
<td>2.8</td>
<td>1.0 x 10⁻⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total Contaminant Mass Discharge (sum of all components)</td>
<td>9.7 x 10⁻²</td>
<td>6.1 x 10⁻²</td>
<td>1.2 x 10⁻⁴</td>
</tr>
</tbody>
</table>

Notes:
1 Mass discharge calculations were based on monitoring well data from the documentation.
2 Mass discharge calculations were based on monitoring well data from the documentation, discrete-depth sampling data, or a combination of discrete-depth sampling data and monitoring well data.
* Mass discharge calculations were based on discrete-depth sampling data only.
* Mass discharge calculations were based on monitoring well data analyzed solely by ASU personnel.
^ Mass discharge calculations were performed for two different geologic settings: 1) shallow, and 2) deep and/or intermediate.
SDC – supplemental data collection site for this project

6.3 SUMMARY OF KEY OBSERVATIONS

In reviewing the information presented above in Sections 6.1 and 6.2, the following are of note:

- Documents from 182 applications were collected and reviewed, which included 87 electrical resistance heating, 46 steam-based heating, 26 conductive heating, and 23 other heating technology applications conducted between 1988 and 2007. This information indicates that a significant number of applications have occurred and this reflects the acceptance of in situ thermal technologies as viable source zone treatment options.

- Approximately half of the 182 applications have been implemented since 2000, and over half of those were ERH systems. ERH applications outnumber all other applications.
since 2000 by about a factor of three. There also seems to be a recent trend in the increasing use of conductive heating and decreasing use of steam-based heating.

- There seems to be a differentiation of the technologies occurring, with it being better understood that steam and ERH are primarily limited to operating temperatures at about the atmospheric boiling point of water (100 °C) or lower and conductive heating is the only option for achieving significantly higher temperatures than that.

- There seems to be a convergence towards relatively closely-spaced energy delivery points in the design of ERH and conductive heating systems. Spacing for most ERH and conductive energy delivery points was less than 20 ft (6 m), while steam application well spacing was usually greater than 20 ft (6 m).

- To date, most applications have been applied to relatively small treatment zones; 117 of 121 treated areas were <4x10^4 ft^2 (<4000 m^2 or an acre) and two-thirds of those were <10^4 ft^2 (<1000 m^2 or one-quarter acre treatment areas). It is also apparent that the spatial extents of many source zones are likely ill-defined prior to treatment. This results in under-sized target treatment zones, untreated source zone areas, and minimal beneficial impact to groundwater quality and mass discharge.

- The effect of geologic setting on performance is difficult to discern in this data set because most treatment systems were installed in layered settings, characterized as either primarily fine-grained materials with higher permeability lenses (Generalized Scenario B) or primarily permeable materials with finer-grained lenses (Generalized Scenario C). Thus, our understanding of system design parameters and operating conditions is limited to those scenarios.

- Most applications (independent of specific technology) lasted less than 6 months; there was little documentation as to the criteria or rationale used to determine the duration of operation. There was little indication that the duration of operation was linked to mass removal-, groundwater quality-, or soil concentration-based criteria.

In using the Summary Tables, practitioners, regulators, and site owners can anticipate the likely performance of thermal-based source zone treatment technologies at their sites. The tables link design, operating condition, and performance experience a small number of generalized geologic scenario site descriptors. The user can choose the generalized scenario that most closely resembles their site and can quickly assess:

a) how the technology has been applied to date in that type of setting,
b) the designs employed,
c) the operating conditions,
d) the performance monitoring that results are based on,
e) the performance observed,
f) indicators of success at other sites, and
g) reasonable bounds on expected performance.
With respect to performance as measured by groundwater quality improvement and mass discharge reduction:

- Data from the five supplemental data collection sites indicated that a 100x order-of-magnitude reduction was achievable if the source zone was adequately delineated and fully encompassed during treatment and if the system was operated for a sufficient period of time. Reductions of less than 100x where seen if the system was not operated for a sufficient period of time and at sites where the source zone was not fully encompassed a reduction of <10x was typical.

- For sites with a concentration reduction of 100x or more, the final groundwater concentrations could be less than 100 ug/L for individual constituents which then could correspond to a mass discharge of 1E-01 kg/yr or less. This type of treatment is desirable and can be achieved if the treatment is applied to the complete source zone and operated for a sufficiently long period of time.

- Further analysis of the data set focused on mass discharge reduction and its correlation with geology and maximum treatment temperature. Correlations between mass discharge reduction and geology were investigated, however, based on the number of sites with usable data and the fact that many had similar generic geological descriptions, it was not possible to correlate these.

- Temperature was one of the significant operational variables for thermal treatments. For each site, the maximum representative temperature or the highest temperature that was achieved throughout most of the treatment zone and held for at least one day was recorded (see Table 5.1). Analysis of the data indicated that contaminant concentration reductions ranged from <10x to 100x and the maximum representative temperatures achieved for each site ranged from 89°C to 100°C. Based on available data, no correlation was found, suggesting achieving a target temperature is insufficient to achieve good clean-up, and that application duration, in combination with the treatment zone temperature and treatment zone size likely control the performance.
7.0 IMPLEMENTATION ISSUES

The purpose of the study was to summarize knowledge on the performance of in-situ heating technologies. The approach, as it pertains to this project, was to identify sites where thermal technologies have been applied and collect and synthesize as much of the available data/documentation for those sites, thus allowing for knowledge on how often each individual technology was being applied. The most challenging implementation issue was a lack of sufficient documentation for most of the 182 applications identified.
8.0 REFERENCES


9.0 APPENDICES
## Appendix A

### Points of Contact

<table>
<thead>
<tr>
<th>POINT OF CONTACT Name</th>
<th>ORGANIZATION Name</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>E-mail</th>
<th>Role in Project</th>
</tr>
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Appendix B

State-of-the-Art Technology Descriptions
Appendix C

Data Logs
Appendix D

Supplemental Site Investigation Reports
Site Specific Demo Plan and Data Analysis Reports
Appendix E

Quality Assurance Project Plan
Appendix F

Uncertainty Analysis for Mass Discharge Calculations
9.0 APPENDICES
# Appendix A

## Points of Contact

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<thead>
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<th>POINT OF CONTACT Name</th>
<th>ORGANIZATION Name</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>E-mail</th>
<th>Role in Project</th>
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APPENDIX B

State-of-the-Art Technology Descriptions for:
- Thermal Conduction Heating
- Electrical Resistance Heating
- Steam Enhanced Extraction
- Hot Air/Steam Injection Thermal Remediation Using Large Diameter Auger (LDA) In-Situ Soil Mixing
Thermal Conduction Heating

By
Gorm Heron (TerraTherm) and Ralph Baker (TerraTherm)
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1. Overview of Technology

1.1 One paragraph description of the state of the thermal application

In-Situ Thermal Desorption (ISTD) is the simultaneous application of heat by thermal conduction heating (TCH) and vacuum to remediate organic source zones. The technology has been applied at full scale to remediate a wide variety of contaminants, ranging from low-boiling VOCs and CVOCs to high-boiling PAHs, PCBs and dioxins. It has been applied to treat both vadose and saturated zone sites, as well as fractured media (clay and rock). Virtually every project achieves much lower post-treatment concentrations than the goals. Treatment costs have been lowered dramatically by technology simplifications.

1.2 New improvements to the technology over the past 5 years

Over the past five years, ISTD has undergone a number of technology improvements. The heater wells have become simpler, less expensive and more able to resist corrosive conditions. They are amenable to installation by most available drilling methods, with installation rates in the range of 200 – 400 ft per day per rig. Control systems have become simplified. Off-gas treatment can be accomplished by a wider array of components, with the choice depending on project requirements. ISTD has been performed over a wide range of thermal well spacings and time durations, and the energy requirements for a range of subsurface conditions are well understood. As treatment costs have decreased, more CVOC DNAPL sites have been treated, where initially ISTD was mostly used for PCB soil decontamination.

2. Energy Delivery/Heating Information

2.1 Basic conceptual overview of the energy delivery/soil heating process (i.e. a conceptual drawing showing the basic components and a simple conceptual time-series of energy transfer/heating in the subsurface)

Figure 1 shows a generic sketch of a small In-Situ Thermal Desorption (ISTD) site.
A typical site has the following components:

- Transformer to supply 480 V, 3-phase power.
- Simple electrical distribution switchgear and controllers for the heaters.
- Cables to all ISTD heater borings.
- Vertically installed heater borings, with a simple resistive heater element hanging inside a 3” diameter steel casing, either driven in or installed with grout and sandpack.
- Vapor recovery wells (horizontal or vertical, or both, depending on geology).
- Where necessary for hydraulic control, groundwater extraction wells or a physical hydraulic barrier.
- Temperature and pressure monitoring wells.
- An off-gas and water treatment system with varying components depending on contaminants and expected mass loading.

Energy transfer is by thermal conduction and fluid convection around the heaters, as the heater borings are heated to temperatures above 500°C. More detail is provided in LaChance et al.¹.

A typical operational period, using treatment to the boiling point of water as an example is provided in Figure 2.

![Figure 2: Typical timeline for operation of an ISTD system for VOC remediation.](image)

The extraction phase is used to document pneumatic control and to demonstrate that the off-gas treatment system meets the regulatory demands for contaminant removal efficiency. If groundwater is extracted, this period is also used to document hydraulic control and sufficient water treatment.

During the heat-up phase, ISTD power is injected into each heater at rates of approximately 300-350 W per linear ft of heater, and the ground heats up due to the temperature gradients created and convection of heated fluids such as steam, air, and water.

The polishing phase is primarily a phase where steam is generated in-situ, and steam stripping is used to lower contaminant concentrations to below target levels. It often overlaps with heating of the bottom-most depths, and/or areas that lag behind the average heating, to the target temperature.

Interim and final confirmatory soil sampling (and groundwater sampling, where required) is used to assess the treatment efficacy. Once the data comes back from the laboratory and shows that the objectives are met, a short cool-down period follows, where steam is removed from the subsurface and the site is cooled to an acceptable final temperature. Then, the ISTD equipment and the well-field are decommissioned.
2.2 *Any available information on relationship or current understanding between energy delivery and heating rates* (i.e. *efficiency of energy conversion to heat*)

To avoid overheating of wells and heater materials, the heater element power input is limited to below 400 W/ft of heater. For instance, a 30-ft long heater will only be able to supply on the order of 10-12 kW of energy to the subsurface. This energy is conducted away from the heaters, and partially used to vaporize groundwater into steam.

The efficiency of converting electric power to heat is around 99% or better – basically all the energy is deposited in the heater elements, with minor losses in switchgear and cables. Since the heating mechanism is based on the Ohmic resistance of the heater rods, which are fully imbedded in the treatment volume, this is a direct and highly efficient way of heating.

Heat losses come from conduction of heat to the surface, perimeter, and bottom, where ISTD heaters typically extend between 2 and 5 ft outside the target treatment zone to ensure heating of the entire volume to the target temperature. These heat losses are inevitable and part of any heating technology where sufficient care is taken to treat the edges of the target volume.

The heating rate is typically calculated for the coolest locations within the target treatment zone, and is directly dependent on the spacing between neighboring heaters (located in a triangular pattern). Typical durations are shown in table 1.

<table>
<thead>
<tr>
<th>Heater boring spacing (ft)</th>
<th>Operational duration for CVOC source zones (days)</th>
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<tr>
<td>10</td>
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<tr>
<td>12</td>
<td>90-120</td>
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<tr>
<td>15</td>
<td>120-180</td>
</tr>
<tr>
<td>20</td>
<td>300-400</td>
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Actual durations are site-specific, and depend on factors such as:

- Initial saturation (the wetter the longer it takes).
- Porosity (the higher the longer it takes).
- Water table position.
- Groundwater seepage velocity and recharge (if a hydraulic barrier is not used).
- Mineral composition (minor differences between common minerals).
- Initial contaminant mass.
- Target contaminant concentration (the lower the longer it takes).

If the project schedule is critical, the heater spacing is chosen for a given site to match the available time. This is typically done for Brownfield sites such as the Richmond site\(^2\), where a property transfer and/or construction of new homes drive the schedule.

2.3 Limitations of the energy delivery/heating process (i.e. what temperatures can be reached?, how even is the heat/energy distribution?, do natural phenomena limit the heating?)

For compounds with boiling points below 150°C, steam stripping and vaporization are effective mechanisms, and the boiling point of water is used as the target treatment temperature.

For sites where dewatering is undesirable or not practical, the presence of water will buffer the temperature to the steam temperature, which is 100°C above the water table and increases with depth and pressure below the water table. At 33 ft depth below water, where the pressure is 2 atm (14.6 psig or 29.2 psia), the steam temperature is 120°C.

For SVOCs such as PCB, coal tar, PAH and creosote, higher temperatures are used as the target treatment temperature. The target temperatures are in the range of 200°C to 350°C, depending on the physical and chemical properties of the limiting contaminant. Heating to these temperatures involves removing or boiling all of the soil moisture, which enables heating the dry soil/sediment above steam temperatures. Due to the high treatment efficiency (including accelerated kinetics of oxidation and pyrolysis\(^3\)) at temperatures below 325°C, sites are rarely heated beyond this temperature.

\(^2\) LaChance et al. 2006. Ibid.
The most critical factors controlling the ability to heat a site to the target temperatures are:

- **Groundwater flow**, which can lead to cooling where water enters the treatment volume. Each design must address the potential for groundwater influx and cooling. In certain clay formations, permeable fractures can lead to rapid groundwater flow and cooling, as observed at a site in Ohio⁴. Other sites with groundwater zones with significant flow rates may be addressed either by limiting the flow using pumping or barriers, or by combining ISTD with the injection of steam to heat the more permeable zones⁵.

- **Air inflow due to the applied vacuum**, leading to cooling. This is typically very minor due to the low heat capacity of atmospheric air, and the modest flow rates.

- **Target zone geometry** (very shallow sites and irregularly shaped sites take longer due to large surface areas and heat losses, deep sites and equidimensional sites heat faster due to low heat losses).

Each thermal design involves a careful review of the geometry, and specifically the hydrogeology and potential impacts of water flow on the heating regime. Where needed, a detailed 3D numerical simulation is used to evaluate impacts and worst-case scenarios.

### 2.4 Unique advantages/disadvantages of this energy delivery/heating approach for contaminant removal or destruction?

Heating depends primarily on thermal conduction – therefore the “sweep” is highly uniform. Clay layers, sand zones, and gravel zones heat up at very similar rates due to small variations in thermal conductivity (varying by a factor of only approximately three from sand to clay) and heat capacity of various minerals, sediments, soils, and rocks. This is the primary advantage of ISTD – that our heating pattern and therefore treatment duration is highly predictable. This allows the treatment performance (as determined by reduction in contaminant concentrations) to be highly predictable as well.

A unique advantage is that the ISTD heaters are simple steel rods which can be as long and deep as the site requires. The same heaters are used in the oil field for heating zones with thicknesses over 500 ft. The heaters are in 3-inch simple casings, and the borehole size does not increase as the heaters need to go deeper. Since the power used to generate


heat in each heater flows through the entire length of the heater, it puts out the same power density along the length of the heater, leading to relatively uniform heating over the length of the heater, despite differences in the sediment/soil/rock properties with depth. This can allow for uniform heating of deep sites with simple surface controls. One example of this, with ISTD heating to 110 ft, is the recent project in Alhambra, CA.

A potential disadvantage is the ability to heat a zone with groundwater flow carrying the heat away or cooling by entry of cold water. As discussed above, such cooling has to be either limited by means of a barrier (hydraulic or physical), overcome by injecting steam into the highly conductive zones, or overcome by adding more ISTD heaters to increase the power density in such zones. A good and detailed analysis of the site hydrogeology is key to managing this potential disadvantage.

For SVOCs, heating to temperatures above boiling can lead to significant in-situ destruction of contaminants. This may reduce the mass loading on the off-gas treatment system. Mechanisms and reaction processes are described by Baker and Kuhlman.

2.5 Is the process applied differently if the contaminants are below the water table?

In principle, no. The ISTD heaters are installed and operated in the same manner. But the hydrogeology issues and potential for groundwater flow discussed above become important. In addition, vapor extraction and control becomes dominated by steam generation and capture, as the heat creates steam. An analysis and example of this for a site where ISTD was used to treat CVOCs 15 ft below the water table is discussed by LaChance et al.

As the heat travels horizontally away from the heater borings, vapors are generated by in-situ boiling of groundwater (and NAPL, if present). The generated vapors travel towards the heaters, and upward along the heater borings where increased gas phase permeability is created by the drying in the immediate vicinity of each heater. The vapors are captured and extracted by vapor collectors located in the vadose zone. This continuous removal of VOC mass, starting a few hours after the onset of heating, is a key mechanism for removal of VOCs from below the water table.

For SVOCs below the water table, water presence can prevent heating to above the boiling point. Therefore, a site-specific analysis of possible treatment efficacy with and without dewatering is performed. The cleanup standard typically drives this, as complete contaminant removal to very low soil concentrations will require dewatering and heating to above boiling, and less aggressive treatment goals such a removal of all VOC

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7 Baker and Kuhlman, Ibid.

8 LaChance et al. 2006. Ibid.
components and stabilization of the leftover NAPL phase allows treatment at the boiling point.

3. Process Configuration Information

3.1 Generic lay-out of the process showing spacings (heaters, electrodes, wells, etc.) of in situ components for a "typical" application

Heaters are typically located in a triangular pattern as shown on Figure 3.

The spacing between heater borings is discussed in Section 1.2. For VOC sites, the heater spacing typically varies between 12 and 20 ft. For SVOC sites heated to above boiling, a typical heater spacing is between 6 and 12 ft.

Vapor and water extraction wells can either be vertical wells within the pattern (heated or unheated), or horizontal or angled wells located in optimized positions to capture the heated fluids. Figure 4 illustrates a cross-sectional view of a site where steam vapors are extracted near each heater (which is used for sites with high NAPL saturations to minimize condensation during heating), and a number of horizontal vapor extraction wells located in the vadose zone.

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Each site is analyzed in detail, and the vapor and water recovery wells and extraction approach is determined based on site-specific conditions.

A vapor cover is typically used when treating to shallow depths. The cover serves three purposes:

1. It provides thermal insulation and prevents contaminants from condensing near the land surface, which will occur if the soil is cool.
2. It prevents rainwater infiltration, which could lead to unwanted cooling of the treatment zone.
3. It provides a vapor seal and increases the radius of influence of the vapor extraction screens.

Temperature and pressure monitoring wells are simple vertical borings used to document performance and pneumatic control during treatment. These are located inside and outside the treatment area, typically at different distances from the heaters to illustrate the heating progression.

3.2 *Generic lay-out of above-ground components, showing the footprint of a "typical" application*

The above-ground equipment varies from site to site depending on treatment area size, volume, nature of contamination, and local regulatory requirements for treating the effluents. A typical simple system is shown in Figure 5.
For sites with large contaminant mass loading, the vapor treatment is often done using thermal oxidation or other methods capable of handling the high recovery rates.

The surface layout is dictated by site-specific conditions such as the location of utility connections, obstructions such as buildings, and an effort to minimize the piping runs from the well field area to the treatment process. For small sites, the treatment system is placed on a trailer or in a container, and mobilized to the site as one unit. For sites requiring large treatment components, individual process equipment units may be mobilized and connected at the site.
3.3 Special utility requirements (power, water, surface cover, security, etc.)

The required utilities are:

- Power (480 V, 3-phase).
- Water (for drilling, cleaning, office trailer, and sometimes for the process if using a cooling tower or wet acid gas scrubbing).
- Gas or diesel when fuel is used for either off-gas treatment (such as an oxidizer) or for generating power as a back-up.
- Telephone and internet for communications and process controls.

3.4 Is the process configured differently if the contaminants are below the water table?

This depends on whether dewatering is necessary, as discussed in Section 1.5. Often, treatment below the water table involves groundwater extraction and treatment.

4. Process Information

4.1 Typical durations of applications, and how does one decide to turn it off?

For VOC sites, typical durations are between 2 months and 1 year, depending on site-specific requirements and the chosen heater spacing (Section 1.2).

For SVOC sites, typical durations are between 6 months and 1 year.

Performance is typically based on soil concentrations, since soil can be readily sampled during operation, using methods identical or similar to those tested and documented by Gaberell et al.\textsuperscript{10} The criteria for turning off the system are typically the same as the criteria for successful remediation – the system is operated until the client has regulatory approval that the remedy is complete.

Sampling of soil eliminates a classical problem – groundwater rebound occurring after the treatment. By sampling the phase from where rebound would originate (by desorption and diffusion out of bypassed solids), the risk of post-remediation contaminant concentration increases is minimized/eliminated.

For some sites without specific numeric cleanup standards, other parameters are used to determine when to cease operation:

- Groundwater concentrations (although these are hard to use due to the complex chemistry at elevated temperatures and difficulty in collection of representative samples without loss of the contaminants). Groundwater samples can potentially show you more impressive remediation results due to the low solubility of most VOCs in hot water. Basing the decision to stop treatment on such samples may be risky – and rebound could occur during cool-down.

- Target treatment temperature. This would be applied to the coolest locations within the target treatment zone and used to focus the heating process towards the end of the operational period. Laboratory treatability tests can be use as guidance for selection of the target temperature and thereby provide an indication of remedial completeness when the target temperature is reached.

- Energy balance calculation showing steam stripping and generation of a certain amount of steam (typically related to the pore volume of the treatment zone). The amount of steam generation/stripping needed can be estimated based on laboratory testing, and depends on initial concentrations and the specific remediation goals.

- Diminishing recovery of contaminants while ensuring that the heating process and fluid extraction process are operated according to specifications. This can be risky, since diminishing returns can be reached without treatment of the entire targeted volume, as documented as an interim result at the Young-Rainey STAR project\(^\text{11}\), where the discovery of a cool area led to focused heating and more complete remediation after the vapor recovery had dropped to low levels temporarily.

Site-specific performance goals are negotiated and typically made part of the contract for the ISTD project. They typically tie directly into the regulatory demands for site closure or remedy acceptance, such that the client and the ISTD contractor work towards the same objective.

4.2 Typical monitoring/diagnostics for the technology during operation (i.e. how do you know it's working?)

The monitoring is based on:

- Hydraulic control (documented using groundwater elevation monitoring).
- Pneumatic control (documented using pressure monitoring).
- Subsurface temperatures (documented using thermocouples). This includes thermocouples located in a subset of the heater borings, used for the thermostat control of the heater elements.

• Contaminant removal rates and totals (estimated by sampling the effluent vapor, water, and NAPL). The totals are compared to initial mass estimates, considering the typical uncertainties of such estimates. However, the total mass recovered is never used to determine when to cease operation, due to the uncertainties in initial mass estimates.
• Vapor treatment efficacy (based on vapor samples before and after the treatment unit).
• Water/condensate treatment efficacy (based on water samples before and after the treatment unit).
• Interim sampling of soil and/or groundwater within and around the treatment zone (showing reductions in contaminant concentrations compared to original levels). These samples are typically the most important for determining when to cease operation.
• Final confirmatory sampling.

In addition, site-specific monitoring related to health and safety and community monitoring may be conducted.

4.3 Post-treatment issues (time period needed for cooling/access/etc.)

This is site-specific and depends on future site use. Typically, live steam is removed from the subsurface over a period of 1 to 2 weeks, while the site starts the cool-down. At some sites, cold water is injected to assist with cooling. When demobilization begins, the subsurface temperatures may be as high as 90°C. Removal of the surface cover enhances the cooling. Demobilization is typically complete between 1 and 2 months after completing the remediation.

5. Technology Selection

5.1 For what scenarios is the technology ideally suited?

Generally, ISTD is favored by the following conditions:

• Recalcitrant contaminants not easily addressed by Monitored Natural Attenuation (MNA), Soil Vapor Extraction (SVE), or pump and treat. The most suited contaminants would include most CVOCs, DNAPL, creosote, coal tar, and PCBs.
• Large contaminant mass and concentrations, with significant NAPL presence (so less aggressive, cheaper methods are ineffective).
• Stringent cleanup standards. ISTD treats to very low final concentrations, largely independent of the starting mass and concentration.
• Sites with a driver to clean within a relatively short time-frame (where long-term solutions suffer due to insecurity about when they can be shut off).
• Sites with target volumes above 3,000 cubic yards (the unit cost is higher for small sites).
Sites deeper than 10 ft (our simple heaters can readily be extended deeper without much additional cost).

SVOC sites where excavation is unpractical or expensive (so we can compete on a unit cost basis).

Most sites treated using ISTD have been CVOC DNAPL sites or SVOC sites with PCBs, coal tar, or creosote.

ISTD is potentially ideally suited for fractured rock sites. All known bedrock types have sufficient thermal conductivity to allow for effective heating using ISTD. The combination of very predictable heating and a high density of wells/borings for extraction, such that all or the majority of the fractures can be contacted and used for extraction of the generated steam, makes this a very promising option.

5.2 Under what conditions is the technology "challenged"?

The following conditions challenge the applicability of ISTD:

- Very shallow and wide-spread contamination. For such sites, heat losses may become prohibitive due to the large surface area. The on-site version of ISTD, termed In-Pile Thermal Desorption (IPTD), may apply to some of these sites.
- Contamination present under structures where vertical drilling is prohibited. Heating can readily be done using angled or horizontal borings, but the complexity and cost of the drilling and installation increases significantly compared to vertical installations.
- SVOCs below the water table with stringent cleanup standards and difficulty of dewatering. If the water prohibits drying and heating to above steam temperatures, complete treatment for SVOCs to low levels may not be possible.
- Sites with high groundwater flow rates and difficulty of controlling it during operation. As described in Section 1.2, management of the groundwater flux or additional heating of the high-flow zones may be used to overcome this challenge.

Typical concerns about geotechnical stability and damage to foundations, buildings, or underground utilities are dealt with relatively easily on a site-specific basis, and have not been a significant barrier to ISTD implementation.
1.0 Overview of Technology

1.1 One paragraph description of the state of the thermal application

Electrical Resistance Heating (ERH) is an aggressive in situ thermal remediation technology that was developed by the U.S. Department of Energy from the original oil production technology to enhance vapor extraction remediation technologies in low permeability soils. Soil and groundwater are heated by the passage of electrical current through saturated and unsaturated soil between electrodes, not by conductive heating from the electrodes themselves. It is the resistance to the flow of electrical current that results in increased subsurface temperatures, and ERH is typically applied to the boiling point of the contaminant and water mixture. It is estimated that more than 75 ERH applications have been performed. Capacity to perform these projects has increased over the years, with as many as 15 to 20 of these applications now being performed at any given time, mainly in North America, with some European applications. ERH has been used to treat a wide variety of contaminants including VOCs, CVOCs (especially where light non-aqueous phase liquids (LNAPL) or dense non-aqueous phase liquids (DNAPL) are present), pesticides, and is now being applied to treat PAH compounds from manufactured gas plant sites and creosote from wood treating operations.

1.2 New improvements to the technology over the past 5 years

Technological improvements over the past 5 years have been in the area of equipment and mode of application. The modifications to the mode of application have incorporated physical, chemical and biological processes that have been observed to occur during ERH. Improvements made to the equipment include simplification of power control units (PCUs), improvements in electrode design, and modification of water drip systems to maintain soil moisture around electrodes.

Improvements have been made to the efficiency of operations, both from an installation and energy focus, but also from an operational focus. More maintenance-friendly condensers are now being used to control costs and improve efficiency. Various electrode designs have been developed over the years for a variety of applications. Most electrode designs incorporate vapor recovery in their design. Electrodes have been constructed from steel pipe, copper plate for heating distinct zones and sheet pile. Sheet pile electrodes allow for quick installation with little to no drilling wastes generated for disposal.

More robust, all-weather drip systems have been developed to maintain soil moisture in the vicinity of the electrodes. This allows for continuous all-weather operation in remote locations.
At the Ft. Lewis, Washington project, TRS was the prime contractor for what is believed to be the most-studied application of in situ thermal remediation to date. This work consisted of laboratory and field testing to evaluate the reductive dehalogenation mechanisms during ERH. At the time of this document preparation, much of this data is being evaluated and some additional studies are being conducted, however, some of the lessons learned from this project are being carried forward to incorporate reductive dehalogenation into the design of new applications.

Chemical processes that had not been considered for environmental remediation such as hydrolysis are now becoming the principal mechanism for cleanup for a variety of pesticides using ERH. Hydrolysis had not typically been considered a chemical process for groundwater remediation because at typical groundwater temperatures, the reaction is too slow. At temperatures that can easily be achieved using ERH, hydrolysis reaction rates increase by several orders of magnitude. For example, methylene chloride, which has a hydrolysis half life of 3,282 years at 15 °C, has a hydrolysis half life of 35 days at 100°C.

Physical reactions that provide enhancements to fluid recovery using ERH include a process that TRS calls steam bubble floatation. This process involves the formation of gas and vapor bubbles at the NAPL/water interface causing the NAPL to rise to the water table where it can be removed using multi-phase extraction. This process was used to recover heavy grease at Ft. Lewis, Washington and oil in Georgia.

2.0 Energy Delivery/Heating Information

2.2 Basic conceptual overview of the energy delivery/soil heating process (i.e. a conceptual drawing showing the basic components and a simple conceptual time-series of energy transfer/heating in the subsurface)

The components required to implement ERH include:

- Electrodes (steel pipe, copper plate, well points, sheet pile).
- Vapor recovery wells (which are typically co-located in the same boreholes as the electrodes).
- A steam and vapor collection system, including piping, blower, and condenser.
- A vapor treatment system.
- An ERH power control unit to condition power for application to the subsurface.
- A computer control system with modem for data acquisition and continuous remote monitoring and control of power.

The ERH electrodes conduct electrical energy into the subsurface and can be designed to allow independent control of the energy input to discrete depth intervals. Electrodes are typically constructed using either steel pipe or copper plate to treat distinct zones in the subsurface, such that multiple electrodes can be installed within the same boring. For some applications, sheet piling has been used as electrodes. Electrodes constructed using
steel pipe are installed in the subsurface in a manner similar to installing groundwater monitoring wells. In the electrically conductive intervals, the surrounding borehole annulus is packed with a conductive material, such as graphite and/or steel shot, to increase the effective (conductive) diameter of the electrode. In those portions of the subsurface where electrical resistance heating is not desired, the electrode construction materials are insulated and the surrounding annulus is filled with relatively non-electrically conductive materials such as sand or cement.

The electrodes provide the opportunity to heat discrete subsurface depth intervals. In applications having layered sequences, it may be desired to treat discrete layers separately or to create thermal barriers. ERH allows this flexibility by placing electrically conductive materials at discrete intervals within the same borehole in which the electrode is constructed. Based on the current state of the technology and experience, the practical minimum thickness of the discrete zone is 8 feet because of electrical fanning and thermal conduction.

Vapor recovery (VR) is accomplished using conventional vapor extraction techniques utilizing shallow wells installed either vertically or horizontally. Once steam and volatile contaminants have been collected by the VR system, the steam is condensed and the vapor is cooled to near ambient temperatures. Conventional vapor treatment techniques are used to adsorb or destroy the vapors. However, owing to temperatures resulting from application of ERH, the materials for the construction of the wells and headers must be able to withstand temperatures in the order of 100ºC.

An ERH power control unit (PCU) is used to step-down standard line voltage for application as three or six separate electrical phases (as desired). The PCU includes isolation transformers that force ERH current to flow between the electrodes only, preventing ERH current from flowing to a distant electrical sink. Isolation transformers are so named because there is no conductive path between the isolated circuit and the rest of the electrical grid. Because there is no electrical path through the isolation transformer, electricity cannot leave the ERH field. Resistance by the subsurface environment to this flow of electrical current heats the soil and groundwater between the electrodes. Because electrically conductive intervals can be installed to different depth intervals, and the application of energy to the different parts of the electrode field can be controlled, it is possible to heat separate subsurface zones either independently or in unison.

The ERH process is automated, with an onsite computer equipped with a modem and appropriate software for remote access and monitoring. Multiple applications can be monitored and controlled remote from the remediation site or sites, connected via modem. Periodic site visits are required for inspection of the system, maintenance of mechanical equipment, monitoring, manual adjustments to the electrode configurations, and troubleshooting equipment malfunctions.

The only additive normally required for ERH is a drip source of potable water that is applied to soil immediately surrounding the operational electrodes. This water addition,
normally incorporated in low permeability environments, prevents the soil adjacent to the electrodes from drying out and becoming nonconductive. Particular attention is paid to maintaining a net extraction of water from the site over the life of the project.

As the subsurface is resistively heated, contaminants are volatilized and soil moisture and groundwater are converted to steam. The production of steam during ERH operations effectively provides for the in situ steam stripping of VOC contaminants from the soil matrix. By raising subsurface temperatures above the boiling point of the mixture of targeted contaminants and groundwater, ERH significantly enhances the speed and effectiveness of physical contaminant removal. ERH provides the physical conditions that result in the chemical, physical, and biological reactions for their removal from the subsurface.

The rate of steam formation during ERH is very slow, typically requiring approximately 2 to 8 weeks to reach the boiling point, depending on site conditions. Once boiling does begin, it is a very gentle process, comparable to the rate of bubble formation in a glass of carbonated beverage.

The process of in situ steam generation converts groundwater to steam and then vapor recovery removes the steam from the subsurface. This has the same effect as groundwater pumping, with the net result being a slight drawdown of the water table and some measure of hydraulic control. Within the vadose zone, some decrease of soil moisture may occur if the site is covered (preventing rainfall percolation).

2.2.1 In Situ and Aboveground Treatment.

During heating, pore water increases in volume 1700-fold as it is converted to steam. This process results in the creation of fissures in clayey and silty soils, facilitating vapor transport. The steam forms very slowly, so that the formation of fissures is on a very small scale.

Above ground treatment typically involves treating vapors, condensate, and entrained water. Vapor treatment involves reducing the moisture content, typically through conventional “knock-out” pot arrangements and heat exchangers, followed by appropriate treatment (e.g., granular activated carbon, combustion, thermal oxidation, etc.) prior to permitted atmospheric discharge. Treatment of condensate and entrained water involves liquid phase granular activated carbon and/or air stripping through a cooling tower. The cooling tower is analogous to an air stripper, with the vapor fed to the vapor stream treatment equipment. The condensate and entrained water makes multiple passes through the cooling tower, significantly reducing concentrations of volatile constituents. The treated water is then disposed as appropriate for the site (e.g., returned to the subsurface as drip water, offsite treatment and disposal, discharge to the local POTW, NPDES-permitted discharge, etc.).
2.2 Any available information on relationship or current understanding between energy delivery and heating rates (i.e. efficiency of energy conversion to heat)

The relationship between energy input and temperature is not straightforward, for there are many factors that influence temperature, including the shape of the volume of the soil and groundwater that is being heated, heat losses (that are influenced by the geometry of the treatment volume), groundwater flow rate, applied vacuum and airflow rates, soil and groundwater electrical conductance, (which changes with temperature), depth of treatment beneath the water table, and other operational issues. Other operational issues relating to the rate of heating deal with the electrical conductivity of the site, the available electrical power, size and type of the vapor treatment system and the rate at which vapors may be discharged from the treatment system.
Figure 2 presents a graph showing the applied power and resultant average temperature for a confidential site in the Chicago, Illinois area. For this site, power was initially applied at a relatively high level, but was reduced prior to the temperature achieving its maximum of 87.5°C on October 25, 2006. It should be noted that the maximum average temperature achieved was adequate and appropriate for this application and achieved the cleanup goals within the projected timeframe.

**Figure 2: Applied Power (kW) and Temperature**

2.3 Limitations of the energy delivery/heating process (i.e. what temperatures can be reached?, how even is the heat/energy distribution?, do natural phenomena limit the heating?)

The maximum temperature achievable is the boiling point of water, which is governed by the atmospheric pressure (i.e., the boiling point increases with depth). Heating increases the total dissolved solids in groundwater, which in turn increases electrical conductivity. The total dissolved solids in groundwater are affected by biogeochemical reactions. For example, zones which may have high chloride from intrinsic biodegradation of chlorinated ethenes heat up rapidly. Heating becomes more even with time, as illustrated in Figure 3.
2.4 Unique advantages/disadvantages of this energy delivery/heating approach for contaminant removal or destruction?

Because ERH involves the electrical resistance of the soil matrix to create increases in temperature, there are several inherent features that create advantages for this technology. First, it seeks out the most conductive areas for treatment first. Electrical current, seeking out the path of least resistance will heat areas of high total dissolved solids (TDS) first. Areas of high TDS are the result of biogeochemical reactions associated with the biodegradation of organic compounds, which also corresponds to areas adjacent to high contaminant concentrations. TDS increases throughout ERH, such that electrical conductivity increases as well. TRS’ own testing has shown that for chlorinated ethenes and ethanes, chloride represents on the order of 90% of the anions and 40% of all major ions in water during ERH. While different zones heat up quicker, the site is typically heated to a uniform temperature at depth as illustrated in Figure 3, providing for complete treatment throughout.

Second, the technology is self correcting. If some areas heat up in preference to others, the moisture content is reduced, in turn reducing the ability of the soil and groundwater to conduct electricity. The electrical current will seek other pathways until the previously heated area is re-hydrated either naturally or from the ERH drip system.

The electrodes, as noted above, are constructed of readily-available materials (steel pipe, copper plate, sheet pile, etc.) using standard drilling techniques and multiple electrodes.
can be constructed within the same borehole to heat selective zones. The deepest heating has been to 100 ft in Paducah, Kentucky.

2.5 *Is the process applied differently if the contaminants are below the water table?*

There is no real difference between applications above and below the water table. The technology requires a minimum of 3% field moisture. The main concern with applications below the water table is groundwater velocity of greater than 1 ft/day, which results in heat losses that need to be controlled. Control can be performed through conventional groundwater control methods (i.e., wells, French drains, sheet pile, slurry walls, freeze walls, etc.).

3.0 **Process Configuration Information**

3.1 *Generic layout of the process showing spacing (heaters, electrodes, wells, temperature, etc.) of in situ components for a "typical" application*

Figure 1 presents the conceptual layout for an ERH application. Electrodes are spaced 15 to 23 ft (4.6 to 7 m) apart. The spacing is dependent upon the characteristics of the contaminants to be treated, the desired rate of heating, expected heat losses, the construction of the electrodes that can be achieved, and the desired final temperature to be achieved.

Temperature monitoring points are located throughout the treatment area, and are typically located equidistant between groups of electrodes to monitor temperatures at the furthest distance from the energy application point. Each temperature monitoring point consists of a string of thermocouples, typically set at 5 ft depths.

3.2 *Generic layout of above-ground components, showing the footprint of a "typical" application*

The layout of the above ground treatment components is dependent upon space available and access. In general, the vapor recovery blower and the condenser are located in a manner to minimize piping from the treatment area, but maintain a safe distance from the area that is being treated. Granular activated carbon vessels and a Baker tank for temporary water storage are typically located in a manner to provide for vehicular access for water removal (if required) and change out of carbon (if required).
3.3 Special utility requirements (power, water, surface cover, security, etc.)

Depending on the equipment needed for a given site, 480 V three-phase or standard 13.8 KV three-phase line voltages are required to power the PCU, which then distributes power to the electrodes and ancillary equipment. A source of potable water is also required during the initial phases of application as a source of drip water and for the cooling tower at start up. Water during operations is normally supplied by the condensate produced from the heating. A data quality telephone line may be necessary for adequate remote communications. Surface covers typically consist of existing pavement or concrete if working in an industrial area. For bare ground applications, the surface may be covered with polyethylene sheeting, depending on depth of treatment depth below grade. The sheeting is used to maintain vacuum and minimize the surface infiltration from precipitation.

The level of security depends on the location where the ERH treatment is being performed. Historically, most locations have involved working in or around active and shuttered factories, where standard chain-link fencing and placarding indicating the electrical hazards has been appropriate. The next level of security that is typically used involves perimeter electronic monitoring to provide alarmed automatic shut down of the system to prevent potential electrical shock to intruders. When the perimeter system is tripped, the operator is notified and the system is restarted once the operator has confirmed that operations can safely continue. TRS has not had to impose a higher level of security, but if needed, this is envisaged as involving a perimeter electronic system.
with periodic to continuous manual security checks provided by a contract security company.

3.4 Is the process configured differently if the contaminants are below the water table?

As noted above under Section 2.5, there is no real difference between applications above and below the water table and as such there is no difference in the configuration.

4.0 Process Information

4.1 Typical monitoring/diagnostics for the technology during operation (i.e. how do you know it's working?)

Monitoring during ERH involves tracking temperature, power and energy application, and organic vapor concentrations. It has been observed that most of the organic vapors are produced during the heat-up portion of operations. When organic vapor concentrations decrease by approximately 80% from peak concentrations, electrical resistance heating typically is temporarily stopped and interim groundwater or soil sampling is performed. The analytical results are then evaluated to determine if and where additional treatment is required. Power application to individual electrodes may be ceased in order to focus treatment in select areas, thus reducing cost. Natural attenuation processes (most importantly intrinsic biodegradation) are also commonly assessed at this time to determine if remediation goals can be attained under post-thermal treatment conditions. Based upon the results of interim sampling, heating can be continued or post-remedial sampling can be conducted to document that the remedial action objectives for soil and groundwater have been met.

4.2 Post-treatment issues (time period needed for cooling/access/etc.)

After ERH treatment, soil and groundwater typically return to ambient temperatures within 6 to 24 months. During this cool down period, groundwater and soil sampling may be safely conducted using the proper precautions. TRS has developed protocols for sampling that have been approved by federal and state environmental protection agencies. Safe access to the site is normally restored within two days to two weeks of cessation of power application.

5.0 Technology Selection

5.1 For what scenarios is the technology ideally suited?

ERH has been most widely applied for the remediation of chlorinated ethenes and ethanes where DNAPL is present, since these groups of chemicals represent the most commonly encountered environmental contaminants, with the exception of fuels. There have been a small number of sites contaminated with fuels that have been remediated
using ERH. ERH has also been used to hydrolyze a few pesticide impacted sites, and is now seeing some application for MGP site and creosote sites.

5.2 Under what conditions is the technology "challenged"?

As noted above, the technology may be challenged in instances where heat losses through high groundwater flow may represent an issue. These conditions can usually be mitigated using engineered solutions.

ERH has been used in buildings where there has been sufficient overhead clearance from which to install the electrodes. This is generally site specific, depending upon the overhead clearance and available drilling equipment with which to install the electrodes. Electrodes drilled at an angle have been successfully installed and used at a number of sites to access difficult areas.

Some PAH compounds may represent a challenge. Generally, significant reduction in concentration (>85%) has been observed for compounds with boiling points of less than 300°C. PAH compounds, with boiling temperatures of greater than 300°C tend to adhere to the soils and are not significantly reduced, but are not considered mobile in groundwater environments.

Concerns over geotechnical stability are dealt with relatively easily and have not represented a problem. ERH does not pose a threat to underground foundations and utilities.
Steam Enhanced Extraction

By
Gorm Heron (TerraTherm) and Gregory Crisp (TerraTherm)

1. Overview of Technology

1.1 One paragraph description of the state of the thermal application

Steam Enhanced Extraction (SEE) has been used successfully for treatment of large sites, and numerous pilot tests have shown great promise for applications to a variety of contaminants, including chlorinated solvents, oil, and creosote. Two large sites have been closed, achieving MCL level groundwater concentrations after effective source removal.

1.2 New improvements to the technology over the past 5 years

The technology was significantly expanded and adapted during the period of 1998-2003 with focus on optimizing steam delivery and heating completeness, use of pressure cycling to enhance removal, and applications in moderately permeable strata and fractured rock. New combinations with thermal conduction heating are promising adaptations for heterogeneous sites, and are currently being implemented.

2. Energy Delivery/Heating Information

2.1 Basic conceptual overview of the energy delivery/soil heating process (i.e. a conceptual drawing showing the basic components and a simple conceptual time-series of energy transfer/heating in the subsurface)

SEE involves installation of a network of injection and extraction wells, installation of temperature monitoring equipment, injection of steam into the wells, and extraction of hot fluids for on-site separation and treatment. The injection of steam is a stable and predictable process, since the steam propagation is governed by heat transfer to the formation, which has been studied intensively for oil recovery. This predictability allows for hydraulic control of non-aqueous phase liquid (NAPL) mobility, as steam sweeps from the outside in and pushes NAPL and vaporized contaminants of concern (COCs) towards the central parts of the site for extraction.

The steam displaces subsurface fluids such as water, NAPL, and air and creates a steam zone with reduced liquid saturations. During the steam front propagation, the target zone is heated both by the steam itself, and by the warm/hot condensate migrating with it. The condensate is formed when some of the steam condenses after being cooled by the subsurface materials.

After the target zone for steam injection has been heated, a steam zone is created between the injection and extraction wells. A period of pressure cycling is induced by varying the injection pressure and rates, as well as the applied vacuum. This pressure cycling has

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been demonstrated to improve removal rates for COCs dramatically, and to achieve very low concentrations in the original source zone.

Figure 1 shows a generic sketch of an SEE site.

![Figure 1. Conceptual Sketch of Steam Enhanced Extraction System.](image)

A more detailed sketch of a steam generating process is shown on Figure 2. Note that the water supply is fresh water, and that the fuel can be either natural gas, propane, or diesel. Some steam generators or boilers have a pre-heating step (de-airator), where the feed water is heated using some of the produced steam.

![Figure 2. Steam generation system schematic.](image)
For treatment of a separate NAPL source area, the treatment zone is typically surrounded by steam injection wells installed in clean material. The extraction wells are located in high-concentration areas, each surrounded by four or six steam injection wells.

A typical site has the following components:

- Transformer to supply 480 V, 3-phase power.
- Vertically installed injection wells installed with grout and sandpack.
- Groundwater and vapor recovery wells (horizontal or vertical, or both, depending on geology).
- Temperature and pressure monitoring wells.
- A water softening and steam generation system.
- An air compressor or blower to deliver air for co-injection with steam (if used).
- An off-gas and water treatment system with varying components depending on contaminants and expected mass loading.

Air co-injection is sometimes used to minimize the risk of forming condensation banks containing NAPL, and to enhance the vapor transport to extraction wells\textsuperscript{13}.

A typical operational period, using treatment to the boiling point of water as an example is provided in Figure 3.

Figure 3. Typical timeline for operation of an SEE system.

The extraction phase is used to document pneumatic control and to demonstrate that the effluent treatment system meets the regulatory demands for contaminant removal efficiency. This period is also used to document hydraulic control and sufficient water treatment.

During the heat-up phase, steam is injected into each well at a pre-determined rate (based on target zone thickness, permeability, and well spacing), and the ground heats up due to the convection of heated fluids such as steam, air, and water. The goal of this phase is to heat the target volume to steam temperature and to allow for steam break-through to the extraction wells. During this period cool groundwater is being displaced to extraction wells, and a steam zone develops until steam sweeps through to the extraction wells. This period is also called the “steam sweep”.

The pressure cycling phase is a period where steam is generated in-situ, and steam stripping is used to lower contaminant concentrations to below target levels. It often overlaps with heating of the bottom-most depths, and/or areas that lag behind the average heating, to the target temperature. Details of the pressure cycling principle was published by Udell 1996\textsuperscript{14}. Heron et al. (2003) used pressure cycling to achieve MCL level groundwater concentrations at the Young-Rainey STAR Center Area A site\textsuperscript{15}.

Interim and final confirmatory soil sampling (and groundwater sampling, where required) is used to assess the treatment efficacy. Once the data comes back from the laboratory and shows that the objectives are met, a short cool-down period follows, where steam is removed from the subsurface and the site is cooled to an acceptable final temperature. Then, the SEE equipment and the well-field are decommissioned.

\textbf{2.2 Any available information on relationship or current understanding between energy delivery and heating rates (i.e. efficiency of energy conversion to heat)}

The hydrogeology controls the rate of steam injection at each site. Typically, the steam is pushed through the formation for steam breakthrough to extraction wells in less than 60 days. This is desirable to (1) limit the operations time at the site and (2) minimize the risk of steam over-ride, where the buoyancy of the steam makes it flow on top of groundwater and/or NAPL, reducing the sweep efficiency. For larger sites, the steam sweep may be staged across the site, such that the operational period is longer than that of each segment being heated with steam. This means that large sites have longer durations.

The following pressure cycle duration depends on the remediation goals. More stringent goals means longer pressure cycling. Typically, between 1 month (for small VOC sites) to a year or longer (for large creosote sites) are used.

Finally, the cool-down period depends on site size and objectives, but typically last between 1 week and several months.

Typical total durations are shown in table 1.

Table 1. Typical duration of SEE operation as a function of well spacing.

<table>
<thead>
<tr>
<th>Steam injection well spacing (ft)</th>
<th>Operational duration for source zones (days)</th>
<th>Example site</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>50-100</td>
<td>Alameda Point Site 5&lt;sup&gt;16&lt;/sup&gt;</td>
</tr>
<tr>
<td>20-40</td>
<td>100-200</td>
<td>Young-Rainey STAR Center Area A&lt;sup&gt;17&lt;/sup&gt;</td>
</tr>
<tr>
<td>&gt;40</td>
<td>200-400+</td>
<td>Visalia Pole Yard (Creosote)&lt;sup&gt;18&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Actual durations are site-specific, and depend on factors such as:

- Initial saturation (the wetter the longer it takes).
- Porosity (the higher the longer it takes).
- Water table position.
- Groundwater seepage velocity and recharge (if a hydraulic barrier is not used).
- Mineral composition (minor differences between common minerals).
- Initial contaminant mass.
- Target contaminant concentration (the lower the longer it takes).
- Target contaminant boiling point and volatility (higher boiling point compounds require longer operation).

If the project schedule is critical, the well spacing is chosen for a given site to match the available time.

Several tools exist for predicting/estimating the steam zone progression and time for the steam to migrate to the extraction wells. These range from simple rule-of-thumb relations to sophisticated 3-dimensional non-isothermal simulators such as T2VOC, TOUGH2, and STARS.

2.3 Limitations of the energy delivery/heating process (i.e. what temperatures can be reached?, how even is the heat/energy distribution?, do natural phenomena limit the heating?)

The largest limitation of SEE is soil permeability. Many sites are too tight to allow steam to be injected and heat the target volume sufficiently. It is typically not considered safe to inject at steam pressure above 0.5 psig per ft of overburden located over the injection.


<sup>17</sup> Heron et al. 2005. Ibid.

<sup>18</sup> Eaker, Craig 2007. Southern California Edison, Rosemead, CA. Personal communication.
screen. Higher pressures can lead to lifting of the formation and surface escape of steam. Example sites where insufficient steam injection rates are achievable are ones dominated by thick clay zones and competent bedrock sites with minimal fracturing. Each site must be carefully evaluated to determine whether SEE technology is the right choice for delivering the energy to the target volume.

For compounds with boiling points above 200°C, steam stripping and vaporization are not effective mechanisms, and technologies that can reach higher temperatures may be more applicable. SEE may only be capable of removing the mobile NAPL and reduce concentrations by steam distillation, which affects the lighter end of the NAPL (lowest molecular weight compounds in the mix).

For SVOCs such as PAH and creosote, SEE has been shown to be effective in long-term applications such as the Visalia Pole Yard\(^\text{19}\), where SEE was followed by a period of enhanced natural attenuation. Field data from other sites also indicate that SEE can remove the bulk of the DNAPL mass in a relatively short period, if the subsurface hydrogeology allows for steam sweep of the DNAPL zones. However, such sites typically are not completely depleted in the organic contaminants, since steam stripping is less effective for the higher molecular weight contaminants such as benz(a)pyrene.

### 2.4 Unique advantages/disadvantages of this energy delivery/heating approach for contaminant removal or destruction?

Steam is by far the cheapest form of energy for injection. Typical boiler efficiencies in the range of 80 to 90% means that ~ 85% of the fuel value in the fuel is injected. For comparison the electricity using in ERH and TCH/ISTD applications is generated at power plants with much lower energy conversion efficiency, plus line losses for delivery. In addition, cold water is displaced by the advancing steam, such that it does not require energy for heating. The result is that the same block of earth can be heated using approximately half the fossil fuel of an electrical heating process, and costing about half. For large sites the savings may be the difference between a project being over or under the acceptable budget.

Steam injection and extraction wells are very simple and inexpensive to construct. Injection wells are 1, 2, or 4-inch diameter carbon steel pipes with a stainless steel screen, set in sandpacks and sealed using high-temperature grout. The borehole size does not increase as the wells need to go deeper.

A potential disadvantage is the inability to heat tight zones, where the steam cannot be injected at a sufficient rate. Another potential disadvantage is the steam buoyancy in deep or thick formations, where steam rise may lead to bypassing of DNAPL layers pooled at the base of an aquifer. A good and detailed analysis of the site hydrogeology is key to managing these potential disadvantages.

\(^{19}\) Eaker 2007. Ibid.
Relatively new heating combinations are designed to minimize the disadvantages of steam (by combining it with TCH) and optimizing the use of the lower-energy heating method (by enhancing electrical heating projects using steam injection).

2.5 *Is the process applied differently if the contaminants are below the water table?*

In principle, no. The steam wells are installed and operated in the same manner. However, for vadose zone applications, recovery of the condensate generated when steam cools in the formation is essential. This condensate can be rich in contaminants, particularly early on in the operational period. Thus, hydraulic control must be ensured.

Below the water table the steam behavior is well-described from decades of enhanced oil recovery, and SEE is an applicable technology.

Most SEE sites to date have treated both a saturated zone and a vadose zone simultaneously. This facilitates easy hydraulic control by pumping, and pneumatic control by vacuum extraction above the water table.

**3. Process Configuration Information**

3.1 *Generic lay-out of the process showing spacings (heaters, electrodes, wells, etc.) of in situ components for a "typical" application*

Steam injection and extraction wells are typically located either in a square pattern (5-spot) or in a triangular pattern (7-spot) as shown on Figure 4. However, the pattern does not have to be regular, since this is a fluid-delivery based process without electrical phasing considerations.
Figure 4. Generic layout of heater borings and process equipment for an SEE project.

The spacing between steam wells is discussed in Section 1.2. Well spacings have ranged from 20 ft at relatively low-permeability sites to more than 50 ft at sites with high hydraulic conductivity and significant depth.

Vapor and water extraction wells can either be vertical wells within the pattern (heated or unheated), or horizontal or angled wells located in optimized positions to capture the heated fluids. Figure 5 shows the wells in a schematic cross-section. The extraction wells are fully screened, allowing for NAPL and water recovery also when the operations lead to partial dewatering and large changes in the depth of the water table. Steam injection wells are typically screened at the base of the treatment zone, or slightly deeper to allow for steam rise into the target treatment zone.

Note that several sites have been heated using more than one steam injection well interval per location. Several projects have used three injection intervals, as for example EarthTech and SteamTech.²⁰

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Each site is analyzed in detail, and both the steam delivery and the vapor and water recovery wells and extraction approach is determined based on site-specific conditions.

A vapor cover is typically used when treating to shallow depths. The cover serves three purposes:

4. It provides thermal insulation and prevents contaminants from condensing near the land surface, which will occur if the soil is cool.
5. It prevents rainwater infiltration, which could lead to unwanted cooling of the treatment zone.
6. It provides a vapor seal and increases the radius of influence of the vapor extraction screens.

Temperature and pressure monitoring wells are simple vertical borings used to document performance and pneumatic control during treatment. These are located inside and outside the treatment area, typically at different distances from the operational wells to illustrate the progression of the SEE process in the subsurface.

3.2 *Generic lay-out of above-ground components, showing the footprint of a "typical" application*
The above-ground equipment varies from site to site depending on treatment area size, volume, nature of contamination, and local regulatory requirements for treating the effluents.

The steam generation system was described in Section 2.1.

A typical extraction and treatment system is shown in Figure 6. Typically, effluent fluids are condensed before vapor treatment, and that conventional vapor and water treatment technologies are acceptable. The heat exchanger/condenser reduces the temperature of the extracted vapors, to remove steam and increase the efficiency of the water and vapor treatment. The fluids then are separated into liquids and vapors in a liquid-vapor separator. The vapor treatment system is assumed to consist of a granular activated carbon (GAC) system, and a vacuum blower. Other vapor treatment options include Catalytic or Thermal Oxidation. Condensate treatment is by liquid phase GAC filtration (sometimes preceded or replaced by air stripping).

Since the extracted fluids include water, potentially NAPL, air, and steam at varying temperatures and pressures, the treatment system is a robust combination of cooling, separation and treatment units previously proven to be effective for their functions.

For sites with large contaminant mass loading, the vapor treatment is often done using thermal oxidation or other methods capable of handling the high recovery rates.
The surface layout is dictated by site-specific conditions such as the location of utility connections, obstructions such as buildings, and an effort to minimize the piping runs from the well field area to the treatment process. For small sites, the treatment system is placed on a trailer or in a container, and mobilized to the site as one unit. For sites requiring large treatment components, individual process equipment units may be mobilized and connected at the site.

3.3 Special utility requirements (power, water, surface cover, security, etc.)

The required utilities are:

- Power (480 V, 3-phase).
- Water (for drilling, cleaning, office trailer, steam generation, and sometimes for the process if using a cooling tower or wet acid gas scrubbing).
- Gas or diesel when fuel is used for steam generation and sometimes for off-gas treatment (such as an oxidizer) or for generating power as a back-up.
- Telephone and internet for communications and process controls.

At some sites, plant steam is used, which reduces the demand for water and fuel.

3.4 Is the process configured differently if the contaminants are below the water table?

No, SEE is well suited for both vadose zone and saturated zone treatment. Condensate collection is important for vadose zone applications, since some of the injected steam condensed and must be extracted. The process equipment is very similar whether the SEE is applied above or below the water table. Vapor and liquid extraction is important in all cases.

4. Process Information

4.1 Typical durations of applications, and how does one decide to turn it off?

For VOC sites, typical durations are between 2 and 6 months, depending on site-specific requirements and the chosen well spacing.

For SVOC sites, typical durations are between 6 months and 1 year. Some sites have taken longer, when coupled with enhanced natural attenuation, or when a very large volume is treated in stages.

Performance is typically based on soil concentrations, since soil can be readily sampled during operation, using methods identical or similar to those tested and documented by Gaberell et al.\textsuperscript{21}. The criteria for turning off the system are typically the same as the

criteria for successful remediation – the system is operated until the client has regulatory approval that the remedy is complete.

Sampling of soil eliminates a classical problem – groundwater rebound occurring after the treatment. By sampling the phase from where rebound would originate (by desorption and diffusion out of bypassed solids), the risk of post-remediation contaminant concentration increases is minimized/eliminated.

For some sites without specific numeric cleanup standards, other parameters are used to determine when to cease operation:

- Groundwater concentrations (although these are hard to use due to the complex chemistry at elevated temperatures and difficulty in collection of representative samples without loss of the contaminants). Groundwater samples can potentially show you more impressive remediation results due to the low solubility of most VOCs in hot water near the boiling point. Basing the decision to stop treatment on such samples may be risky – and rebound could occur during cool-down.
- Target treatment temperature. This would be applied to the coolest locations within the target treatment zone and used to focus the heating process towards the end of the operational period.
- Energy balance calculation showing steam stripping and generation of an exchange of a certain amount of steam (typically related to the pore volume of the treatment zone). The amount of steam flushing and pressure cycling needed can be estimated based on laboratory testing, and depends on initial concentrations and the specific remediation goals.
- Diminishing recovery of contaminants while ensuring that the heating process and fluid extraction process are operated according to specifications. This can be risky, since diminishing returns can be reached without treatment of the entire targeted volume, as documented as an interim result at the Young-Rainey STAR project22, where the discovery of a cool area led to focused heating and more complete remediation after the vapor recovery had dropped to low levels temporarily.

Site-specific performance goals are negotiated and typically made part of the contract for the SEE project. They typically tie directly into the regulatory demands for site closure or remedy acceptance, such that the client and the SEE contractor work towards the same objective.

4.2 Typical monitoring/diagnostics for the technology during operation (i.e. how do you know it's working?)


The monitoring is based on:

- Hydraulic control (documented using groundwater elevation monitoring).
- Pneumatic control (documented using pressure monitoring).
- Subsurface temperatures (documented using thermocouples, fiberoptic sensors or similar temperature monitoring equipment).
- Contaminant removal rates and totals (estimated by sampling the effluent vapor, water, and NAPL). The totals are compared to initial mass estimates, considering the typical uncertainties of such estimates. However, the total mass recovered is never used to determine when to cease operation, due to the uncertainties in initial mass estimates.
- Vapor treatment efficacy (based on vapor samples before and after the treatment unit).
- Water/condensate treatment efficacy (based on water samples before and after the treatment unit).
- Energy balance calculations.
- Interim sampling of soil and/or groundwater within and around the treatment zone (showing reductions in contaminant concentrations compared to original levels). These samples are typically the most important for determining when to cease operation.
- Final confirmatory sampling.

In addition, site-specific monitoring related to health and safety and community monitoring may be conducted.

4.3 Post-treatment issues (time period needed for cooling/access/etc.)

This is site-specific and depends on future site use. Typically, live steam is removed from the subsurface over a period of 1 to 2 weeks, while the site starts the cool-down. At some sites, cold water is injected to assist with cooling. When demobilization begins, the subsurface temperatures may be as high as 90°C. Removal of the surface cover enhances the cooling. Demobilization is typically complete between 1 and 2 months after completing the remediation.
5. Technology Selection

5.1 For what scenarios is the technology ideally suited?

Generally, SEE is favored by the following conditions:

- Recalcitrant contaminants not easily addressed by Monitored Natural Attenuation (MNA), Soil Vapor Extraction (SVE), or pump and treat. The most suited contaminants would include most CVOCs, DNAPL, and creosote.
- Large contaminant mass and concentrations, with significant NAPL presence, such as large fuel spills with substantial LNAPL accumulation on a water table (so less aggressive, cheaper methods are ineffective).
- Sites with a driver to clean within a relatively short time-frame (where long-term solutions suffer due to insecurity about when they can be shut off).
- Sites deeper than 10 ft (the wells can readily be extended deeper without much additional cost).
- Sites where excavation is unpractical or expensive (so SEE can compete on a unit cost basis).

SEE is potentially partially suited for fractured rock sites. To date, three pilot test demonstrations have been conducted, with varying degree of success. Highly weathered and fractured rock sites with significant mass above the water table are the most promising candidate sites for SEE in rock.

5.2 Under what conditions is the technology "challenged"?

The following conditions challenge the applicability of SEE:

- Very shallow and wide-spread contamination. For such sites, heat losses may become prohibitive due to the large surface area, and the injection rates are limited by the weight of the overburden, restricting injection pressures to 5 psig or less.
- Contamination present under structures where vertical drilling is prohibited. SEE can readily be done using angled or horizontal borings, but the complexity and cost of the drilling and installation increases significantly compared to vertical installations.
- Sites dominated by low-permeability materials such as clay, fine silt, or competent bedrock with sparse fracturing. Intrinsic permeabilities below 0.1 darcy, equivalent to a hydraulic conductivity of $10^{-4}$ cm/sec, is considered the lower range for SEE applications. For sites with tighter zones, combinations with ERH or TCH may be applicable.
- Sites with a very stringent numerical cleanup standard for soil and groundwater and a heterogeneous geology. Generally, it is difficult to predict the exact steam migration paths and heating pattern, and thus also the final COC concentrations when using SEE than when using TCH, since the fluid-based delivery is more
sensitive to heterogeneity and permeability contrasts that TCH which relies on thermal conduction.

Typical concerns about geotechnical stability and damage to foundations, buildings, or underground utilities are dealt with relatively easily on a site-specific basis, and have not been a significant barrier to SEE implementation.
Hot Air/Steam Injection Thermal Remediation Using Large Diameter Auger (LDA) In-Situ Soil Mixing

by

Phil La Mori and Elgin Kirkland, FECC Corporation

1. Overview of Technology

1.1 One paragraph description of the state of the thermal application

Thermal treatment of contaminated soils and groundwater by in-situ soil mixing using large diameter augers (LDA) while injecting hot air and steam is an effective way to remove source zone volatile organic compounds (VOCs), semi-volatile organic compounds (SVOC) and petroleum hydrocarbons (TPHC) contamination. The technology operates one treatment cell at a time by advancing a single 6’ to 10’ auger to depths of over 70’. During active mixing the permeability increases, permitting the soil and groundwater to be treated evenly by the injected high-pressure hot air and steam. Steam heats the contaminated soil and groundwater to a temperature of approximately 75 degrees Celsius, thermally desorbing the VOCs and volatilizing the non-adsorbed VOCs, while the air carries the volatilized off-gas contamination to the surface for capture and treatment. The process, which appears to follow pseudo first-order kinetics, is very effective in removing a large percentage of VOCs during the early treatment stages, but requires extended treatment times to further increase the percentage of removal, i.e. there is a diminishing return for thermal treatment versus cost. Typically the in-situ thermal technology removes 90 % to 97 % of the VOC and 50% to 90% of the SVOC.

1.2 New improvements to the technology over the past 5 years

The major improvement to the technology over the last 5 years has been the development of the combined thermal remediation followed by injection of zero valent iron (ZVI) powder in a water/guar slurry for remediation of chlorinated DNAPL source zones. The ZVI continues the remediation after the thermal treatment has stopped. This approach takes advantage of the strengths of both treatment technologies: for thermal treatment this is the effective removal of large amounts of contamination early on and the mixing, distribution and dissolution of the DNAPL that allows the iron to continue remediation of the chlorinated VOC long after the drilling unit has been removed. Removal efficiencies of over 99% are routinely achieved at significant cost savings when compared to thermal treatment alone.

2. Energy Delivery/Heating Information

2.1 Basic conceptual overview of the energy delivery/soil heating process (i.e. a conceptual drawing showing the basic components and a simple conceptual time-series of energy transfer/heating in the subsurface)

23 Dual 5’ to 7’ diameter augers are also used.
The technology consists of three main units; 1) the track mounted crane with the drill unit and hot air, steam and reagent injection unit, 2) an off gas capture and process and treatment system, and 3) a Data Acquisition System (DAS) and a process control system. These components are configured to meet site-specific conditions and vary depending on the site conditions, characterization and cleanup requirements.

The drill platform, which contains the drilling system and air, steam and reagent dispensing systems, is attached to a track mounted crane that moves around the site on mats. The drill platform turns the drill bar, called the Kelly, that has one end attached to single bladed auger, 6’ to 10’ feet in diameter, that is capable of penetrating the ground surface to depths in excess of 70’. The top end of the Kelly is attached to the crane and provides the pathway for the air, steam and reagent injection. From there the treatment agents travel down a pipe inside the Kelly and are injected into the soil by ports along the trailing edges of the two bladed auger. Thermal treatment is achieved by injection of hot air and steam. Steam, which is generated by boilers with adequate total capacity, e.g. of 20,000 lb/hr at 335 F, provides the energy to volatilize VOC and SVOC. Hot air, which is channeled to the surface along an annular space created by the rotating drill Kelly, entrains the volatilized VOC and SVOC and TPHC and transfers them to the surface where the off gas is captured and treated. The ZVI slurry which is mixed in batches up to 600 gallons is injected into the soil through the same ports as the steam and air, either separately or with the steam and air. Figure 1 provides a conceptual overview of the thermal treatment operation and equipment.

The off gas capture system consists of a steel can (shroud) placed on the surface covering the drilling area. The diameter of the shroud is approximately 1.5 times the diameter of the auger to insure complete capture of the off gas. The hot off gas (100 F to 185 F) is removed from the shroud and is passed through a gas conditioning unit by a blower operating from 750 to 1200 CFM. The gas conditioning unit cools the gas to 90 F to 100 F and removes the water vapor and dirt particles before being sent to a contaminant destruction unit such as a catalytic oxidizer, flameless thermal oxidizer or thermal oxidizer. Carbon absorption beds are used as emergency backup should the oxidizer unit need to be shutdown for any reason. For small sites with lower concentration of contamination the direct use of the carbon bed is more efficient and costs less than the oxidizer.

The Data Acquisition system (DAS) and process control system are located in an operations and control trailer unit. This unit contains readouts of instrumentation to monitor and control selected key operational parameters. All the instruments also have inline display for field operational use. Also located in the unit are the flame ionization detector(s) (FID) to continuously monitor the concentration of total hydrocarbons and the gas chromatograph(s) (GC) that provides periodic data on the identification of the specific compounds in the off gas stream. The output of the FID, GC, temperature sensors, depth gage and other key instruments are stored in a computerized logging system operated at a pre-selected recording interval, e.g. 1 to 30 seconds. The measured parameters are displayed in tabular form on a monitor screen while selected key parameters are displayed as a function of time on a second monitor screen. Table 1 provides a list of the measured and displayed operational parameters. A typical display of the key operational parameters is shown in Figure 2.
Figure 1. Conceptual overview of the thermal treatment operation and equipment.

Table 1. List of Measured and Displayed Operational Parameters

<table>
<thead>
<tr>
<th>Operational Location</th>
<th>Parameters Measured</th>
<th>Key Parameters Displayed for Operation &amp; Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auger Drill</td>
<td>Depth</td>
<td>Depth</td>
</tr>
<tr>
<td>Steam Production</td>
<td>Flow rate, temperature, pressure</td>
<td>Flow rate</td>
</tr>
<tr>
<td>Air Compressor</td>
<td>Flow rate, temperature, pressure</td>
<td>Flow rate</td>
</tr>
<tr>
<td>Off Gas Conditioning Unit</td>
<td>Flow rate, temperature, pressure, off gas composition by FID and GC</td>
<td>Flow rate, temperature, pressure, off gas composition by FID and GC</td>
</tr>
<tr>
<td>Off Gas Shroud</td>
<td>Flow rate, temperature, vacuum</td>
<td>Flow rate, temperature, vacuum</td>
</tr>
<tr>
<td>Iron Slurry Mixer</td>
<td>Flow rate</td>
<td>Flow rate</td>
</tr>
<tr>
<td>Downhole Condition</td>
<td>Temperature</td>
<td>-</td>
</tr>
</tbody>
</table>
The measured parameters are uploaded in real time to a remote location that stores, analyzes and retrieves the data. The operational data can be accessed in real time over the internet by remotely located technical staff that can then interface with the field operator and take part in the operational decisions.

2.2 - Any available information on relationship or current understanding between energy delivery and heating rates (i.e. efficiency of energy conversion to heat)

The main thermal input, i.e. energy delivery, is accomplished by steam generated from boilers as the hot air provides less than 5% of the heating. The subsurface target temperature is about 170°F (76°C). This temperature is high enough to increase the vapor pressure of most VOC enough to insure high removal rates. In many cases 170°F is greater than their boiling point or exceeds the boiling point of a mixture of the VOC and water. Heating a column of soil to this temperature usually occurs in less than 1 hour.

A typical sandy soil (located for example in Florida) has a mass of 100 lb/ft³ and contains about 30% porosity. Thus, a saturated cubic foot of this soil contains about 18.8 lb of water and 81.2 lb of sand. Since water has a heat capacity of 1 BTU/lb/°F and the sand has a heat capacity of about 0.25 BTU/lb/°F the heat capacity of the soil is about 0.391 BTU/lb/°F. Assuming that the column of soil to be heated is 30' thick and the auger is 8' in diameter, i.e. has an area of 50.27 ft², the mass of soil to be heated is 50 ft² x 30 ft x 100 lb/ft³ = 150,000 lb. The energy to heat the soil from an ambient 70°F to 170°F is approximately 5,850,000 BTU. This calculation indicates that it will take approximately 30 minutes to heat the soil using heat input of 12,000,000 BTU/hr.

This calculation and analysis implies an initial drilling penetration rate of about 1 ft/min. This rate is often difficult to achieve during the initial penetration of the auger for the reason that during the initial penetration the ground is hard and compacted. Drilling rates of 0.5 ft/min or less are often encountered during the initial pass. When these conditions occur the heating rate is lowered to control the process.
2.3 - *Limitations of the energy delivery/heating process (i.e. what temperatures can be reached, how even is the heat/energy distribution, and do natural phenomena limit the heating?)*

The limitation on energy delivery caused by ground conditions and drilling rates was noted above.

There are 3 other controlling factors for the thermal input, the boiling point of water with depth, the stability of the subsurface operation to handle the steam/air flow and the cooling capacity of the off gas process treating system. The soil/groundwater can be heated to a maximum temperature of the boiling point of water at depth. In practice the operational temperature limitation is about 70 C to 80 C (158 F to 176 F) in the shroud with somewhat higher temperatures in the subsurface.\textsuperscript{24} This surface temperature limitation is the result of the fact that the off gas reaching the surface is saturated with water vapor and this vapor must be removed from the off gas stream before it enters the thermal oxidizer and/or activated carbon beds. Above 80 C the vapor pressure increases rapidly and the heat rejection requirement of the off gas cooling unit increases quickly and the cost becomes prohibitive. Figure 3 shows the temperature/vapor pressure curve of water.

\textbf{Figure 3. Temperature/vapor pressure curve of water.}

![Temperature/vapor pressure curve of water.](image)

Also, the subsurface stability of the operation becomes critical at higher temperatures. When the off gas temperature exceeds about 60 C in the shroud and the downhole temperature is above 70 C the annular pathway to the surface starts to collapse and open in a pulsating manner causing pressure burping and over pressuring the shroud. This can result in raising the shroud and the release of contaminated vapors into the atmosphere and work area as well as injecting steam directly into the process system. The steam is injected into the process system because the

\textsuperscript{24} Post treatment temperature surveys show that the temperature at depth approaches the boiling point of water. Downhole temperature surveys taken during treatment also indicated that the soil temperature at depth approaches the boiling point curve.
subsurface temperature will be close to the boiling point and when the annular column reopens the first vapors to release are at the atmospheric boiling point and are saturated with steam. This problem is fairly easily controlled by diligently managing the air and steam flow.

2.4 - _Unique advantages/disadvantages of this energy delivery/heating approach for contaminant removal or destruction_

Some of the advantages of this technology are:
- The below ground mixing provides active remediation and assures that treatment agents contact all the contamination.
- The Data Acquisition System, including the FID and GC, for process monitoring, feed-back and control, allow operational decisions to be made real time and allow the remediation to be focused on the depths where there is contamination.
- Immediate removal and capture and/or destruction of the contamination occurs through the off gas treatment system.
- The use of the FID and GC when combined with the off gas flow permits calculation of the amount of each species removed.
- The technology provides the capability to combine the thermal treatment with other treatment processes in a single operation to achieve more complete removal and faster closure at lower cost.
- The technology operates equally well in vadose and saturated zones to 70’-100’ below ground surface.

Another advantage of the technology arises from the fact that water and Cl- VOCs are highly insoluble. The insoluble mixture forms a minimum boiling point azeotrope that is concentrated with the organic compound(s). The lower boiling point and azeotrope properties are believed to improve the thermal removal efficiency of the technology. The following table lists two azeotropes of interest.

<table>
<thead>
<tr>
<th>Components</th>
<th>Boiling Point (BP)° C.</th>
<th>Azeotrope BP° C.</th>
<th>Composition Azeotrope wt. %</th>
<th>Upper Layer wt. %</th>
<th>Lower Layer wt. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>100</td>
<td>--</td>
<td>6.30</td>
<td>99.8</td>
<td>0.02</td>
</tr>
<tr>
<td>TCE</td>
<td>87.10</td>
<td>73.1</td>
<td>93.7</td>
<td>0.2</td>
<td>99.98</td>
</tr>
<tr>
<td>Water</td>
<td>100</td>
<td>--</td>
<td>17.2</td>
<td>99.98</td>
<td>0.01</td>
</tr>
<tr>
<td>PCE</td>
<td>121.0</td>
<td>88.5</td>
<td>82.8</td>
<td>.02</td>
<td>99.99</td>
</tr>
</tbody>
</table>

Other innovative aspects of the technology application include measurement and/or control of all key process parameters including downhole temperature, auger depth and real time measurement of off-gas contaminant concentration using both flame ionization detector (FID) and gas chromatograph (GC). The FID/GC allow profiling the concentration of contamination vs. depth, providing field personnel real time data to make decisions such as focusing the interval of treatment on depths showing higher contaminated levels until the removal objectives have been met. This is shown in the enclosed chart, Figure 4 where the FID increases at 17’ depth with peaks at 20’, 40’ and 52’. This chart shows 4 thermal treatment passes from 15’ to 57’ plus 1 iron treatment pass (a pass is defined as full movement in both directions).
One disadvantage of the technology is the long time required to achieve very high removal efficiencies with the thermal treatment. This is the result of an observed pseudo first order thermal removal rate; i.e. high removal early in the treatment but much lower removal later in the treatment. The actual contaminant removal is believed to be more complex than pseudo first order and is probably made up of air stripping, volatilization and desorption components. The air stripping and volatilization components are believed to dominate the early removal while the desorption component is much slower and dominates the later remediation. Combining the high early thermal removal with the addition of a second treatment agent has resulted in very high total contaminant removal at a reduced cost. The addition of ZVI for removal of chlorinated VOC has been very effective. The addition of an inorganic oxidizer has been proposed for petroleum hydrocarbons.

Another disadvantage of the technology is the temperature limitations of the boiling point of water and of about 80°C in the shroud. This problem was discussed above. The effect of the azeotrope formation mitigates this to some extent. Experience has shown however that the thermal remediation of semi-volatile organic compounds (SVC) is less efficient than for VOC, e.g. 60% versus over 90%.
2.5 - Is the process applied differently if the contaminants are below the water table?

The LDA Thermal treatment technology has been applied separately in the vadose zone and saturated zone as well as in both zones in one treatment cell. There appears to be no obvious difference in the application to either zone. Calculation of the energy required to heat vadose zone soils is about $\frac{3}{4}$ of the energy to heat saturated soils. This does not present a problem because the boiler output easily supplies this difference and, as stated above, the initial drilling into the ground is often slowed so that the steam input is cut back to prevent over heating.

3. Process Configuration Information

Generic layout of the process showing spacing (heaters, electrodes, wells, temperature, etc.) of in situ components for a "typical" application

The technology operates as a batch process with each cell being remediated separately. Once the cell is remediated to pre-selected criteria the drill is removed from the cell and setup over the next cell. Figure 5 shows how the cells are laid out and overlapped to insure 100% areal coverage with dimensions for a 7 foot diameter auger. Figure 5 also shows the cross section of the Kelly with its welded angle brackets that create the annulus as the auger rotates. This cross section also shows the 3” diameter stainless steel injection pipe.

**Figure 5. Typical cell layout surface view and Kelly cross section.**

A typical layout of the equipment for site remediation is shown in Figure 1.

**Special utility requirements (power, water, surface cover, security, etc.)**

The utility requirements are nominal. A typical operation will require 500 to 1000 kilowatts of electricity, a maximum of 1500 gallons of water per hour and minimal security. An exclusion zone of about 30 meters is maintained during actual operation for personal H&S. Experience has shown that this size exclusion zone and operation with a shroud vacuum of over 1” water is
adequate to control emissions and insure worker H&S. The equipment operates off of mats, but the site needs to be graded flat and have less than 3 degree slope.

*Is the process configured differently if the contaminants are below the water table?*

As indicated above there are no special requirements for operation below the water table.

4. **Process Information**

*Typical durations of applications, and how does one decide to turn it off?*

The decision to turn off the thermal treatment is typically based upon two factors; 1. off gas temperature in the shroud and/or downhole temperature if that measurement is available and 2. the value of the FID, or GC for a key chemical compound(s) like TCE. The temperature component is used to insure that the downhole soil temperature will provide needed thermal desorption after the treatment is complete. The actual stopping value(s) is a function of the cell contamination as determined by the first pass (i.e. a pass is defined as a descent and an ascent to the cell) maximum FID and GC readings.

The FID and/or GC component is used as an indication to turn off the thermal treatment when the reduction in values indicates that extended treatment time is needed to further increase the percentage of removal, i.e. the point where there is a diminishing return for thermal treatment versus cost. Typically this occurs when there is an 80% to 90% reduction in the maximum value observed during the initial pass into the cell. When this occurs the reduction in FID and/or GC values versus time usually becomes asymptotic.

The following table provides a typical decision tree for determining when to turn off the treatment. This table doesn’t include GC criteria but these are often used. For example a GC value of less than 200 ppm TCE might be a criterion for initial FID value between 1000 and 10,000 ppm.

<table>
<thead>
<tr>
<th>Initial Max FID</th>
<th>Shroud Temperature</th>
<th>Final FID*</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 400 ppm</td>
<td>No criteria</td>
<td>No criteria</td>
<td>In and out and add ZVI</td>
</tr>
<tr>
<td>&gt; 400 ppm but &lt;1000 ppm</td>
<td>&gt; 150 F</td>
<td>&lt; 250 ppm</td>
<td>Should be 1 thermal treatment pass</td>
</tr>
<tr>
<td>&gt; 1000 ppm but &lt; 10,000 ppm</td>
<td>&gt; 160 F</td>
<td>90% reduction or asymptotic</td>
<td></td>
</tr>
<tr>
<td>&gt; 10,000 ppm</td>
<td>&gt; 170 F</td>
<td>&gt; 80% reduction and asymptotic</td>
<td>FID values as high as 1000 ppm to 2000 ppm are acceptable.</td>
</tr>
</tbody>
</table>

* Measured methane is excluded
After the thermal treatment is complete, a second treatment agent, e.g. ZVI, can be injected to provide additional long term remediation for the desorbing contamination. Figure 4 illustrates how this decision process might work. After 2 complete passes it is clear that the FID as well as the GC values for TCE and DCE had been reduced to over 90% of their initial maximum and that the decrease in values was approaching asymptotic. However the shroud temperature had not yet reached the target temperature of 170 F. Two additional passes were made to heat the cell before iron was added and the treatment completed.

Although the technology is mature there is limited information available to define the exact values of FID/GC and shroud temperature and when to stop the thermal treatment. A pilot test to determine the decision tree is recommended for most projects. If the pilot test is not included in the budget it can become part of the site treatment for a modest additional cost.

*Typical monitoring/diagnostics for the technology during operation (i.e. how do you know it's working?):*

The key monitoring points for process operation are the depth of auger, steam flow, air flow, FID, off gas temperature and off gas flow. A GC is useful for determination of the off gas chemistry profile but is not a requirement to determine the functioning of the technology. In fact the technology has often been utilized without a GC. These measurements indicate that the process is functioning as well as providing the key control information to determine when the remediation is completed. These data are measured continuously at a selected time interval, e.g. 10 seconds, and also are displayed in tabular and graphical form to the control operator.

*Post-treatment issues (time period needed for cooling/access/etc.):*

When the cell treatment is completed there is often a decrease of column length in volume, e.g. ~5%, with the need to add soil to return the site to grade level. This is particularly note worthy in sandy soils. In clay soils there is often an immediate slight increase in volume followed by a slightly greater decrease in volume a day or twolater. These volume changes need to be dealt with so that the remediation operation can be completed and also to restore the surface to pretreatment elevations at the completion of the project.

Heating the soils raises their temperature to approximately the boiling point of water as a function of depth. Because most of the sites are relatively thick, e.g. 30’ to 50’, and cover a wide area the subsurface cools slowly in the absence of cold water influx. Locations where the groundwater flow is measured in inches per day will take from one to two years to cool to their pretreatment temperatures. This presents safety and handing issues for post treatment verification groundwater and soil sampling.

5. **Technology Selection**

*For what scenarios is the technology ideally suited?*

This technology is ideally suited for sites where the advantages of soil mixing and rapid treatment are important. These sites come under that category:
- Sites with large concentration and mass of contamination. These sites would probably have significant NAPL presence so that other methods would be less effective or ineffective.
- Sites with uneven or variable lithology where other treatment methods would be confounded by differing permeability and contaminant concentration.
- Sites with mostly VOC or lower boiling point SVOC.
- Sites with target volumes above 3,000 cubic yards. The mobilization cost is an issue for small sites.
- Sites with stringent cleanup standards. The thermal technology when combined with ZVI will treat chlorinated VOC and when combined with an inorganic oxidizer will treat petroleum hydrocarbons, both to ppb levels.
- Sites where there is a need to achieve cleanup in a short period of time, e.g. Brownfields.
- Sites below the water table or in the groundwater.
- Sites where excavation is impractical, i.e. very expensive or difficult because of environmental concerns.
- Shallow sites where the depth is at least 5 feet.
- Sites where focused depth treatment is important.
- Sites with high groundwater flow rates.

_Under what conditions is the technology "challenged"?_

The technology is challenged by:

- Smaller sites, e.g. less than 2000 cubic yards, due to the high cost of mobilization.
- Sites with low concentrations are more effectively dealt with by other approaches.
- Site with infrastructure, e.g. overhead lines, buildings etc.
- Sites at great depths, e.g. over 100 feet.
- Sites with high boiling point SVOC although oxidization is a potential solution because the mixing capabilities provide excellent treatment.
APPENDIX C

Data Logs
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT PD</th>
<th>Date:</th>
<th>11/10/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive Steam ERH Other:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test Full Scale System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start of Test:</td>
<td>varied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End of Test:</td>
<td>varied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration:</td>
<td>42 to 47 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD DoD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Facility Information

- **Facility Name:** Ft. Richardson (Arrays 1, 2, and 3)
- **Address:**
- **City, State, Zip Code:** Ft. Richardson, Alaska
- **OU# or Site #:** OU B: Poleline Rd Disposal Area (Arrays 4, 5, and 6)

### Primary Contact Information

- **Primary point of contact:** Scott Kendall
- **Organization:** US Army Corps - Alaska District
- **Address:**
- **City, State, Zip Code:**
- **Phone #:** 907-753-5661
- **email:** scott.kendall@poa02.useace.army.mil

### Other Contacts or Vendors

- **None**

### Point of Contact Information

- **Type:** Vendor, Consultant Vendor, Technical Applications Other
- **Organization:**
- **Address:**
- **City, State, Zip Code:**
- **Phone #:**
- **email:**

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
### General Site Assessment Data

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): 225
  - Width (ft.): 87
  - Thickness (ft.): Unknown
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: None
  - Pre-treatment: None
  - Post-treatment: None
  - Number of wells relative to treatment zone:
    - Pre-treatment: Upgradient: Unknown
    - Downgradient: Unknown
    - Crossgradient: Unknown
    - Post-treatment: Upgradient: Unknown
    - Downgradient: Unknown
    - Crossgradient: Unknown

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: 4
  - Number of relevant soil borings with post-treatment data: 4
  - Number inside treatment zone: 4
  - Number outside treatment zone: 4

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Benzene</td>
<td></td>
<td></td>
<td></td>
<td>None 10 mg/kg</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None 1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None 0.5 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None 0.5 mg/kg</td>
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</tr>
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<td></td>
<td></td>
<td>None 0.1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None 0.1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None 0.1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None 0.1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None 0.1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None 0.1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>Chloroform</td>
<td></td>
<td></td>
<td></td>
<td>None 0.1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
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<td></td>
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<tr>
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<td></td>
<td></td>
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<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>Benzene</td>
<td></td>
<td></td>
<td></td>
<td>None 0.1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
<tr>
<td>Hexachlorobutadiene</td>
<td></td>
<td></td>
<td></td>
<td>None 0.1 mg/kg</td>
<td>None 0.1 mg/kg</td>
</tr>
</tbody>
</table>

### Comments:

- Additional comments related to the assessment data.

### Attachments:

- Information for ARRAY 1

---

**Facility ID:** 0010
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 225
- Width (ft.): 87
- Thickness (ft.): ______

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment: ______
  - Post-treatment: ______

**Monitor Wells (continued):**
- Number of wells relative to treatment zone:
  - Pre-treatment: Upgradient: ______
    - Downgradient: ______
    - Crossgradient: ______
  - Post-treatment: Upgradient: ______
    - Downgradient: ______
    - Crossgradient: ______

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: ______
- Number of relevant soil borings with post-treatment data: ______
- Number inside treatment zone: ______
- Number outside treatment zone: ______

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
<td>10 mg/L</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>1 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>0.5 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
<td>0.1 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Benzene</td>
<td>None</td>
<td>0.1 mg/kg</td>
<td>None</td>
</tr>
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<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>Benzene</td>
<td>None</td>
<td>0.05 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Chloroform</td>
<td>None</td>
<td>None</td>
<td>0.05 mg/kg</td>
<td>None</td>
</tr>
<tr>
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<td>carbon tetrachloride</td>
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<td>Benzoic acid</td>
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<td>Hexachlorobutadiene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

Information for ARRAY 1

**Attachments:**
**General Site Assessment Data**

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 365
- Width (ft.): 67
- Thickness (ft.): ____________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: None

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: ____________
- Number of relevant soil borings with post-treatment data: ____________
- Number inside treatment zone: ____________
- Number outside treatment zone: ____________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
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<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>1</td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Cross</td>
<td>None</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>2</td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>3</td>
<td>1,1-Dichloroethene</td>
<td>Naphthalene</td>
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<td>None</td>
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<tr>
<td>4</td>
<td>cis-1,2-Dichloroethene</td>
<td>Benzene</td>
<td></td>
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<td>0.1 mg/kg</td>
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<tr>
<td>5</td>
<td>trans-1,2-Dichloroethene</td>
<td>Toluene</td>
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</tr>
<tr>
<td>6</td>
<td>1,1-Dichloroethane</td>
<td>Ethylbenzene</td>
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<td>None</td>
<td>None</td>
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<td>7</td>
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<td>m,p-xylene</td>
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<td>None</td>
</tr>
<tr>
<td>8</td>
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<td>o-xylene</td>
<td></td>
<td>None</td>
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<tr>
<td>9</td>
<td>1,1,2-Trichloroethane</td>
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<td></td>
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<td>1,2-Dichloroethene</td>
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<td>11</td>
<td>Vinyl Chloride</td>
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<tr>
<td>12</td>
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<td>13</td>
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<td>None</td>
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<td>14</td>
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<td>None</td>
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<td>15</td>
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<td>None</td>
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<td>16</td>
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<td>1,1-Dichloroethene</td>
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<td>None</td>
<td>0.1 mg/kg</td>
</tr>
</tbody>
</table>

**Information for ARRAY 1**

**Attachments:**

---

Comments:

---
Hydrogeologic Conceptual Model

x Geology: Zone Unconsolidated Sediments
Vadose Zone:  
  __ Relatively homogeneous and permeable unconsolidated sediments
  __ Relatively homogeneous and impermeable unconsolidated sediments
  x Largely permeable sediments with inter-bedded lenses of lower permeability material
  __ Largely impermeable sediments with inter-bedded layers of higher permeability material
  __ Competent, but fractured bedrock (i.e. crystalline rock)
  __ Weathered bedrock, limestone, sandstone
Saturated Zone:  
  __ Relatively homogeneous and permeable unconsolidated sediments
  __ Relatively homogeneous and impermeable unconsolidated sediments
  x Largely permeable sediments with inter-bedded lenses of lower permeability material
  __ Largely impermeable sediments with inter-bedded layers of higher permeability material
  __ Competent, but fractured bedrock (i.e. crystalline rock)
  __ Weathered bedrock, limestone, sandstone

x Ground surface elevation based on wells in or adjacent to treatment zone: ______ ft amsl ______ Unknown

x Aquifer Characteristics:
Is more than 1 aquifer present?  No  Yes (number): _______  ______ Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water: low value (ft bgs):</th>
<th>4</th>
<th>14</th>
<th>Unknown</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

x Flow direction  NE

x Horizontal hydraulic gradient (feet/foot):  _______  _______  _______  _______  x Unknown
Vertical hydraulic gradient (feet/foot):  _______  _______  _______  x Unknown

x K range (ft/day)  Measured using:  Slug Test  Laboratory  Field data
|          | low 0.05 |                     |          | Unknown |
|          | high 0.5 |                     |          |         |
Transmissivity (ft²/day):  Measured using:  Slug Test  Laboratory  Field data
|          | low     |                     |          | Unknown |
|          | high    |                     |          |         |

Comments:  
Attachments:  

Thermal Treatment - Design

Thermal treatment: [ ] Conductive [ ] Electrical Resistance

Array 1

[ ] 3 phase [ ] 6 phase [ ] AC power [ ] DC power

Steam

[ ] Steam [ ] Steam + air [ ] Steam + O2

[ ] Other (describe)

Type of Test: [ ] Pilot test [ ] Full-scale System

Geology of Treatment Zone:

[ ] Relatively homogeneous and permeable unconsolidated sediments

[ ] Relatively homogeneous and impermeable unconsolidated sediments

[ ] Largely permeable sediments with inter-bedded lenses of lower permeability material

[ ] Largely impermeable sediments with inter-bedded layers of higher permeability material

[ ] Competent, but fractured bedrock (i.e. crystalline rock)

[ ] Weathered bedrock, limestone, sandstone

Treatment Target Zone: [ ] Saturated only [ ] Vadose only [ ] Both (Saturated and Vadose zones)

Start of Thermal Test: 7/11/1997 (ended 8/22/97) Duration: 42 d

Hydraulic Control [ ] Yes [ ] No

Treatment Cell Design:

Size of target zone (ft2): [ ]

Thickness of target zone (ft): [ ]

Depth to top of target zone (ft bgs): [ ]

Thickness of target zone below water table (ft): [ ]

Number of energy delivery points: [ ]

Number of extraction points: [ ]

Temperature Profile:

Initial formation temperature (deg C): [ ]

Maximum representative formation temperature (deg C): [ ]

Time to reach maximum representative temperature (days): [ ]

Duration of treatment at representative temperature (days): [ ]

Mass of contaminant removed:

Via liquid pumping: [ ]

In vapor stream: [ ]

Total: [ ]

Attachments:

Array 1 of 3

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment - Design

Thermal treatment:  x Conductive
                     x Electrical Resistance  Array 2
                         ____________
                     x 3 phase  x 6 phase  ____________
                     ____________
Steam  ____________
       ____________  Steam + air  ____________
       ____________  Steam + O2
       ____________
     ____________

Type of Test:  x Pilot test  x Full-scale System

Geology of Treatment Zone:
 x Relatively homogeneous and permeable unconsolidated sediments
 x Relatively homogeneous and impermeable unconsolidated sediments
 x Largely permeable sediments with inter-bedded lenses of lower permeability material
 x Largely impermeable sediments with inter-bedded layers of higher permeability material
 x Competent, but fractured bedrock (i.e. crystalline rock)
 x Weathered bedrock, limestone, sandstone

Treatment Target Zone:  x Saturated only  x Vadose only  x Both (Saturated and Vadose zones)

Start of Thermal Test:  8/24/97 (ended 10/9/97)  Duration:  47 d

Hydraulic Control  x  Yes  ____________

Treatment Cell Design:

Size of target zone (ft2):  570  ____________
Thickness of target zone (ft):  27  ____________
Depth to top of target zone (ft bgs):  8  ____________
Thickness of target zone below water table (ft):  25  ____________
Number of energy delivery points:  6  ____________
Number of extraction points:  1  ____________

Temperature Profile:

Initial formation temperature (deg C):  18  ____________
Maximum representative formation temperature (deg C):  100  ____________
Time to reach maximum representative temperature (days):  27  ____________
Duration of treatment at representative temperature (days):  20  x  Unknown

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping:  27  x  lb  ____________
In vapor stream:  217  x  lb  ____________
Total:  219.7  x  lb  ____________

Comments:

Array 2 of 3

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
  - Steam
  - Steam + air
  - Steam + O2
  - Other (describe)

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 11/6/97 (ended 12/18/97)
- Duration: 42 d

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:
- Size of target zone (ft2): 570
- Thickness of target zone (ft): 27
- Depth to top of target zone (ft bgs): 8
- Thickness of target zone below water table (ft): 25
- Number of energy delivery points: 6
- Number of extraction points: 1

Temperature Profile:
- Initial formation temperature (deg C): 8
- Maximum representative formation temperature (deg C): 100
- Time to reach maximum representative temperature (days): 17
- Duration of treatment at representative temperature (days): 30

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:
- Via liquid pumping: 42 lb unknown kg unknown
- In vapor stream: 138 lb unknown kg unknown
- Total: 142.9 lb unknown kg unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: Goals in mg/L: TCE-0.005, 1,1,2,2-tetrachloroethene (PCA)-0.052, PCE-0.005, cis-12-DCE - 0.007, trans-12-DCE - 0.1, benzene - 0.005, carbon tetrachloride - 0.005
- In Soil: 1,1,2-trichloroethane - 0.1 mg/kg; PCE - 4.0 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater
- In Soil

Comment:

General comments on the thermal application:

The application was considered only one application even though the heating of the 3 arrays was ran sequentially.

Lessons Learned

- Energy
- Total Energy Used: kWhr/kWhr/m³/kWhr/yd³
  - Total energy applied to treatment zone: kWhr/m³/kWhr/yd³
  - Other energy: kWhr/m³/kWhr/yd³
    - Please note other energy:

- Cost
- Total Project Cost: $967822
  - Consultant Cost:
  - Thermal Vendor Cost:
  - Energy Cost: $30000 per month m³ yd³
  - Other Cost 1:
  - Other Cost 2:
  - Other Cost 3:
    - Please note other cost:
      - Other Cost 1:
      - Other Cost 2:
      - Other Cost 3:
### General Site Information

- **File Analyzed By:** JT PD
- **Date:** 9/18/2006
- **Facility Name:** Ft. Richardson (Arrays 4, 5, and 6)
- **Address:**
- **City, State, Zip Code:** Ft. Richardson, Alaska
- **OU# or Site #:** OU B; Poleline Rd Disposal Area (Arrays 4, 5, and 6)
- **Primary point of contact:** Scott Kendall
- **Organization:** US Army Corps - Alaska District
- **Address:**
- **City, State, Zip Code:**
- **Phone #:** 907-753-5661
- **Email:** scott.kendall@poa02.useace.army.mil
- **Type of Site:** Non-DOD DoD

### Type of Treatment
- Conductive
- Steam
- ERH
- Other: 

### Type of Contaminant
- Chlorinated Solvents
- Petroleum Hydrocarbons
- Pesticides
- Wood Treating
- Other: 

### Treatment Status
- Active
- Post

### Type of Test
- Pilot Test
- Full Scale System

### Start of Test: 7/31/1999
### End of Test: 10/4/1999
### Duration: 65 DAYS

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Hydric Conductivity information
  - Geologic cross-section
### General Site Assessment Data

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.): 225</th>
<th>Width (ft): 27</th>
<th>Thickness (ft):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacted zone as defined by documentation</td>
<td>Alternative method for determining size of impacted zone (See source zone definition attachments)</td>
<td>Map attachment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitor Wells:</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of wells relative to treatment zone:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-treatment</td>
<td>Upgradient:</td>
<td>Downgradient:</td>
<td>Crossgradient:</td>
</tr>
<tr>
<td>Post-treatment</td>
<td>Upgradient:</td>
<td>Downgradient:</td>
<td>Crossgradient:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>Number of relevant soil borings with post-treatment data:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number inside treatment zone:</td>
<td></td>
<td>Number outside treatment zone:</td>
</tr>
</tbody>
</table>

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>BTEX</td>
<td>Cross</td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>0.01 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>0.001 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>0.1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethene</td>
<td>p/xylene</td>
<td></td>
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<td>None</td>
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<td></td>
<td>1,2,2-trichloroethene</td>
<td>Hexane</td>
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<td></td>
<td>Vinyl Chloride</td>
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<td>None</td>
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<tr>
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<td>Carbon tetrachloride</td>
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<td>0.01 mg/L</td>
<td>None</td>
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<td></td>
<td>cis-1,2-dichloroethene</td>
<td></td>
<td></td>
<td>0.1 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

Impacted zone is only the source zone.

### Attachments:

...
### Hydrogeologic Conceptual Model

**Geology:**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

**Aquifer Characteristics:**

- Is more than 1 aquifer present? No (number): 
  - Aquifer 1
  - Aquifer 2
  - Aquifer 3

<table>
<thead>
<tr>
<th>Depth to water:</th>
<th>low value (ft bg):</th>
<th>high value (ft bg):</th>
<th>Unknown:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.5</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

**Flow direction:**

- NE

**Horizontal hydraulic gradient (feet/foot):** Unknown

**Vertical hydraulic gradient (feet/foot):** Unknown

**K range (ft/day):**

- Measured using: Slug Test Laboratory Field data

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
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</thead>
<tbody>
<tr>
<td>low</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>0.5</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Transmissivity (ft²/day):**

- Measured using: Slug Test Laboratory Field data

<table>
<thead>
<tr>
<th>Transmissivity (ft²/day)</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ground surface elevation based on wells in or adjacent to treatment zone:**  

- ft amsl
- Unknown

**X-section in Tech Report on pages 30-35**

**Attachments:**
Thermal Treatment - Design

Facility ID#: 0020

Thermal treatment: conductivity

Type of Test: Pilot test

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 7/31/1999
Duration: 65 days

Hydraulic Control: Yes

Treatment Cell Design:
- Size of target zone (ft²): 5500
- Thickness of target zone (ft): 12
- Depth to top of target zone (ft bgs): 8
- Thickness of target zone below water table (ft): 30
- Number of energy delivery points: 31
- Number of extraction points: 9

Temperature Profile:
- Initial formation temperature (deg C): 10
- Maximum representative formation temperature (deg C): 100
- Time to reach maximum representative temperature (days): 8
- Duration of treatment at representative temperature (days): 65

Formation temperature immediately post-treatment:
- Date: Unknown
- Temperature (deg C): Unknown

Formation temperature post-treatment monitoring event 1:
- Date: Unknown
- Temperature (deg C): Unknown

Duration of post-treatment monitoring (days):
- Date: Unknown
- Temperature (deg C): Unknown

Mass of contaminant removed:
- Via liquid pumping: 29.6 lb
- In vapor stream: 628 lb
- Total: 658 lb

Comments:

Attachments: 3 arrays

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

___ In Groundwater:_____________________

___ In Soil:_____________________

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:_____________________________________________________

___ In Soil

Comment:_____________________________________________________

General comments on the thermal application:

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

Energy

Total Energy Used:______________________ kWhr kWhr/m³ kWhr/yd³

___ Total energy applied to treatment zone:______________________ kWhr/m³ kWhr/yd³

___ Other energy:______________________ kWhr/m³ kWhr/yd³

Please note other energy:________________________________________________________

Cost

Total Project Cost:_____________________

___ Consultant Cost:_____________________

___ Thermal Vendor Cost:_____________________

___ Energy Cost: ____________________ 30000 per month m³ yd³

___ Other Cost 1:_____________________

___ Other Cost 2:_____________________

___ Other Cost 3:_____________________

Please note other cost:___ Other Cost 1:_____________________

___ Other Cost 2:_____________________

___ Other Cost 3:_____________________

Lessons Learned

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By: JT</th>
<th>PD</th>
<th>Date: 11/6/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
</tr>
<tr>
<td>Start of Test:</td>
<td>3/26/1998</td>
<td>End of Test: 5/13/1999</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
</tr>
</tbody>
</table>

### Facility Name:

- Ft. Wainwright

### Address:

- CH2M Hill

### City, State, Zip Code:

- Ft. Wainwright, Alaska

### OU# or Site #:

- OU 5

### Primary point of contact:

- Rich Horn

### Organization:

- 

### Phone #:

- 907-646-0287

### email:

- rhorn@ch2m.com

### Other contacts or vendors who worked on site

- None

### QA/QC

- Characteristics of Interest
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
General Site Assessment Data

Impacted Zone: Length (parallel to flow direction)(ft.): _______ Width (ft.): _______ Thickness (ft.): _______ Impacted zone as defined by documentation: _______________ Alternative method for determining size of impacted zone (See source zone definition attachments): _______________ Map attachment: _______________

Monitor Wells: Number of relevant monitoring wells with groundwater data: _______________ Pre-treatment: _______ Post-treatment: _______

Monitor Wells relative to treatment zone:

Pre-treatment: In: _______ Upgradient: _______ Downgradient: _______ Crossgradient: _______
Post-treatment: In: _______ Upgradient: _______ Downgradient: _______ Crossgradient: _______

Soil Borings: Number of relevant soil borings with pre-treatment data: _______

Number of relevant soil borings with post-treatment data: _______

Number inside treatment zone: _______ Number outside treatment zone: _______

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>5 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
<td>DRO</td>
<td>None</td>
<td>5,000 mg/kg</td>
<td>None</td>
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<td></td>
<td>1,1,2,2-tetrachloroethene</td>
<td>DRO</td>
<td>None</td>
<td>5,000 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Average Pre-treatment Concentration per Chemical: Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)

Average Post-treatment Concentration per Chemical: Groundwater (mg/L) Soil (mg/kg)

Comments: No post-treatment soils data after final phase of heating and no groundwater wells in the RFH plot.

Attachments: _______________
### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>X Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>___ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>___ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>X Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

---

- Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

---

### Aquifer Characteristics:

- Is more than 1 aquifer present? **No** **Yes** (number): ___________ Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low value (ft bgs):</td>
<td>NNW</td>
</tr>
<tr>
<td>Aquifer 1</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Flow direction

- NNW

---

### Horizontal hydraulic gradient (feet/foot):

- __________

### Vertical hydraulic gradient (feet/foot):

- __________

---

### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low (ft/day)</td>
<td></td>
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</tr>
<tr>
<td>high (ft/day)</td>
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### Transmissivity (ft²/day):

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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<tbody>
<tr>
<td>low</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
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---

### Comments:

- ____________________________________________________________________________

---

### Attachments:

- ____________________________________________________________________________
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID#</th>
<th>0030</th>
</tr>
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<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 phase 6 phase AC power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam + air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam + O2</td>
<td></td>
<td></td>
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<tr>
<td><strong>Type of Test:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot test</td>
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<td></td>
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<tr>
<td>Full-scale System</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Geology of Treatment Zone:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
<td></td>
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<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Treatment Target Zone:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vadose only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both (Saturated and Vadose zones)</td>
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<td></td>
</tr>
<tr>
<td><strong>Start of Thermal Test:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/26/1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration: 413 day</td>
<td></td>
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<td><strong>Hydraulic Control:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Treatment Cell Design:</strong></td>
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<td></td>
</tr>
<tr>
<td>Size of target zone (ft²):</td>
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<td></td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
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<td>Thickness of target zone below water table (ft):</td>
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<tr>
<td>Number of energy delivery points:</td>
<td>4</td>
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<td>Number of extraction points:</td>
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<td></td>
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<td>Initial formation temperature (deg C):</td>
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<tr>
<td>Maximum representative formation temperature (deg C):</td>
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<tr>
<td>Time to reach maximum representative temperature (days):</td>
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<td></td>
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<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>274</td>
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</tr>
<tr>
<td><strong>Mass of contaminant removed:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RF antennas originally set at 10 ft bgs to 20 ft bgs. Moved on May 13th to 6 to 16 ft bgs because of electrical problems thus heating only the vadose zone instead of vadose and saturated zone.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Attachments:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Objective - 1) prevent benzene migration to Chena River and 2) reduce total dissolved hydrocarbons in river.

Energy numbers only for 351 days of heating and does not include high-temperature kWhr heating period.

2 phases of heating: 1) 351 days to get to 15 to 40°C and 2) 62 days to get to ?

General comments on the thermal application:

Please note other cost:

Energy Cost:

Thermal Vendor Cost:

Consultant Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:
Type of treatment: ______ Conductive ______ Steam ______ ERH ______ Other: ________________
Type of Contaminant: ______ Chlorinated Solvents ______ Petroleum Hydrocarbons ______ Pesticides
__________ Wood Treating ______ Other: ________________
Treatment Status: ______ Active ______ Post
Type of Test: ______ Pilot Test ______ Full Scale System
Type of Site: ______ Non-DOD ______ DoD

File Analyzed By: JT    PD    Date: 11/6/2006

Facility Name: Ft. Wainwright
Address: CH2M Hill
City, State, Zip Code: ________________
OU# or Site #: ________________

Primary point of contact: Rich Horn
Organization: ________________
Address: ________________
City, State, Zip Code: ________________
Phone #: 907-646-0287    email: rhorn@ch2m.com

Other contacts or vendors who worked on site: ______ None
Point of contact: ________________
Type: ______ Vendor, Consultant ______ Vendor, Technical Applications ______ Other ______
Organization: ________________
Address: ________________
City, State, Zip Code: ________________
Phone #: ___________________ email: ___________________

QA/QC

Characteristics of Interest
____ Good pre- and post-treatment groundwater data
____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information
____ Flux assessment
____ Groundwater elevations
____ Geologic cross-section
____ Hydraulic Conductivity information
### General Site Assessment Data

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): 
  - Width (ft.): 
  - Thickness (ft.): 
  - Impacted as defined by documentation: 
  - Alternative method for determining size of impacted zone (See source zone definition attachments) 
  - Map attachment: 

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: 
  - Number of wells relative to treatment zone:
    - Pre-treatment:
      - In: 
      - Upgradient: 
      - Downgradient: 
      - Crossgradient: 
    - Post-treatment:
      - In: 
      - Upgradient: 
      - Downgradient: 
      - Crossgradient: 

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: 
  - Number of relevant soil borings with post-treatment data: 
  - Number inside treatment zone: 
  - Number outside treatment zone: 

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trihalomethane</td>
<td>Hexane</td>
<td>None</td>
<td>None (mg/L)</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None (mg/L)</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>0.1 mg/kg</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>0.1 mg/kg</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
<td>0.5 mg/kg</td>
<td>None (mg/kg)</td>
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<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>0.1 mg/kg</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None (mg/L)</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>None</td>
<td>None (mg/L)</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
<td>GRO</td>
<td>None</td>
<td>1,000 mg/kg</td>
<td>50 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethene</td>
<td>DRO</td>
<td>None</td>
<td>5,000 mg/kg</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>total xylenes</td>
<td>None</td>
<td>0.05 mg/L</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GRO 10-12</td>
<td>None</td>
<td>500 mg/kg</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GRO 15-17</td>
<td>None</td>
<td>None (mg/L)</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DRO 10-12</td>
<td>None</td>
<td>500 mg/kg</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DRO 15-17</td>
<td>None</td>
<td>None (mg/L)</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TAH</td>
<td>None</td>
<td>None (mg/L)</td>
<td>None (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TAqH</td>
<td>None</td>
<td>None (mg/L)</td>
<td>None (mg/kg)</td>
</tr>
</tbody>
</table>

**Comments:**

TAH - total aromatic hydrocarbons and TAqH - total aqueous hydrocarbons for the Chena River surface water samples

### Attachments:

---

None
## Hydrogeologic Conceptual Model

### Geology:

**Vadose Zone:**
- X Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely permeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- X Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely permeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Aquifer Characteristics:

- **Is more than 1 aquifer present?** No, Yes (number): 
  - Aquifer 1
  - Aquifer 2
  - Aquifer 3

- **Ground surface elevation based on wells in or adjacent to treatment zone:** ft amsl

### Flow direction

- NNW

### Horizontal hydraulic gradient (feet/foot): Unknown

### Vertical hydraulic gradient (feet/foot): Unknown

### K range (ft/day)

<table>
<thead>
<tr>
<th>Low Value</th>
<th>High Value</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>600</td>
<td>Slug Test</td>
</tr>
</tbody>
</table>

### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Low Value</th>
<th>High Value</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Slug Test</td>
</tr>
</tbody>
</table>
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
  - Steam
  - Steam + air
  - Steam + O2
  - Other (describe)

Type of Test:  
- Pilot test
  - Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- Duration: 155 days

Hydraulic Control  
- Yes
- No

Treatment Cell Design:  
- Size of target zone (ft²): 700
- Thickness of target zone (ft): 13
- Depth to top of target zone (ft bgs): 10
- Thickness of target zone below water table (ft): 7
- Number of energy delivery points: 6
- Number of extraction points: 1

Temperature Profile:  
- Initial formation temperature (deg C): 5
- Maximum representative formation temperature (deg C): 90
- Time to reach maximum representative temperature (days): 118
- Duration of treatment at representative temperature (days): 35

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
- Via liquid pumping: __________________________ lb kg Unknown
- In vapor stream: __________________________ lb kg Unknown
- Total: __________________________ lb kg Unknown

Comments:  
15 ft spacing

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater: DRO - 1.5 mg/L; GRO - 1.3 mg/L; 1,2-DCA - 0.005 mg/L; Benzene - 0.005 mg/L; Toluene - 1 mg/L; RRO - 1.11 mg/L

In Soil: DRO - 200 mg/kg; GRO - 50 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment:

- In Soil
  - Comment:

General comments on the thermal application:

2 separate phases of heating: 1) 98 days to heat to between 20 and 40°C for 3 months and 2) 57 days to get to 80 to 100°C for 1 month

Lessons Learned

Energy

Total Energy Used:

<table>
<thead>
<tr>
<th>kWh</th>
<th>kWh/m³</th>
<th>kWh/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td>205016</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Total energy applied to treatment zone: 
- Other energy: 
  - Please note other energy: 

Cost

Total Project Cost:

- Consultant Cost: 
- Thermal Vendor Cost: 
- Energy Cost: 
- Other Cost 1: 
- Other Cost 2: 
- Other Cost 3: 
- Please note other cost: 
  - Other Cost 1: 
  - Other Cost 2: 
  - Other Cost 3:
General Site Information

File Analyzed By: JT PD
Type of treatment: x Conductive Steam ERH Other: ________________
Type of Contaminant: ____ Chlorinated Solvents Petroleum Hydrocarbons Pesticides
____ Wood Treating Other: ________________
Treatment Status: Active Post
Type of Test: x Pilot Test Full Scale System
Start of Test: ________________ End of Test: Aug-07 Duration: __________
Type of Site: x Non-DOD DoD

Facility Name: NASA Marshal Space Flight Center
City, State, Zip Code: Huntsville, AL
OU# or Site #: ________________

Primary point of contact: Ralph Baker
Organization: TerraTherm, Inc.
Address: 10 Stevens Road
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: rbaker@teratherm.com

Other contacts or vendors who worked on site
Point of contact: Jason Cole
Type: x Vendor, Consultant __ Vendor, Technical Applications __ Other __________
Organization: CH2M HILL, Inc
Address: 2035 Lakeside Centre Way; Suite 200
City, State, Zip Code: Knoxville, TN 37922
Phone #: (865)-560-2987 email: Jason.Cole@ch2m.com

QA/QC

Characteristics of Interest
____ Good pre- and post-treatment groundwater data
____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information
____ Flux assessment
____ Groundwater elevations
____ Geologic cross-section
____ Hydraulic Conductivity information
### General Site Assessment Data

- **Facility ID:** (Redacted)
- **Comments:**
  - None

#### Impacted Zone

- Length (parallel to flow direction) (ft.):
- Width (ft.):
- Thickness (ft.):
- Unknown

- Impacted zone as defined by documentation

- Alternative method for determining size of impacted zone (See source zone definition attachments)

- Map attachment

#### Monitor Wells

- Number of relevant monitoring wells with groundwater data: None

- Number of relevant monitoring wells with pre-treatment data: None

- Number of relevant monitoring wells with post-treatment data: None

#### Soil Borings

- Number of relevant soil borings with pre-treatment data: None

- Number of relevant soil borings with post-treatment data: None

- Number inside treatment zone: None

- Number outside treatment zone: None

### Types of Contaminants

#### Chlorinated Solvents

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>vinyl chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Petroleum Hydrocarbons

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Naphtalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>m-p-xylene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Other

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossdr</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:

- None

#### Attachments:

- None
Geology: 

Vadose Zone: 
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone: 
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

Aquifer Characteristics:

Is more than 1 aquifer present? 
- No 
- Yes (number): ____________ 
- Unknown (assume single aquifer)

Aquifer 1 | Aquifer 2 | Aquifer 3
--- | --- | ---
Depth to water: 
- low (ft bgs): 
- high (ft bgs): 
- Unknown:

Flow direction

Horizontal hydraulic gradient (feet/foot): ____________ ____________ ____________ ____________ Unknown

Vertical hydraulic gradient (feet/foot): ____________ ____________ ____________ ____________ Unknown

K range (ft/day) Measured using: 
- Slug Test 
- Laboratory 
- Field data
- low: 
- high: ____________ ____________ ____________ ____________ Unknown

Transmissivity (ft²/day): Measured using: 
- Slug Test 
- Laboratory 
- Field data
- low: 
- high: ____________ ____________ ____________ ____________ Unknown

Comments:

Attachments:
Thermal Treatment - Design

Thermal treatment: x Conductive
Electrical Resistance
   3 phase
   6 phase
   AC power
   DC power
Steam
Steam
Steam + air
Steam + O2
Other (describe)

Type of Test: x Pilot test
   Full-scale System
Geology of Treatment Zone:
   Relatively homogeneous and permeable unconsolidated sediments
   Relatively homogeneous and impermeable unconsolidated sediments
   Largely permeable sediments with inter-bedded lenses of lower permeability material
   Largely impermeable sediments with inter-bedded layers of higher permeability material
   Competent, but fractured bedrock (i.e. crystalline rock)
   Weathered bedrock, limestone, sandstone

Treatment Target Zone:
   Saturated only
   Vadose only
   Both (Saturated and Vadose zones)
Start of Thermal Test:
Duration:
Hydraulic Control
   Yes
   No

Treatment Cell Design:
Size of target zone (ft²): 858
Thickness of target zone (ft): 22
Depth to top of target zone (ft bgs): 7
Thickness of target zone below water table (ft): 3
Number of energy delivery points: 18
Number of extraction points: 11

Temperature Profile:
Initial formation temperature (deg C):
Maximum representative formation temperature (deg C): 110
Time to reach maximum representative temperature (days): 55
Duration of treatment at representative temperature (days): 20

Formation temperature immediately post-treatment:
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:
  Via liquid pumping:
  In vapor stream:
  Total:

Date
Temperature (deg C)

Notes: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

___ In Groundwater: ___________________________________________

___ In Soil: ___________________________________________

Was the Remediation Goal Achieved:

___ In Groundwater

Comment: ___________________________________________

___ In Soil

Comment: ___________________________________________

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ____________________________ kWhr/yd³ kWhr/m³ kWhr/yd³ kWhr/m³ kWhr/yd³ kWhr/m³ kWhr/yd³

___ Total energy applied to treatment zone: ____________________________ kWhr/yd³ kWhr/m³ kWhr/yd³ kWhr/m³ kWhr/yd³ kWhr/m³ kWhr/yd³

___ Other energy: ____________________________ kWhr/yd³ kWhr/m³ kWhr/yd³ kWhr/m³ kWhr/yd³ kWhr/m³ kWhr/yd³

___ Please note other energy: ___________________________________________

Cost

Total Project Cost:

___ Consultant Cost: ___________________________________________

___ Thermal Vendor Cost: ___________________________________________

___ Energy Cost: ____________________________________________ m³ yd³

___ Other Cost 1: ___________________________________________

___ Other Cost 2: ___________________________________________

___ Other Cost 3: ___________________________________________

___ Please note other cost: ___________________________________________

___ Other Cost 1: ___________________________________________

___ Other Cost 2: ___________________________________________

___ Other Cost 3: ___________________________________________
General Site Information

File Analyzed By: JT PD  
Date: 10/29/2006

Type of treatment:
- Conductive  
- Steam  
- Other: ____________

Type of Contaminant:
- Chlorinated Solvents  
- Petroleum Hydrocarbons  
- Pesticides  
- Wood Treating  
- Other: ____________

Treatment Status:
- Active  
- Post  

Type of Test:
- Pilot Test  
- Full Scale System  

Start of Test: ____________  
End of Test: ____________  
Duration: 21 months

Type of Site:
- Non-DOD  
- DoD  

Facility Name: Defense Fuel Support Point Whittier
Organization: Defense Energy Support Center
Address: 8725 John J. Kingman Road
City, State, Zip Code: Fort Belvoir, Virginia 22060-6222
OU# or Site #: ____________
Primary point of contact:
- Wayne Barnum (DESC Headquarters contact)  
- Jack Appolloni (DESC Alaska contact)
Phone #: 617-767-8314, 907-552-4650  
Email: jack.appolloni@dla.mil

Other contacts or vendors who worked on site: None

QA/QC

Characteristics of Interest
- Good pre- and post-treatment groundwater data  
- Good pre- and post-treatment soil data  
- Good temperature profile vs. time information  
- Flux assessment  
- Groundwater elevations  
- Geologic cross-section  
- Hydraulic Conductivity information
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 200
- Width (ft.): 300
- Thickness (ft.): 10
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: None
- Pre-treatment: 33
- Post-treatment: 17
- Number of wells relative to treatment zone:
  - Pre-treatment: In: 34, Upgradient: 4, Downgradient: 24, Crossgradient: 8
  - Post-treatment: In: 34, Upgradient: 4, Downgradient: 24, Crossgradient: 8

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 35
- Number of relevant soil borings with post-treatment data: 23
- Number inside treatment zone: 58
- Number outside treatment zone: 35

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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<tbody>
<tr>
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<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
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<td>Jet Fuel</td>
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**Comments:**

JP4 estimated loss of 100,000 gallons

**Attachments:**

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<th>Unconsolidated Sediments</th>
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<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<td>Weathered bedrock, limestone, sandstone</td>
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| Saturated Zone: | Relatively homogeneous and permeable unconsolidated sediments |
|                | Relatively homogeneous and impermeable unconsolidated sediments |
| x              | Largely permeable sediments with inter-bedded lenses of lower permeability material |
|                | Largely impermeable sediments with inter-bedded layers of higher permeability material |
|                | Competent, but fractured bedrock (i.e. crystalline rock) |
|                | Weathered bedrock, limestone, sandstone |

- Ground surface elevation based on wells in or adjacent to treatment zone: __________ fi amsl __________ Unknown

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<td>Is more than 1 aquifer present?</td>
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<td>Yes (number):</td>
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<td>Unknown (assume single aquifer)</td>
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<td>Depth to water:</td>
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<tr>
<td>low value (ft bgs):</td>
<td>15</td>
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<tr>
<td>high value (ft bgs):</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Unknown:</td>
<td></td>
<td></td>
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</table>

- Flow direction

| Horizontal hydraulic gradient (feet/foot): |       |       |       |       |       |
| Vertical hydraulic gradient (feet/foot): |       |       |       |       |       |

- K range (ft/day) | Measured using: | Slug Test | Laboratory | Field data |
| low |       |       |       | Unknown |
| high |       |       |       |       |

- Transmissivity (ft²/day): | Measured using: | Slug Test | Laboratory | Field data |
| low |       |       |       | Unknown |
| high |       |       |       |       |

Comments: ___________________________________________________________
Attachments: _________________________________________________________

Thermal Treatment - Design  

Thermal treatment:  ___ Conductive  ___ Electrical Resistance  
  ___ 3 phase  ___ 6 phase  ___ AC power  ___ DC power  

Steam  ___ Steam  ___ Steam + air  ___ Steam + O2  

Type of Test:  ___ Pilot test  ___ Full-scale system  

Geology of Treatment Zone:  ___ Relatively homogeneous and permeable unconsolidated sediments  
  ___ Largely permeable sediments with inter-bedded lenses of lower permeability material  
  ___ Largely impermeable sediments with inter-bedded layers of higher permeability material  
  ___ Competent, but fractured bedrock (i.e. crystalline rock)  
  ___ Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  ___ Saturated only  ___ Vadose only  ___ Both (Saturated and Vadose zones)  

Start of Thermal Test:  _______________  Duration:  21 months  

Hydraulic Control  ___ Yes  ___ No  

Treatment Cell Design:  

Size of target zone (ft²):  ____________  ___ Unknown  ___ ( 150 x 150 ft)  

Thickness of target zone (ft):  ____________  ___ Unknown  

Depth to top of target zone (ft bgs):  ____________  ___ Unknown  

Thickness of target zone below water table (ft):  ____________  ___ Unknown  

Number of energy delivery points:  ____________  ___ Unknown  

Number of extraction points:  ____________  ___ Unknown  

Temperature Profile:  

Initial formation temperature (deg C):  ____________  ___ Unknown  

Maximum representative formation temperature (deg C):  ____________  ___ Unknown  

Time to reach maximum representative temperature (days):  ____________  ___ Unknown  

Duration of treatment at representative temperature (days):  ____________  ___ Unknown  

Formation temperature immediately post-treatment:  ____________  

Formation temperature post-treatment monitoring event 1:  ____________  

Duration of post-treatment monitoring (days):  ____________  

Mass of contaminant removed:  

Via liquid pumping:  1000 gal  ___ lb  ___ kg  ___ Unknown  

In vapor stream:  15000 gal  ___ lb  ___ kg  ___ Unknown  

Total:  16000 gal  ___ lb  ___ kg  ___ Unknown  

Attachments:  

Note:  When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ________________ kWhr ________________ kWhr/m^3 ________________ kWhr/yd^3

Total energy applied to treatment zone: ________________ kWhr/m^3 ________________ kWhr/yd^3

Other energy: ________________ kWhr/m^3 ________________ kWhr/yd^3

Please note other energy: ________________

Cost

Total Project Cost: 3,800,000

Consultant Cost: ________________

Thermal Vendor Cost: ________________

Energy Cost: ________________ m^3 ________________ yd^3

Other Cost 1: ________________

Other Cost 2: ________________

Other Cost 3: ________________

Please note other cost: ________________

Other Cost 1: ________________

Other Cost 2: ________________

Other Cost 3: ________________
General Site Information

File Analyzed By: JT PD Date: 5/23/2005

Type of treatment: x Conductive ___ Steam ___ ERH ___ Other: _________________

Type of Contaminant: ___ Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides

dx Wood Treating x Other: PAH, Dioxins/Furans, PCBs

Treatment Status: ___ Active x Post

Type of Test: ___ Pilot Test x Full Scale System

Start of Test: 2/27/2003 End of Test: 9/24/2005 Duration: 836 d

Type of Site: x Non-DOD ___ DoD

Facility Name: Alhambra Pole Yard

Address: ________________________________

City, State, Zip Code: Alhambra CA 91803

OU# or Site #: AOC-2

Primary point of contact: Tony Landler

Organization: SCE

Address: 2244 Walnut Grove Avenue

City, State, Zip Code: Rosemead CA 91770

Phone #: 626-302-8692 email: tony.landler@sce.com

Other contacts or vendors who worked on site ___________ None

Point of contact: John Bierschenk

Type: ___ Vendor, Consultant ___ Vendor, Technical Applications x Other ___ Contractor

Organization: TerraTherm

Address: 10 Stevens Road

City, State, Zip Code: Fitchburg, MA 01420

Phone #: 978-343-0300 email: jbierschenk@terratherm.com

QA/QC

________ Characteristics of Interest

________ Good pre- and post-treatment groundwater data x Good pre- and post-treatment soil data

________ Good temperature profile vs. time information _______ Flux assessment

________ Groundwater elevations _______ Geologic cross-section

________ Hydraulic Conductivity information
### General Site Assessment Data

#### Impacted Zone:
- Length (parallel to flow direction)(ft.): ______
- Width (ft.): ______
- Thickness (ft.): ______

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment: ______
  - Post-treatment: ______
- Number of wells relative to treatment zone:
  - Pre-treatment In: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______
  - Post-treatment In: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: ______
- Number of relevant soil borings with post-treatment data: ______
- Number inside treatment zone: ______
- Number outside treatment zone: ______

#### Types of Contaminants

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<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
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<tr>
<td></td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Other</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
<td>5,000 mg/kg</td>
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<td>1,1-dichloroethene</td>
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<td>5 mg/kg</td>
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<td>cis,1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
<td>1,000 mg/kg</td>
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<td>trans,1,2-dichloroethene</td>
<td>Benzene</td>
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<td>Ethylbenzene</td>
<td>total PAH</td>
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</table>

- Comments:
  - Volume treated: 16,200 yd³ from 7 to 105 ft
  - *Dioxin as 2,3,7,8-TCDD TEQ and the final concentration was actually 0.0001 mg/kg.
  - PCP was ND in post-treatment samples.

#### Attachments:

- None
### Hydrogeologic Conceptual Model

#### Facility ID#:

<table>
<thead>
<tr>
<th>x</th>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<td>Largely permeable sediments with inter-beded lenses of lower permeability material</td>
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<td>x</td>
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<td>Largely impermeable sediments with inter-beded layers of higher permeability material</td>
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<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<td>Weathered bedrock, limestone, sandstone</td>
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<td></td>
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<td>Weathered bedrock, limestone, sandstone</td>
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</tbody>
</table>

- Ground surface elevation based on wells in or adjacent to treatment zone: 470 ft amsl, __Unknown__, Unknown (assume single aquifer)

- Aquifer Characteristics:
  - Is more than 1 aquifer present? No, Yes (number): __Unknown__, Unknown (assume single aquifer)
  - Depth to water:
    - low value (ft bgs): 240
    - high value (ft bgs): 270
    - Unknown:

- Flow direction: SSE

- Horizontal hydraulic gradient (feet/foot): 0.063, __Unknown__, Unknown
- Vertical hydraulic gradient (feet/foot): __Unknown__, __Unknown__, __Unknown__

- K range (ft/day)
  - Measured using:
    - Slug Test
    - Laboratory
    - Field data
    - Unknown

- Transmissivity (ft²/day):
  - Measured using:
    - Slug Test
    - Laboratory
    - Field data
    - Unknown

#### Comments:

__________________________________________________________________________________________
__________________________________________________________________________________________
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#### Attachments:

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<th>Phases 1 &amp; 2</th>
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<td>X Full-scale System</td>
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<tr>
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<td>No</td>
</tr>
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<td>Unknown</td>
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<td>Thickness of target zone (m):</td>
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<td>Depth to top of target zone (m bgs):</td>
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<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (m):</td>
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<td>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
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<td>Unknown</td>
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<tr>
<td>Number of extraction points:</td>
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<td>Unknown</td>
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<td>Initial formation temperature (°C):</td>
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</tr>
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<td>(°C)</td>
</tr>
<tr>
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<td>(days)</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
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<td>(days)</td>
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<tr>
<th>Date</th>
<th>Temperature (°C)</th>
</tr>
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<td></td>
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</tbody>
</table>

| Mass of contaminant removed: |              |              |
| Via liquid pumping: | 0 | lb | kg | Unknown |
| In vapor stream: | 1,785,661 | lb | kg | Unknown |
| Total: | 1,785,661 | x | lb | kg | Unknown |

| Comments: | Treatment was performed in 2 phases. Phase 1 ended in early 2004 and phase 2 was completed in September 2005. 7 ft (2.1 M) spacing with depths ranging from 7 to 105 ft with an average of 31 ft bgs in a volume of 12,400 m³ (16,200 yd³).

Mass Removal Calculation Methods: (1) Combustion Method (2) MicroFID® Method (3) CO2 Method

Attachments: |              |              |
|

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
<table>
<thead>
<tr>
<th><strong>Thermal Treatment - Design</strong></th>
<th>Facility ID#: 0960</th>
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</thead>
<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td><em>x</em> Conductive</td>
</tr>
<tr>
<td><em>x</em> Electrical Resistance</td>
<td><em>x</em> 3 phase</td>
</tr>
<tr>
<td><em>x</em> Steam</td>
<td><em>x</em> Steam</td>
</tr>
<tr>
<td><em>x</em> Steam + O2</td>
<td><em>x</em> Steam + O2</td>
</tr>
<tr>
<td><strong>Type of Test:</strong></td>
<td><em>x</em> Pilot test</td>
</tr>
<tr>
<td><strong>Geology of Treatment Zone:</strong></td>
<td><em>x</em> Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td><em>x</em> Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td><em>x</em> Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
</tr>
<tr>
<td><em>x</em> Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td><em>x</em> Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td><em>x</em> Weathered bedrock, limestone, sandstone</td>
<td></td>
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<tr>
<td><strong>Treatment Target Zone:</strong></td>
<td><em>x</em> Saturated only</td>
</tr>
<tr>
<td><em>x</em> Both (Saturated and Vadose zones)</td>
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<tr>
<td><strong>Start of Thermal Test:</strong></td>
<td>2/27/03 (ended 2/11/04)</td>
</tr>
<tr>
<td><strong>Hydraulic Control:</strong></td>
<td><em>x</em> Yes</td>
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<td><strong>Treatment Cell Design:</strong></td>
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<tr>
<td>Size of target zone (ft²):</td>
<td>15,278</td>
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<tr>
<td>Thickness of target zone (ft):</td>
<td>33 (average)</td>
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<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td><em>Unknown</em></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td><em>Unknown</em></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>604</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>85</td>
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<tr>
<td><strong>Temperature Profile:</strong></td>
<td></td>
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<tr>
<td>Initial formation temperature (deg C):</td>
<td><em>23</em></td>
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<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td><em>315</em></td>
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<td>Time to reach maximum representative temperature (days):</td>
<td><em>Unknown</em></td>
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<td>Duration of treatment at representative temperature (days):</td>
<td><em>Unknown</em></td>
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<td><strong>Formation temperature immediately post-treatment:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Formation temperature post-treatment monitoring event 1:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Duration of post-treatment monitoring (days):</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mass of contaminant removed:</strong></td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td><em>Unknown</em></td>
</tr>
<tr>
<td>In vapor stream:</td>
<td><em>Unknown</em></td>
</tr>
<tr>
<td>Total:</td>
<td><em>Unknown</em></td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Phase 1 ended in early 2004</strong> 7 ft (2.1 M) spacing with depths ranging from 7 to 105 ft with an average of 33ft bgs in a volume of 8,360 m3 (11,000 yd³) 419 heater-only wells and 85 heater-vacuum wells</td>
<td></td>
</tr>
<tr>
<td><strong>Attachments:</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment - Design

Thermal treatment: x Conductive  Phase 2

Electrical Resistance

x 3 phase  6 phase  AC power  DC power

Steam

Steam  Steam + air  Steam + O2

Other (describe)

Type of Test: x Pilot test  4 Full-scale System

Geology of Treatment Zone:

x Relatively homogeneous and permeable unconsolidated sediments

x Relatively homogeneous and impermeable unconsolidated sediments

x Largely permeable sediments with inter-bedded lenses of lower permeability material

x Largely impermeable sediments with inter-bedded layers of higher permeability material

x Competent, but fractured bedrock (i.e. crystalline rock)

x Weathered bedrock, limestone, sandstone

Treatment Target Zone: x Saturated only  x Vadose only  x Both (Saturated and Vadose zones)

Start of Thermal Test: 5/27/04 (ended 9/24/05) Duration: 486 days

Hydraulic Control: x Yes  x No

Treatment Cell Design:

Size of target zone (ft2): 7222

Thickness of target zone (ft): 28 (average)

Depth to top of target zone (ft bgs): 0

Thickness of target zone below water table (ft): 0

Number of energy delivery points: 281

Number of extraction points: 46

Temperature Profile:

Initial formation temperature (deg C): 29

Maximum representative formation temperature (deg C): 335

Time to reach maximum representative temperature (days):

Duration of treatment at representative temperature (days):

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping: ___________ lb  ___________ kg  ___________ Unknown

In vapor stream: ___________ lb  ___________ kg  ___________ Unknown

Total: ___________ lb  ___________ kg  ___________ Unknown

Comments:
Phase 2 ended in September 2005  7 ft (2.1 M) spacing with depths ranging from 7 to 105 ft with an average of 28 ft bgs in a volume of 3,952 m3 (5,200 yd3)  235 heater-only wells and 46 heater-vacuum wells

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

1. In Groundwater:
2. In Soil:

Was the Remediation Goal Achieved:

1. In Groundwater
2. In Soil

General comments on the thermal application:

Goal was to hit interwell temperature of 635°F (335°C) for at least 3 days or hit 570°F (300°C) for 30 days

No Further Action letter issued by Department of Toxic Substances Control 2/8/07.

Energy

Total Energy Used: 19,359,051 kWhr

Other energy:

Please note other energy:

Cost

Total Project Cost: 17,900,000.00

Other Cost 1: 2,169,000

Other Cost 2: 600,000

Other Cost 3: 2,265,000.00

Please note other cost:

Laboratory and Air Quality Testing Expenses

SCE Labor Costs

($266,000) Waste Disposal

(1,488,000) Miscellaneous Project Costs
General Site Information

File Analyzed By: JT × PD ____ Date: 10/26/2006
Type of treatment: ____ Conductive ____ Steam ____ ERH × Other: RFH
Type of Contaminant: ____ Chlorinated Solvents × Petroleum Hydrocarbons ____ Pesticides
____ Wood Treating ____ Other: ____________________________
Treatment Status: ____ Active × Post
Type of Test: × Pilot Test ____ Full Scale System
Start of Test: ________________ End of Test: ________________ Duration: ___________
Type of Site: × Non-DOD ____ DoD

Facility Name: Texaco
Address: ________________________________
City, State, Zip Code: Bakersville, CA
OU# or Site #: ________________________________

Primary point of contact: Ray Kasevich
Organization: KSN Energies
Address: 291 Main St., 3rd Floor, PO Box 612
City, State, Zip Code: Great Barrington, MA 01230
Phone #: 413-528-4651 email: rkasevich@ksnenergies.com

____ Other contacts or vendors who worked on site: ____ None
Point of contact:
Type: ____ Vendor, Consultant ____ Vendor, Technical Applications ____ Other _________
Organization: ________________________________
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: ________________________________ email: ________________________________

QA/QC

____ Characteristics of Interest
____ Good pre- and post-treatment groundwater data ____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information ____ Flux assessment
____ Groundwater elevations ____ Geologic cross-section
____ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 065

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td><strong>Groundwater (mg/L)</strong></td>
<td><strong>Soil (mg/kg)</strong></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Cross-dip</td>
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<td>None</td>
<td>None</td>
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<td>Tetrahydrofuran</td>
<td>Jet Fuel</td>
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<td>1,1-dichloroethene</td>
<td>Napthalene</td>
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<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>None</td>
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<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
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<td>None</td>
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<td>1,1,1-trichloroethane</td>
<td>α-xylene</td>
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<td>None</td>
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<td>1,1,2-trichloroethane</td>
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<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

**Number of wells relative to treatment zone:**
- Pre-treatment:
  - In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________
- Post-treatment:
  - In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
  - Pre-treatment: __________
  - Post-treatment: __________

**Types of Contaminants**

**Comments:**

**Attachments:**
Hydrogeologic Conceptual Model

---

**Geology:**

**Zone**

- **Vadose Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Saturated Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

---

**Aquifer Characteristics:**

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): _____________
  - Unknown (assume single aquifer)

- **Depth to water:**
  - Low value (ft bgs):
  - High value (ft bgs):
  - Unknown:

- **Flow direction:**

- **Horizontal hydraulic gradient (feet/foot):**

- **Vertical hydraulic gradient (feet/foot):**

---

**K range (ft/day):**

- Measured using: Slug Test Laboratory Field data
  - Low
  - High
  - Unknown

**Transmissivity (ft²/day):**

- Measured using: Slug Test Laboratory Field data
  - Low
  - High
  - Unknown

---

**Comments:**

---

**Attachments:**

---
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-beded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  Duration:  

Hydraulic Control:  
- Yes
- No

Size of target zone (ft²):  Thickness of target zone (ft):  Depth to top of target zone (ft bgs):  Thickness of target zone below water table (ft):  Number of extraction points:  Number of energy delivery points:  

Temperature Profile:  
- Initial formation temperature (deg C):  Unknown
- Maximum representative formation temperature (deg C):  Unknown
- Time to reach maximum representative temperature (days):  Unknown
- Duration of treatment at representative temperature (days):  Unknown

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
- Via liquid pumping:  Unknown lb kg
- In vapor stream:  Unknown lb kg
- Total:  Unknown lb kg

Notes: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

__ In Groundwater:

__ In Soil:

Was the Remediation Goal Achieved:

__ In Groundwater

__ In Soil

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ___ kWhr ___ kWhr/m³ ___ kWhr/yd³

__ Total energy applied to treatment zone: ___ kWhr/m³ ___ kWhr/yd³

__ Other energy: ___ kWhr/m³ ___ kWhr/yd³

__ Please note other energy: _______________________________________________________

Cost

Total Project Cost:

__ Consultant Cost: ____________________________________________

__ Thermal Vendor Cost: _______________________________________

__ Energy Cost: _____________________________________________

__ Other Cost 1: ____________________________

__ Other Cost 2: ____________________________

__ Other Cost 3: ____________________________

__ Please note other cost: __ Other Cost 1: ____________________________

__ Other Cost 2: ____________________________

__ Other Cost 3: ____________________________
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
<td></td>
</tr>
<tr>
<td>Start of Test:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End of Test:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration:</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
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</tr>
</tbody>
</table>

| Facility Name: | GATX Annex Terminal | 
| Address: | | 
| City, State, Zip Code: | San Pedro, CA | 
| OU# or Site #: | | 

| Primary point of contact: | Paul DePercin | 
| Organization: | SITE/ US EPA | 
| Address: | | 
| City, State, Zip Code: | | 
| Phone #: | 513-569-7797 | 
| email: | | 

| Other contacts or vendors who worked on site: | None | 
| Point of contact: | | 
| Type: | Vendor, Consultant | Vendor, Technical Applications | Other | 
| Organization: | | 
| Address: | | 
| City, State, Zip Code: | | 
| Phone #: | | 
| email: | | 

### QA/QC

| Characteristics of Interest | 
| Good pre- and post-treatment groundwater data | Good pre- and post-treatment soil data |
| Good temperature profile vs. time information | Flux assessment |
| Groundwater elevations | Geologic cross-section |
| Hydraulic Conductivity information | |
## General Site Assessment Data

<table>
<thead>
<tr>
<th><strong>Impacted Zone:</strong> Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
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</thead>
<tbody>
<tr>
<td>Impacted zone as defined by documentation</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Alternative method for determining size of impacted zone (See source zone definition attachments)</td>
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<tr>
<td>Map attachment</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Monitor Wells:</strong> Number of relevant monitoring wells with groundwater data:</th>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Number of wells relative to treatment zone:** |
| Pre-treatment | In: | Upgradient: | Downgradient: | Crossgradient: |
| Post-treatment | In: | Upgradient: | Downgradient: | Crossgradient: |

| **Soil Borings:** Number of relevant soil borings with pre-treatment data: | Number inside treatment zone: |
| Number inside treatment zone: |

| **Soil Borings:** Number of relevant soil borings with post-treatment data: |
| Number outside treatment zone: |

## Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<td>Tetrachloroethene</td>
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</tr>
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<td>None</td>
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<td></td>
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<td>Ethylbenzene</td>
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<td>1,2-dichloroethene</td>
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<tr>
<td>Vinyl Chloride</td>
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<td><strong>Total VOCs</strong></td>
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<td>None</td>
<td>None</td>
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</tbody>
</table>

| Comments: |

8925 cubic yards of contaminated soil - total Only treated 65 cubic yards

| Attachments: |

____________________________________________________________________________________

____________________________________________________________________________________
Hydrogeologic Conceptual Model

Geology: Unconsolidated Sediments

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl × Unknown

Is more than 1 aquifer present? No Yes (number): ___________ × Unknown (assume single aquifer)

Depth to water:
- Low value (ft bgs): ___________ ___________ ___________
- High value (ft bgs): ___________ ___________ ___________
- Unknown: ___________ ___________ ___________

Flow direction

Horizontal hydraulic gradient (feet/foot): ___________ ___________ ___________ × Unknown
Vertical hydraulic gradient (feet/foot): ___________ ___________ ___________ × Unknown

K range (ft/day) Measured using: __ Slug Test __ Laboratory __ Field data
- Low: ___________ ___________ ___________ × Unknown
- High: ___________ ___________ ___________

Transmissivity (ft2/day): Measured using: __ Slug Test __ Laboratory __ Field data
- Low: ___________ ___________ ___________ × Unknown
- High: ___________ ___________ ___________

Comments:

Attachments:
Thermal Treatment - Design

**Thermal treatment:**
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
- Steam
  - Steam + air
  - Steam + O2
- Other (describe)

**Type of Test:**
- Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- Duration: __________

**Hydraulic Control:**
- Yes
- No

**Temperature Profile:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total:**
- Mass of contaminant removed:
  - Via liquid pumping: __________
  - In vapor stream: __________
  - Total: __________

**Notes:**
- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Attachments:**
- __________
- __________
- __________
- __________

**Comments:**
- __________
- __________
- __________
### Performance

Remediation Goal:

- **In Groundwater:**

- **In Soil:**

Was the Remediation Goal Achieved:

- **In Groundwater**

- **In Soil**

General comments on the thermal application:

- **1. SITE demo of the Toxic treatments (USA), Inc (TTUSA) Detoxifer**
- **2. Cost based on 8925 cubic yards of contaminated Soil**

$252 to $317/cubic yards

### Lessons Learned

- **Energy**
  
  Total Energy Used: $kWhr$ $kWhr/m^3$ $kWhr/yd^3$

  - Total energy applied to treatment zone: $kWhr/m^3$ $kWhr/yd^3$
  - Other energy: $kWhr/m^3$ $kWhr/yd^3$

  Please note other energy:

- **Cost**
  
  Total Project Cost:

  - Consultant Cost: 
  - Thermal Vendor Cost: 
  - Energy Cost: $m^3$ $yd^3$
  - Other Cost 1: 
  - Other Cost 2: 
  - Other Cost 3:

  Please note other cost: 

  Other Cost 1: 
  Other Cost 2: 
  Other Cost 3:
General Site Information

File Analyzed By: JT PD ERH
Type of treatment: Conductive Steam ERH Other: 
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 
Treatment Status: Active Post 
Type of Test: Pilot Test Full Scale System 
Start of Test: 10/23/2002 End of Test: 11/20/2002 Duration: 29 days 
Type of Site: Non-DOD DoD

Facility Name: Beale AFB
Address: ____________________________________________________________________________
City, State, Zip Code: Marysville, CA
OU# or Site #: SWMU 23

Primary point of contact: Phil Welker
Organization: URS
Address: ____________________________________________________________________________
City, State, Zip Code: __________________________________________________________________
Phone #: 916-679-2262 email: phil_welker@urscorp.com

Other contacts or vendors who worked on site
Point of contact: Kent Hawley
Type: Vendor, Consultant Vendor, Technical Applications Other AFB
Organization: Beale AFB
Address: 6601 B Street
City, State, Zip Code: Beale AFB, CA 95903-1708
Phone #: (530) 634-2657 email: kent.hawley@beale.af.mil

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Hydraulic Conductivity information
Geologic cross-section
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): 400
- Width (ft.): 200
- Thickness (ft.): 5

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

Monitor Wells:
- Number of relevant monitoring wells with groundwater data: None

Number of wells relative to treatment zone:
- Pre-treatment: 1
  - In: 1
    - Upgradient: 10
    - Downgradient: 10
    - Crossgradient: 10
- Post-treatment: 1
  - In: 1
    - Upgradient: 10
    - Downgradient: 10
    - Crossgradient: 10

Soil Borings:
- Number of relevant soil borings with pre-treatment data: 11
- Number of relevant soil borings with post-treatment data: 11
- Number inside treatment zone: 1
- Number outside treatment zone: 1

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross</td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>0.1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>0.001 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Have screen intervals on: BAI-01, 02, 04, 08, 4D, 5S, and

Have well coordinates of some wells pgs 5, 7 and

Hydraulic conductivity pg 6

Pre GW concs pg 7, post GW concs pg 71

Attachments:

Map for impacted zone pg 8
### Hydrogeologic Conceptual Model

**Facility ID#: 0080**

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

**Ground surface elevation based on wells in or adjacent to treatment zone:** 130 ft amsl  
Unknown

**Aquifer Characteristics:**

Is more than 1 aquifer present?  
No  
Yes (number): Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Depth to water:</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low value (ft bgs):</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction  
SW

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.012</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vertical hydraulic gradient (feet/foot):</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

K range (ft/day)  
Measured using:  
 Slug Test  
 Laboratory  
 Field data  

<table>
<thead>
<tr>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75</td>
<td>14.3</td>
</tr>
</tbody>
</table>

Transmissivity (ft²/day):  
Measured using:  
 Slug Test  
 Laboratory  
 Field data  

<table>
<thead>
<tr>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

Aquifer test conducted in 2003 resulted in dwatering at extraction point at low flow rates of 2.3 gpm

**Attachments:**

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#:</th>
<th>0080</th>
</tr>
</thead>
</table>

- **Thermal treatment:**
  - [x] Conductive
  - [x] Electrical Resistance
  - [x] Steam
  - [x] DUS/HPO
  - [x] 3 phase
  - [ ] 6 phase
  - [x] AC power
  - [ ] DC power

- **Type of Test:**
  - [x] Pilot test
  - [x] Full-scale System

- **Geology of Treatment Zone:**
  - [x] Relatively homogeneous and permeable unconsolidated sediments
  - [x] Largely permeable sediments with inter-bedded lenses of lower permeability material
  - [x] Largely impermeable sediments with inter-bedded layers of higher permeability material
  - [ ] Competent, but fractured bedrock (i.e. crystalline rock)
  - [x] Weathered bedrock, limestone, sandstone

- **Treatment Target Zone:**
  - [x] Saturated only
  - [ ] Vadose only
  - [ ] Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - 10/23/2002
  - Duration: 29 days

- **Hydraulic Control:**
  - [x] Yes
  - [ ] No

- **Treatment Cell Design:**
  - Size of target zone (ft²): 652
  - Thickness of target zone (ft): 6
  - Depth to top of target zone (ft bgs): 24
  - Thickness of target zone below water table (ft): 15
  - Number of energy delivery points: 1
  - Number of extraction points: 1

- **Temperature Profile:**
  - Initial formation temperature (deg C): 21
  - Maximum representative formation temperature (deg C): 100
  - Time to reach maximum representative temperature (days): 2
  - Duration of treatment at representative temperature (days): Unknown

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/20/2002</td>
<td>100</td>
</tr>
<tr>
<td>12/2/2002</td>
<td>88</td>
</tr>
</tbody>
</table>

- **Duration of post-treatment monitoring (days):** Atleast 14 days

- **Mass of contaminant removed:**
  - Via liquid pumping: Unknown
  - In vapor stream: Unknown
  - Total: Unknown

- **Attachments:**
  - 12/9/06 - 80C

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
General comments on the thermal application:

__Aquifer region immediately adjacent to extraction well dried out__

Lessons Learned

__Energy__

Total Energy Used: 

- Total energy applied to treatment zone: 
- Other energy: 

Please note other energy: 

__Cost__

Total Project Cost:

- Consultant Cost: 930,160
- Thermal Vendor Cost:
- Energy Cost: m³ yd³
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:

Please note other cost: Other Cost 1:
Other Cost 2:
Other Cost 3:
Facility Name: Pemaco Superfund Site
City, State, Zip Code: Los Angeles County, CA
OU# or Site #: ____________________________

Primary point of contact: Tim Garvey
Organization: TN & Associates
City, State, Zip Code: Ventura, CA 93001
Phone #: 805-585-6386 email: ____________________________

Other contacts or vendors who worked on site
Point of contact: David Flemings
Type: ______ Vendor, Consultant ______ Vendor, Technical Applications ______ Other
Organization: TRS
City, State, Zip Code: ____________________________
Phone #: 425-396-4266 email: dfleming@thermalrs.com

QA/QC

____ Characteristics of Interest
____ Good pre- and post-treatment groundwater data
____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information
____ Flux assessment
____ Groundwater elevations
____ Geologic cross-section
____ Hydraulic Conductivity information
### General Site Assessment Data

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetracloroethylene</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>cis,1,2-dichloroethylene</td>
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<td></td>
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<tr>
<td>trans,1,2-dichloroethylene</td>
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<tr>
<td>1,1-dichloroethane</td>
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<td></td>
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<tr>
<td>Ethylbenzene</td>
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<td></td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>m,p-xylene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Impacted Zone:
- Length (parallel to flow direction)(ft): __________
- Width (ft): __________
- Thickness (ft): __________
- Unknown

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: None
  - Pre-treatment: __________
  - Post-treatment: __________

### Soil Borings:
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:


### Attachments:


### Hydrogeologic Conceptual Model

#### Geology:

- **Zone**: Vadose Zone
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Zone**: Saturated Zone
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?**: No
- **Yes (number)**: 
- **Unknown (assume single aquifer)**: 

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depth to water</strong>:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction**: 

- **Horizontal hydraulic gradient (feet/foot)**: 
- **Vertical hydraulic gradient (feet/foot)**: 

- **K range (ft/day)**: 
  - Measured using: Slug Test, Laboratory, Field data
  - low: 
  - high: 

- **Transmissivity (ft²/day)**: 
  - Measured using: Slug Test, Laboratory, Field data
  - low: 
  - high: 

#### Ground surface elevation based on wells in or adjacent to treatment zone: 

| Facility ID# | 0085 |

#### Geology:

- **Unconsolidated Sediments**: 
  - Weathered bedrock, limestone, sandstone
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

#### Ground surface elevation based on wells in or adjacent to treatment zone: 

- **ft amsl**: 
- **Unknown**: 

### Facility ID:

- **0085**
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#:</th>
<th>0005</th>
</tr>
</thead>
</table>

#### Thermal treatment:
- [x] Conductive
- [x] Electrical Resistance

#### Type of Test:
- [x] Pilot test
- [x] Full-scale System

#### Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

#### Treatment Target Zone:
- [x] Saturated only
- [x] Vadose only
- [x] Both (Saturated and Vadose zones)

#### Start of Thermal Test:
- Jun-05

#### Duration of post-treatment monitoring (days):

#### Formation temperature immediately post-treatment:

#### Formation temperature post-treatment monitoring event 1:

#### Mass of contaminant removed:
- Via liquid pumping: ____________ lb ____________ kg
- In vapor stream: ____________ lb ____________ kg
- Total: ____________ lb ____________ kg

#### Temperature Profile:
- Initial formation temperature (deg C):
- Maximum representative formation temperature (deg C):
- Time to reach maximum representative temperature (days):
- Duration of treatment at representative temperature (days):

### Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater: ________________________________
- In Soil: ________________________________

Was the Remediation Goal Achieved:

- In Groundwater: ________________________________
  Comment: ___________________________________________________________________________________
- In Soil: ________________________________
  Comment: ___________________________________________________________________________________

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ________________________________ kWhr ________________________________ kWhr/m³ ________________________________ kWhr/yd³

- Total energy applied to treatment zone: ________________________________ kWhr/m³ ________________________________ kWhr/yd³
- Other energy: ________________________________ kWhr/m³ ________________________________ kWhr/yd³

Please note other energy: ___________________________________________________________________________________

Cost

Total Project Cost: ________________________________

- Consultant Cost: ________________________________
- Thermal Vendor Cost: ________________________________
- Energy Cost: ________________________________ m³ ________________________________ yd³
- Other Cost 1: ________________________________
- Other Cost 2: ________________________________
- Other Cost 3: ________________________________

Please note other cost: ________________________________

- Other Cost 1: ________________________________
- Other Cost 2: ________________________________
- Other Cost 3: ________________________________

Other energy:

- Energy Cost: ________________________________
- Thermal Vendor Cost: ________________________________
- Consultant Cost: ________________________________
- Other Cost 1: ________________________________
- Other Cost 2: ________________________________
- Other Cost 3: ________________________________

Please note other energy: ________________________________
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<th>File Analyzed By:</th>
<th>JT PD</th>
<th>Date: 5/1/2007</th>
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<tr>
<td>Type of treatment:</td>
<td>Conductive, Steam, ERH, Other:</td>
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<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides, Wood Treating, Other:</td>
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<td>Treatment Status:</td>
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<td>Type of Test:</td>
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<td>Start of Test:</td>
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<td>End of Test: Nov-05</td>
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<tr>
<td>Duration:</td>
<td>480 day</td>
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<tr>
<td>Type of Site:</td>
<td>Non-DOD, DoD</td>
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<td>Carson, CA</td>
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<td>Other contacts or vendors who worked on site</td>
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<tr>
<td>Point of contact:</td>
<td></td>
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<tr>
<td>Type:</td>
<td>Vendor, Consultant, Vendor, Technical Applications, Other</td>
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<tr>
<td>Organization:</td>
<td>TerraTherm</td>
</tr>
<tr>
<td>Address:</td>
<td>10 Stevens Rd</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Fitchburg, MA 01420</td>
</tr>
<tr>
<td>Phone #:</td>
<td>978-343-0300</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:jbierschenk@terratherm.com">jbierschenk@terratherm.com</a></td>
</tr>
</tbody>
</table>

**QA/QC**

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>x Good pre- and post-treatment groundwater data</td>
</tr>
<tr>
<td>x Good pre- and post-treatment soil data</td>
</tr>
<tr>
<td>x Good temperature profile vs. time information</td>
</tr>
<tr>
<td>Groundwater elevations</td>
</tr>
<tr>
<td>Hydraulic Conductivity information</td>
</tr>
<tr>
<td>Flux assessment</td>
</tr>
<tr>
<td>Geologic cross-section</td>
</tr>
</tbody>
</table>
### Impacted Zone
- Length (parallel to flow direction)(ft.):
- Width (ft.):
- Thickness (ft.):
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells
- Number of relevant monitoring wells with groundwater data:
- Pre-treatment: 
- Post-treatment: 
- Number of wells relative to treatment zone:
  - Pre-treatment:
  - Post-treatment:
  - Upgradient:
  - Downgradient:
  - Crossgradient:

#### Soil Borings
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number inside treatment zone: 
- Number outside treatment zone: 

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
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<tbody>
<tr>
<td></td>
<td>Trichloromethane</td>
<td>Hexane</td>
<td>Crossdr</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m+p-xylene</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Total CVOCs 20 ft</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Total CVOCs 25 ft</td>
<td>None</td>
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<td></td>
<td>Total CVOCs 30 ft</td>
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</tr>
<tr>
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<td>Total CVOCs 35 ft</td>
<td>None</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>10 mg/L</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>0.5 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>0.01 mg/kg</td>
<td>500 mg/kg</td>
</tr>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- 
- 
- 
- 
- 

### Attachments:

-
### Geology:

#### Zone: Unconsolidated Sediments

- Vadose Zone:
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e., crystalline rock)
  - Weathered bedrock, limestone, sandstone

- Saturated Zone:
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e., crystalline rock)
  - Weathered bedrock, limestone, sandstone

### Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td>20 ft amsl</td>
</tr>
<tr>
<td>Saturated</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

- Is more than 1 aquifer present? **Yes**
- Number of aquifers: **3**

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>20</td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>25</td>
</tr>
<tr>
<td>Aquifer 3</td>
<td>30</td>
</tr>
</tbody>
</table>

- Flow direction

### Horizontal hydraulic gradient (feet/foot): 0.002 to 0.004

### Vertical hydraulic gradient (feet/foot): 0.141

### K range (ft/day):

- Measured using: Slug Test, Laboratory, Field data
- Low: 1.44 ft/day
- High: Unknown

### Transmissivity (ft²/day):

- Measured using: Slug Test, Laboratory, Field data
- Low: Unknown
- High: Unknown

### Comments:

- 
- 
- 

### Attachments:

- 
- 
- 

Thermal Treatment - Design

Thermal treatment: Conductive  
Electrical Resistance  
3 phase  6 phase  AC power  DC power  
Steam  
Steam + air  Steam + O2  
Other (describe)  

Type of Test: Pilot test  
Full-scale System  

Geology of Treatment Zone:  
Relatively homogeneous and permeable unconsolidated sediments  
Relatively homogeneous and impermeable unconsolidated sediments  
Largely permeable sediments with inter-bedded layers of lower permeability material  
Largely impermeable sediments with inter-bedded layers of higher permeability material  
Competent, but fractured bedrock (i.e. crystalline rock)  
Weathered bedrock, limestone, sandstone  

Treatment Target Zone: Saturated only  Vadose only  Both (Saturated and Vadose zones)  

Start of Thermal Test: Jul-04  
Duration: 480 day  

Hydraulic Control: Yes  No  

Treatment Cell Design:  
Size of target zone (ft²): 7200  
Thick ness of target zone (ft): 20  
Depth to top of target zone (ft bgs): 17  
Thick ness of target zone below water table (ft): 17  
Number of energy delivery points: 20  
Number of extraction points: 6  

Temperature Profile:  
Initial formation temperature (deg C): 21  
Maximum representative formation temperature (deg C): 100  
Time to reach maximum representative temperature (days): 253  
Duration of treatment at representative temperature (days):  

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
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</thead>
<tbody>
<tr>
<td>11/8/2005</td>
<td>100</td>
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</tbody>
</table>

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
Via liquid pumping:  
In vapor stream:  
Total: 24800 (1,2-DCA)  

Comments:  
22 ft spacing between thermal wells, approximately 250 to 330 watts/ft power input to each well. Treated 3,233 yd³. 

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:

___ In Soil

Comment:

General comments on the thermal application:

Target temp 100C achieved within treatment zone. No specific treatment goals established. Pilot Project Goals: 1) evaluate whether ISTD will remove the CVOCs from the saturated clay and 2) evaluate whether this removal would have an impact on CVOC concentrations in Unit A aquifer below thermal treatment zone.

Lessons Learned

1, 2 DCA groundwater concentrations in the Unit A aquifer, as measured by two monitor wells placed directly beneath thermal treatment zone, were reduced from 1,600 mg/l to 1.4 mg/l or 99.91% reduction (MW-18); and 390 mg/l to .09 mg/l or 99.98% (MW-19).

Energy

Total Energy Used: 2085.3 kWhr

kWhr/m³ kWhr/yd³

Total energy applied to treatment zone: kWhr/m³ kWhr/yd³

Other energy: kWhr/m³ kWhr/yd³

Please note other energy:

Cost

Total Project Cost:

___ Consultant Cost: ____________________

Thermal Vendor Cost: ____________________

___ Energy Cost: ____________________ m³ yd³

___ Other Cost 1: ____________________

___ Other Cost 2: ____________________

___ Other Cost 3: ____________________

Please note other cost: ___ Other Cost 1: ____________________

___ Other Cost 2: ____________________

___ Other Cost 3: ____________________
General Site Information

File Analyzed By: JT  PD

Type of treatment:  Conductive  Steam  ERH  Other:  

Type of Contaminant:  Chlorinated Solvents  Petroleum Hydrocarbons  Pesticides  Wood Treating  Other: 

Treatment Status:  Active  Post  

Type of Test:  Pilot Test  Full Scale System  

Start of Test:  

End of Test:  

Duration:  

Type of Site:  Non-DOD  DoD

Facility Name:  Operating Dry Cleaner

Address:  

City, State, Zip Code:  Carson, CA

OU# or Site #:  

Primary point of contact:  Bill Heath

Organization:  CES

Address:  419 W. Entiat St

City, State, Zip Code:  Kennewick, WA 99336

Phone #:  509-727-4276  email:  bill@cesiweb.com

Other contacts or vendors who worked on site:  

Point of contact:  James Keegan

Type:  Vendor, Consultant  Vendor, Technical Applications  Other  

Organization:  TerraVac

Address:  1211 N Barsten Way

City, State, Zip Code:  Anaheim, CA 92806

Phone #:  714-666-1974  email:  jkeegan@terravac.com

QA/QC

___ Characteristics of Interest

___ Good pre- and post-treatment groundwater data
___ Good pre- and post-treatment soil data
___ Good temperature profile vs. time information
___ Flux assessment
___ Groundwater elevations
___ Geologic cross-section
___ Hydraulic Conductivity information
## General Site Assessment Data

**Facility ID:** 0005

### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- None

### Soil Borings:
- Number of wells relative to treatment zone:
  - Pre-treatment: In: ________ Upgradient: ________ Downgradient: ________ Crossgradient: ________

### Chemicals of Concern

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
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### Comments:

________________________
________________________
________________________
________________________

### Attachments:

________________________
### Hydrogeologic Conceptual Model

#### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Characteristics</th>
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<tbody>
<tr>
<td>Vadose Zone:</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
<thead>
<tr>
<th></th>
<th>ft amsl</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

#### Aquifer Characteristics:

- Is more than 1 aquifer present? No, Yes (number): _____________ Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low value (ft bgs): _____________</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs): _____________</td>
</tr>
<tr>
<td></td>
<td>Unknown: _____________</td>
</tr>
</tbody>
</table>

- Flow direction: _____________

- Horizontal hydraulic gradient (feet/foot): _____________
- Vertical hydraulic gradient (feet/foot): _____________

- K range (ft/day):
  - Measured using: Slug Test, Laboratory, Field data
  - low: _____________
  - high: _____________

- Transmissivity (ft²/day):
  - Measured using: Slug Test, Laboratory, Field data
  - low: _____________
  - high: _____________

#### Comments:

- _____________
- _____________

#### Attachments:

- _____________
- _____________
- _____________
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  
  - Steam  
  - Steam + air  
  - Steam + O2  
  - Other (describe)  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded layers of lower permeability material  
- Largely impermeable sediments with inter-bedded lenses of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
Duration:  

Hydraulic Control  
- Yes  
- No  

Treatment Cell Design:  
- Size of target zone (ft^2):  
- Thickness of target zone (ft):  
- Depth to top of target zone (ft bgs):  
- Thickness of target zone below water table (ft):  
- Number of energy delivery points:  
- Number of extraction points:  

Temperature Profile:  
- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C):  
- Time to reach maximum representative temperature (days):  
- Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
- Via liquid pumping:  
- In vapor stream:  
- Total:  

Comments:  
Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:

___ In Soil

Comment:

General comments on the thermal application:

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

Lessons Learned

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

______________________________________________________________________________________________________

Energy

Total Energy Used: ________________________________________________ kWhr  kWhr/m$^3$  kWhr/yd$^3$

___ Total energy applied to treatment zone: ________________________ kWhr/m$^3$  kWhr/yd$^3$

___ Other energy: ________________________________________________ kWhr/m$^3$  kWhr/yd$^3$

___ Please note other energy: _____________________________________

Cost

Total Project Cost: _____________________________________________

___ Consultant Cost: ___________________________________________

___ Thermal Vendor Cost: _______________________________________

___ Energy Cost: ________________________________________________ m$^3$  yd$^3$

___ Other Cost 1: _______________________________________________

___ Other Cost 2: _______________________________________________

___ Other Cost 3: _______________________________________________

___ Please note other cost: ___ Other Cost 1: _______________________

___ Other Cost 2: _______________________________________________

___ Other Cost 3: _______________________________________________
General Site Information

File Analyzed By: JT PD ERH Date: 9/18/2006
Type of treatment: Conductive Steam ERH Other: ________________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: ________________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 3/27/1997 End of Test: 8/14/1997 Duration: 137 days
Type of Site: Non-DOD DoD

Facility Name: Defense Fuel Support Point
Address: 3171 N Gaffey St.
City, State, Zip Code: San Pedro, CA
OU# or Site #: ________________

Primary point of contact: Paul Rogers
Organization: ________________
Address: ________________
City, State, Zip Code: ________________
Phone #: 703-767-8318 email: paul.rogers@dla.mil

Other contacts or vendors who worked on site None
Point of contact: Neil Irish
Type: Vendor, Consultant Vendor, Technical Applications Other ________________
Organization: The Source Group
Address: 1962 Freeman Ave
City, State, Zip Code: Signal Hill, CA 90755
Phone #: 562-597-1055 email: nirish@thesourcegroup.net

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data
Good temperature profile vs. time information Flux assessment
Groundwater elevations Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.):
- Width (ft.): 500
- Thickness (ft.): __________

**Number inside treatment zone:** 13

**Map attachment**

**Number of relevant monitoring wells with groundwater data:**
- Pre-treatment: 
- Post-treatment: 

**Number of wells relative to treatment zone:**
- Pre-treatment: 
  - Upgradient: 4
  - Downgradient: 1
  - Crossgradient: 1
- Post-treatment: 
  - Upgradient: 4
  - Downgradient: 1
  - Crossgradient: 1

**Number of relevant soil borings with post-treatment data:**
- Upgradient: 5
- Post-treatment: 13

**Number of relevant soil borings with pre-treatment data:**
- Upgradient: 6
- Post-treatment: 0

**Number of wells outside treatment zone:**
- Upgradient: 0
- Post-treatment: 0

**Number of relevant soil borings with post-treatment data:**

**Number of relevant soil borings with pre-treatment data:**

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>0.001 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>0.001 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>0.001 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td></td>
<td>0.001 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td></td>
<td>0.001 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>JP 4</td>
<td></td>
<td></td>
<td>1 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>JP 5</td>
<td></td>
<td></td>
<td>1 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Diesel</td>
<td></td>
<td></td>
<td>1 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td>1,1,1,2-tetrachloroethane</td>
<td>TPHd</td>
<td></td>
<td></td>
<td>1 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
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<td>None</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________

**Attachments:**

**Figure 3 (impacted zone) - defined from cross-section map and borehole data**
<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Largely permeable sediments with inter-beded lenses of lower permeability</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-beded layers of higher permeability</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-beded lenses of lower permeability</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-beded layers of higher permeability</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geology:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground surface elevation based on wells in or adjacent to treatment zone: 40 ft amsl Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
</tr>
</thead>
</table>
| Is more than 1 aquifer present?  
  No | Yes (number): | Unknown (assume single aquifer) |
| Depth to water:  
  low value (ft bgs): | 24 | 25 |
| high value (ft bgs): | | |
| Unknown: | | |

<table>
<thead>
<tr>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE - E</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.008 to 0.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vertical hydraulic gradient (feet/foot):</th>
</tr>
</thead>
</table>
| Measured using:  
  Slug Test | Laboratory | Field data |
| low | | | Unknown |
| high | | | |

<table>
<thead>
<tr>
<th>K range (ft/day):</th>
</tr>
</thead>
</table>
| Measured using:  
  Slug Test | Laboratory | Field data |
| low | | | Unknown |
| high | | | |

<table>
<thead>
<tr>
<th>Transmissivity (ft²/day):</th>
</tr>
</thead>
</table>
| Measured using:  
  Slug Test | Laboratory | Field data |
| low | | | Unknown |
| high | | | |

Comments:

aquifer DTW is 11 to 31 feet regionally and regional flow is to the NW, but different in treatment area

Attachments:
Thermal Treatment - Design

Thermal treatment:  

- Conductive  
- Electrical Resistance  

- 3 phase  
- 6 phase  
- AC power  
- DC power  

Steam  

Steam + air  
Steam + O2  

Other (describe)  

Type of Test:  

- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  

- Relatively homogeneous and permeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  

- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  

3/27/1997  

Duration:  

177 days  

Hydraulic Control:  

- Yes  
- No  

Treatment Cell Design:  

Size of target zone (ft2):  

Thickness of target zone (ft):  

Depth to top of target zone (ft bgs):  

Thickness of target zone below water table (ft):  

Number of energy delivery points:  

Number of extraction points:  

Temperature Profile:  

Initial formation temperature (deg C):  

Maximum representative formation temperature (deg C):  

Time to reach maximum representative temperature (days):  

Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  

- Via liquid pumping:  
- In vapor stream:  
- Total:  

Attachments:  

Total mass was 800 gallons of Diesel, etc.  

Steam wells installed - 5

(2 not used); Recovery wells installed - 2 (1 not used)  

Said  

20 ft radius of influence and 20 ft columnar per injection well  

Comments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater:
- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater
  Comment:
- In Soil
  Comment:

General comments on the thermal application:

Target temp of 150F in vadose zone

Basis of success was from recovery data and that was only graphic showing recovery rate and cumulative recovery

Boilers only ran 10hrs/day with many at 4 hours. Total Boiler operation time of 552 hours for SI-4B and 356.5 for SI-1.

Lessons Learned

-
-
-
-
-
-  

Energy

Total Energy Used: 

- Total energy applied to treatment zone: 
- Other energy:
  Please note other energy: 

Cost

Total Project Cost:

- Consultant Cost: 
- Thermal Vendor Cost: 
- Energy Cost: 
  m^3  yd^3
- Other Cost 1: 
- Other Cost 2: 
- Other Cost 3: 
  Please note other cost: 
  Other Cost 1: 
  Other Cost 2: 
  Other Cost 3:
General Site Information

File Analyzed By: JT PD

Type of treatment:
- Conductive
- Steam
- ERH
- Other: ____________________

Type of Contaminant:
- Chlorinated Solvents
- Petroleum Hydrocarbons
- Pesticides
- Wood Treating
- Other: ____________________

Treatment Status:
- Active
- Post

Type of Test:
- Pilot Test
- Full Scale System

Start of Test: 5/28/2002
End of Test: 7/12/2002
Duration: 45 d

Type of Site:
- Non-DOD
- DoD

Facility Name: Edwards AFB
Address: ________________________________________________
City, State, Zip Code: California
OU# or Site #: Site 61, OU-8

Primary point of contact: Dr. Stephen Watts
Organization: USAF
Address: 95 ABW/CEVX 5 E. Popson Ave., Bldg. 2650a
City, State, Zip Code: Edwards AFB, CA 93524
Phone #: 661-277-1443 email: stephen.watts@edwards.af.mil

Other contacts or vendors who worked on site: None
Point of contact:
Type: Vendor, Consultant
Vendor, Technical Applications
Other
Organization: SteamTech
Address: Bakersfield CA -- no longer in business
Phone #: ____________________ email: ____________________

QA/QC

Characteristics of Interest
- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): 1025
- Width (ft.): 20
- Thickness (ft.): 60
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

Monitor Wells:
- Number of relevant monitoring wells with groundwater data: None
  - Pre-treatment: 1
  - Post-treatment: 1
  - Number of wells relative to treatment zone:
    - Pre-treatment: In: 3
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________
    - Post-treatment: In: 3
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________

Soil Borings:
- Number of relevant soil borings with pre-treatment data: 3
- Number of relevant soil borings with post-treatment data: 3
- Number inside treatment zone: 3
- Number outside treatment zone: 3

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross</td>
<td>0.005 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>0.001 mg/L</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>0.005 mg/L</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benene</td>
<td></td>
<td>0.01 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Benzene (deep)</td>
<td></td>
<td>0.005 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>TCE (deep)</td>
<td>1 mg/L</td>
<td>0.01 mg/kg</td>
<td>0.5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>PCE (deep)</td>
<td>0.01 mg/L</td>
<td>0.01 mg/kg</td>
<td>0.001 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-DCE (deep)</td>
<td>0.01 mg/L</td>
<td>0.01 mg/kg</td>
<td>0.001 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:
Avg post treatment GW concentrations for PCE, Benzene, PCE (deep), 1,1-DCE (deep), and Benzene (deep) are all listed as 0.001 mg/L but were in fact all ND. First set of data is from shallow interval, the second all listed as “deep” are from deeper interval of single groundwater zone. All deep soil were ND before treatment and Benzene and 1,1-DCE were ND before treatment.

Attachments:

_____________________________________________________________________________________________________________________________
### Hydrogeologic Conceptual Model

**Facility ID#:** 0130

#### Geology:

**Zone**

**Vadose Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

#### Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
<thead>
<tr>
<th>FT AMSL</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>2335</td>
<td></td>
</tr>
</tbody>
</table>

#### Aquifer Characteristics:

**Is more than 1 aquifer present?**

- No
- Yes (number): _____________

**Depth to water:**

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Low Value (ft bgs)</th>
<th>High Value (ft bgs)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>32</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flow direction**

- Southeast

**Horizontal hydraulic gradient (feet/foot):**

- 0.044 reported, likely much less

**Vertical hydraulic gradient (feet/foot):**

- None

**K range (ft/day):**

<table>
<thead>
<tr>
<th>Measured using</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slug Test</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Transmissivity (ft²/day):**

<table>
<thead>
<tr>
<th>Measured using</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slug Test</td>
<td>31.32</td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**S=0.007 to 0.05**

#### Attachments:

- 
- 
- 

### Vadose Zone

- Weathered bedrock, limestone, sandstone

### Saturated Zone

- Weathered bedrock, limestone, sandstone
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geology of Treatment Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Target Zone:</td>
<td>Saturated only</td>
<td>Vadose only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both (Saturated and Vadose zones)</td>
</tr>
<tr>
<td>Start of Thermal Test:</td>
<td>5/8/2003</td>
<td>Duration: 45 d</td>
</tr>
<tr>
<td>Hydraulic Control:</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Temperature Profile:</td>
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<td></td>
</tr>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>20</td>
<td>Unknown</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>100</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>44</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>1</td>
<td>Unknown</td>
</tr>
<tr>
<td>Date</td>
<td>Temperature (deg C)</td>
<td></td>
</tr>
<tr>
<td>7/12/2002</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>8/5/2002</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Mass of contaminant removed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td>&lt;1.81 lb x kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td>1234 lb x kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>1342 lb x kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Objective: Determine if steam is an effective technology to remove TCE and other COCs from fractured bedrock at Site 61. Steam was judged very effective. High capital cost of full scale system made USAF reluctant to scale up, although complete cleanup of plume could probably have been achieved in a short time making life-cycle cost favorable.

Lessons Learned:
Initial plan and funding for 30-day pilot test was insufficient for technology evaluation.

Energy:
Total Energy Used: 

Total energy applied to treatment zone: 109901 kw-hr kWh/m^3 kWh/yd^3

Other energy: 33703 ke-hr kWh/m^3 kWh/yd^3

Please note other energy: extracted water-115x10^6 BTUs (30% of injected energy) Total energy - 375x10^6 BTUs

Cost:
Total Project Cost: 525,000

Consultant Cost:
Thermal Vendor Cost:
Energy Cost: m^3 yd^3
Other Cost 1:
Other Cost 2:
Other Cost 3:
Please note other cost: Other Cost 1:
Other Cost 2:
Other Cost 3:
**General Site Information**

- **Type of treatment:**
  - Conductive
  - Steam
  - ERH
  - Other: 

- **Type of Contaminant:**
  - Chlorinated Solvents
  - Petroleum Hydrocarbons
  - Pesticides
  - Wood Treating
  - Other: 

- **Treatment Status:**
  - Active
  - Post

- **Type of Test:**
  - Pilot Test
  - Full Scale System

- **Start of Test:**

- **End of Test:**

- **Type of Site:**
  - Non-DOD
  - DoD

- **Facility Name:** Former Agricultural Products
- **Address:**
- **City, State, Zip Code:** Newark, CA

- **Primary point of contact:** Bill Heath
- **Organization:** CES
- **Address:** 419 W. Entiat St
- **City, State, Zip Code:** Kennewick, WA 99336
- **Phone #:** 509-727-4276
- **email:** bill@cesiweb.com

- **Other contacts or vendors who worked on site:** None

- **Point of contact:**
  - Type: Vendor, Consultant
  - Vendor, Technical Applications
  - Other

- **Organization:**
- **Address:**
- **City, State, Zip Code:**
- **Phone #:**
- **email:**

**QA/QC**

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
## General Site Assessment Data

### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- **Unknown**

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrahydrocarbon</td>
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<td></td>
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<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
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<tr>
<td>Ethylbenzene</td>
<td></td>
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<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
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<td></td>
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<td>None</td>
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<td>1,1,1-trichloroethene</td>
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<td>None</td>
</tr>
<tr>
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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Toluene</td>
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<td>None</td>
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<td>Benzene</td>
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<td>m/p-xylene</td>
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<td>Napthalene</td>
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<td>Hexane</td>
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<td>Jet Fuel</td>
<td></td>
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<td></td>
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<td>None</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:
- ______________________________________________________
- ______________________________________________________
- ______________________________________________________
- ______________________________________________________

### Attachments:
- ______________________________________________________
- ______________________________________________________
- ______________________________________________________
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology: Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

Aquifer Characteristics:

**Is more than 1 aquifer present?** No Yes (number): __________ Unknown (assume single aquifer)

**Depth to water:**
- low value (ft bgs): __________ __________ __________
- high value (ft bgs): __________ __________ __________
- Unknown: __________ __________ __________

**Flow direction:** __________ __________ __________

**Horizontal hydraulic gradient (feet/foot):** __________ __________ __________ __________ Unknown

**Vertical hydraulic gradient (feet/foot):** __________ __________ __________ __________ Unknown

**K range (ft/day):**
- low: __________ __________ __________ __________ Unknown
- high: __________ __________ __________ __________

**Transmissivity (ft²/day):**
- low: __________ __________ __________ __________ Unknown
- high: __________ __________ __________ __________

**Comments:**

**Attachments:**

---
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AC power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam + air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam + O2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other (describe)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>Duration:</th>
</tr>
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<tbody>
<tr>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydraulic Control</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
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<tr>
<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
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<th>Size of target zone (ft²):</th>
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<th>( _ x _ ft)</th>
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</thead>
<tbody>
<tr>
<td>thickness of target zone (ft):</td>
<td>unknown</td>
<td></td>
</tr>
<tr>
<td>depth to top of target zone (ft bg):</td>
<td>unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction delivery points:</td>
<td>unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>unknown</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
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</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Formation temperature immediately post-treatment: | |
| Formation temperature post-treatment monitoring event 1: | |
| Duration of post-treatment monitoring (days): | |

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
</tr>
<tr>
<td>In vapor stream:</td>
</tr>
<tr>
<td>Total:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Performance

**Remediation Goal:**

- **In Groundwater:**
  - Comment:

- **In Soil:**
  - Comment:

**Was the Remediation Goal Achieved:**

- **In Groundwater:**
  - Comment:

- **In Soil:**
  - Comment:

**General comments on the thermal application:**

- [Multi-line text]
- [Multi-line text]
- [Multi-line text]
- [Multi-line text]
- [Multi-line text]
- [Multi-line text]
- [Multi-line text]

### Lessons Learned

- [Multi-line text]
- [Multi-line text]
- [Multi-line text]
- [Multi-line text]
- [Multi-line text]
- [Multi-line text]
- [Multi-line text]

### Energy

**Total Energy Used:**

- **Total energy applied to treatment zone:**
  - **kWh:**
  - **kWh/m³:**
  - **kWh/yd³:**

- **Other energy:**
  - **kWh/m³:**
  - **kWh/yd³:**

**Please note other energy:**

### Cost

**Total Project Cost:**

- **Consultant Cost:**
- **Thermal Vendor Cost:**
- **Energy Cost:**
  - **m³:**
  - **yd³:**

- **Other Cost 1:**
- **Other Cost 2:**
- **Other Cost 3:**

**Please note other cost:**

- **Other Cost 1:**
- **Other Cost 2:**
- **Other Cost 3:**
General Site Information

Type of treatment: Conductive  x  Steam  ERH  __ Other: ____________
Type of Contaminant: Chlorinated Solvents  x  Petroleum Hydrocarbons  __ Pesticides
Wood Treating  __  Other: ____________
Treatment Status: Active  x  Post
Type of Test:  x  Pilot Test  __  Full Scale System
Type of Site:  x  Non-DOD  ____  DoD

Facility Name: Guadalupe
Address: ________________________________
City, State, Zip Code: Guadalupe, CA
OU# or Site #: ________________________________
Number of Contacts: 1
Primary point of contact: Paul Johnson
Organization: Arizona State University
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: 480-965-1730  email: paul.c.johnson@asu.edu
Other contacts or vendors who worked on site:  ____ None
Point of contact: ________________________________
Type:  ____ Vendor, Consultant  ____ Vendor, Technical Applications  ____ Other  ____________
Organization: ________________________________
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: ________________________________  email: ________________________________

QA/QC

Characteristics of Interest
____ Good pre- and post-treatment groundwater data
____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information
____ Flux assessment
____ Groundwater elevations
____ Geologic cross-section
____ Hydraulic Conductivity information
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): 2000
- Width (ft.): 2000
- Thickness (ft.): 15

Impacted zone as defined by documentation
Alternative method for determining size of impacted zone (See source zone definition attachments)
Map attachment

Monitor Wells:
Number of relevant monitoring wells with post-treatment data: None

Number of wells relative to treatment zone:
- Pre-treatment: 4
- Post-treatment: 4

Number of wells upstream:
- Pre-treatment: 1
- Post-treatment: 1

Number of wells downstream:
- Pre-treatment: 1
- Post-treatment: 1

Number of wells crossgradient:
- Pre-treatment: 1
- Post-treatment: 1

Number of wells outside treatment zone: 10

Number of relevant soil borings with pre-treatment data: 20
Number of relevant soil borings with post-treatment data: 20
Number inside treatment zone: 10
Number outside treatment zone: 10

Soil Borings:

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdye</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
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<td>None</td>
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<tr>
<td>1,1-dichloroethane</td>
<td>Ethybenzene</td>
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<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>p-xylene</td>
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<td>1,1,2-trichloroethane</td>
<td>TPH (leachate)</td>
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<td>10 mg/L</td>
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<td>5 mg/L</td>
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<td>1,1,2,2-tetrachloroethane</td>
<td>PAH (leachate)</td>
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<td>0.05 mg/L</td>
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<td>0.005 mg/L</td>
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<td>Vinyl Chloride</td>
<td>BTEX (leachate)</td>
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<td>0.01 mg/L</td>
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<td>0.001 mg/L</td>
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<tr>
<td></td>
<td>TPH</td>
<td></td>
<td>5 mg/L</td>
<td>None</td>
<td>5 mg/L</td>
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<tr>
<td></td>
<td>PAH</td>
<td></td>
<td>0.01 mg/L</td>
<td>None</td>
<td>0.005 mg/L</td>
</tr>
<tr>
<td></td>
<td>BTEX</td>
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<td>0.01 mg/L</td>
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<td>0.001 mg/L</td>
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<tr>
<td></td>
<td>Diluent</td>
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<td>None</td>
<td>10,000 mg/kg</td>
<td>None 10,000 mg/kg</td>
</tr>
</tbody>
</table>

Comments:

Diluent - Pre-treatment concentration was actually 100,000 mg/kg.
BTEX - Benzene, Toluene, Ethybenzene, and m-, o-, p-xylenes

Attachments:

____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
## Hydrogeologic Conceptual Model

### Geology:
- **Unconsolidated Sediments**
  - Vadose Zone: Relatively homogeneous and permeable unconsolidated sediments
  - Saturated Zone: Relatively homogeneous and permeable unconsolidated sediments

### Aquifer Characteristics:
- **Is more than 1 aquifer present?** No
- **Depth to water:**
  - Low value (ft bgs): 55
  - High value (ft bgs): 60
  - Unknown: 55
- **Flow direction:** W
- **Horizontal hydraulic gradient (feet/foot):** 0.003 to 0.004
- **Vertical hydraulic gradient (feet/foot):** Unknown
- **K range (ft/day):**
  - Low: 25
  - High: 60
  - Measured using: Slug Test, Laboratory, Field data
- **Transmissivity (ft²/day):**
  - Low: 75
  - High: 60
  - Measured using: Slug Test, Laboratory, Field data

### Ground surface elevation based on wells in or adjacent to treatment zone:
- 50 ft AMSL

### Aquifer 1
- **Aquifer 2**
- **Aquifer 3**

### Vadose Zone:
- Weathered bedrock, limestone, sandstone

### Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely impermeable sediments with inter-bedded layers of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Porosity - 0.4
### Velocity - 1 ft/day
### Thermal Treatment - Design

**Facility ID#: 0145**

<table>
<thead>
<tr>
<th><strong>Thermal treatment:</strong></th>
<th>Conductive</th>
<th>Electrical Resistance</th>
<th>3 phase</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Steam + air</td>
<td>Steam + O2</td>
</tr>
</tbody>
</table>

| **Other (describe)** |            |

| **Type of Test:** | Pilot test | Full-scale System |

<table>
<thead>
<tr>
<th><strong>Geology of Treatment Zone:</strong></th>
<th>Relatively homogeneous and permeable unconsolidated sediments</th>
<th>Relatively homogeneous and impermeable unconsolidated sediments</th>
<th>Largely permeable sediments with inter-bedded lenses of lower permeability material</th>
<th>Largely impermeable sediments with inter-bedded layers of higher permeability material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Treatment Target Zone:</strong></th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
</table>

| **Start of Thermal Test:** | 6/19/2003 | Duration: 270 d |

| **Hydraulic Control** | Yes | No |

| **Treatment Cell Design:** | Size of target zone (ft²): 4000 | Thickness of target zone (ft): 12 | Depth to top of target zone (ft bg): 50 | Thickness of target zone below water table (ft): 2 | Number of energy delivery points: 4 | Number of extraction points: 1 |

<table>
<thead>
<tr>
<th><strong>Temperature Profile:</strong></th>
<th>Initial formation temperature (deg C):</th>
<th>Unknown</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum representative formation temperature (deg C):</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Duration of treatment at representative temperature (days):</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Formation temperature immediately post-treatment:</strong></th>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Formation temperature post-treatment monitoring event 1:</strong></th>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

| **Duration of post-treatment monitoring (days):** | |

<table>
<thead>
<tr>
<th><strong>Mass of contaminant removed:</strong></th>
<th>Via liquid pumping: 23000 gallons</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In vapor stream: 1850 gallons</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Total: 24850 gallons</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### Comments:

- **Steam injection** began on 10/22/03 and ended on 3/17/04 so 145 days of steam injection. The other days included air injection. Steam injection pressure was cycled after steam breakthrough.
- Injection well spacing - 34.5 ft.

### Attachments:

- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Objective questions: 1) What is optimum design and operating conditions? 2) What are improvements to groundwater quality? 3) What will remaining be the diluent saturation and compositions? 4) What are the projected costs? 5) What are the environmental impacts?

Objective answers: 1) Target temperature of a minimum of 100°C 2) Minimum of equivalent 2 large treatment zone pore volumes of steam and no single well injecting more than 40% of cumulative steam 3) Water mass balance is established 4) Data collection to satisfy the DQO

General comments on the thermal application:

Lessons Learned

Energy

Cost
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT X PD</th>
<th>Date:</th>
<th>4/11/2005</th>
</tr>
</thead>
</table>

**Type of treatment:**
- X Conductive
- X Steam
- ERH
- Other: __________

**Type of Contaminant:**
- Chlorinated Solvents
- Petroleum Hydrocarbons
- Pesticides
- Wood Treating
- Other: __________

**Treatment Status:**
- Active
- Post

**Type of Test:**
- Pilot Test
- Full Scale System

**Start of Test:** Nov-92

**End of Test:** Dec-93

**Duration:** 21 weeks

**Type of Site:**
- Non-DOD
- DoD

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**Facility Name:** Lawrence Livermore National Laboratory (LLNL)

**Address:** ________________________________________________________________________

**City, State, Zip Code:** California

**OU# or Site #:** Gas Pad

---

**Primary point of contact:** Roger Aines

**Organization:** LLNL

**Address:** _______________________________________________________________________

**City, State, Zip Code:** Livermore, CA

**Phone #:** 925-423-7184

**email:** aines1@llnl.gov

---

**Other contacts or vendors who worked on site:** __________

**Point of contact:** __________

**Type:**
- Vendor, Consultant
- Vendor, Technical Applications
- Other
- __________

**Organization:** ____________________________________________________________________

**Address:** _______________________________________________________________________

**City, State, Zip Code:** _______________________________________________________________________

**Phone #:** _______________________________________________________________________

**email:** _______________________________________________________________________

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### QA/QC

**Characteristics of Interest**

- __________ Good pre- and post-treatment groundwater data
- __________ Good pre- and post-treatment soil data
- __________ Good temperature profile vs. time information
- __________ Flux assessment
- __________ Groundwater elevations
- __________ Geologic cross-section
- __________ Hydraulic Conductivity information
General Site Assessment Data

X Impacted Zone:
  - Length (parallel to flow direction)(ft.): ______
  - Width (ft.): ______
  - Thickness (ft.): ______
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

X Monitor Wells:
  - Number of relevant monitoring wells with groundwater data: ______
  - Pre-treatment: 14
  - Post-treatment: 12
  - Number of wells relative to treatment zone:
    - Pre-treatment: Upgradient: ______
    - Post-treatment: Upgradient: ______

X Soil Borings:
  - Number of relevant soil borings with pre-treatment data: 47
  - Number of relevant soil borings with post-treatment data: 26

X Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical: Groundwater (mg/L) Soil (mg/kg)</th>
<th>Average Post-treatment Concentration per Chemical: Groundwater (mg/L) Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossover</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>5 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td>0.1 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>Xylenes</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Xylenes</td>
<td></td>
<td>None</td>
<td>None</td>
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<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td>5 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
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<td>None</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

1,2-DCA post treatment concentration was ND. Average post treatment concentrations based on 9/1/94 analysis. Estimated spill of 6200 gallons.
### Hydrogeologic Conceptual Model

**Facility ID#: 0150**

<table>
<thead>
<tr>
<th>Geology: Unconsolidated Sediments</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
<td></td>
</tr>
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<tr>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ground surface elevation based on wells in or adjacent to treatment zone:** 640 ft amsl, Unknown

**Aquifer Characteristics:**

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>X</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth to water:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>low value (ft bgs): 100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs): 120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flow direction:** West

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0095</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**K range (ft/day):**

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>4 units with differing K</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td>see below</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Transmissivity (ft²/day):**

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Comments:**

1) high permeability channels - 2 to 143 ft/day (avg. 37.4).  
2) relatively high permeability channels - 1.74 to 133.7 ft/day (avg. 20.6).  
3) moderate permeability - 2.14 to 22.7 ft/day (avg. 15.5).  
4) low permeability - <0.67 to 2.4 ft/day (avg. 1.47).

**Attachments:**

________________________
________________________
________________________
Thermal Treatment - Design

Thermal treatment:  

Conductive  

Electrical Resistance  

3 phase  6 phase  AC power  DC power  

Steam with electrodes  

Steam  Steam + air  Steam + O2  

Other (describe)

Type of Test:  Pilot test  Full-scale System

Geology of Treatment Zone:  

Relatively homogeneous and permeable unconsolidated sediments  

Relatively homogeneous and impermeable unconsolidated sediments  

Largely permeable sediments with inter-beded lenses of lower permeability material  

Largely impermeable sediments with inter-beded layers of higher permeability material  

Competent, but fractured bedrock (i.e. crystalline rock)  

Weathered bedrock, limestone, sandstone

Treatment Target Zone:  

Saturated only  Vadose only  Both (Saturated and Vadose zones)

Start of Thermal Test:  Nov-92  Duration:  21 weeks

Hydraulic Control:  Yes  No

Treatment Cell Design:

Size of target zone (ft2):  1304  Unknown  (120 x 80 ft)

Thickness of target zone (ft):  80  Unknown

Depth to top of target zone (ft bgs):  60  Unknown

Thickness of target zone below water table (ft):  30  Unknown

Number of energy delivery points:  2  Unknown

Number of extraction points:  3  Unknown

Temperature Profile:

Initial formation temperature (deg C):  23  Unknown

Maximum representative formation temperature (deg C):  100  Unknown

Time to reach maximum representative temperature (days):  21  Unknown

Duration of treatment at representative temperature (days):  15  Unknown

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping:  1000 gal  lb  kg  Unknown

In vapor stream:  6600 gal  lb  kg  Unknown

Total:  7600 gal  lb  kg  Unknown

Comments:  

Energy delivery points: 6 injection/electric heating and 3 electric heating only. Temp of 100 deg C occurred during both steam passes. Timing: 11/92 to 7/93 then 11/93. 1st steam (continuous) 2/13/93 to 3/11/93. 2nd steam (cyclical) 6/2/93 to 6/30/93.

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater: MCLs: 1,2-DCA - 1 ug/L; xylene - 1750 ug/L; toluene - 100 ug/L; benzene - 1 ug/L.

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

ERH objective: raise clay layers 20 deg C so zone always above steam-temperatures in gravel zones; tests electrical safety; optimize heating method. Steam objective: Heat to steam temperature; optimize monitoring/control methods; evaluate treatment procedures and facility; quantify possible deleterious effects.

Lessons Learned

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_______________________________________________________
x File Analyzed By: JT PD
Type of treatment: x Conductive ___ Steam ___ ERH ___ Other: ____________
Type of Contaminant: ___ Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides
___ Wood Treating ___ Other: PCBS
Treatment Status: ___ Active x Post
Type of Test: x Pilot Test ___ Full Scale System
Start of Test: 10/11/1997 End of Test: 11/17/1997 Duration: 37 days
Type of Site: ___ Non-DOD x DoD

x Facility Name: Mare Island Naval Shipyard
Address: Building 866, junction of Suisun Avenue and Mesa Road
City, State, Zip Code: Vallejo, CA
OU# or Site #: Site 11

x Primary point of contact: Ralph Baker
Organization: TerraTherm
Address: 10 Stevens Rd.
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: tbaker@terratherm.com

x Other contacts or vendors who worked on site ___ None
Point of contact: Richard Faris
Type: ___ Vendor, Consultant ___ Vendor, Technical Applications x Other client
Organization: EFA West, NAVFAC (U.S. Navy)
Address: 900 Commodore Drive, Code 182
City, State, Zip Code: San Bruno, CA 94066
Phone #: 650-244-22704 email: jrfaris@efawest.navfac.navy.mil

QA/QC

x Characteristics of Interest
___ Good pre- and post-treatment groundwater data x Good pre- and post-treatment soil data
x Good temperature profile vs. time information ___ Flux assessment
___ Groundwater elevations ___ Geologic cross-section
___ Hydraulic Conductivity information
### General Site Assessment Data

<table>
<thead>
<tr>
<th>Impact Zone</th>
<th>Length (parallel to flow direction)(ft.)</th>
<th>Width (ft.)</th>
<th>Thickness (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unknown</td>
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</tr>
</tbody>
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- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

<table>
<thead>
<tr>
<th>Monitor Wells</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
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- None

<table>
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<tr>
<th>Soil Borings</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
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- 4 composite
- None

<table>
<thead>
<tr>
<th>Soil Borings</th>
<th>Number of relevant soil borings with post-treatment data:</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
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<tr>
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- 4 composite
- None

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
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<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
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</tbody>
</table>

**Comments:**

Samples are composite samples at 0-1 ft, 4-5 ft, 8-9 ft and 11-12 ft

**Attachments:**

- None
Hydrogeologic Conceptual Model

Geology:

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: 26 ft amsl

Aquifer Characteristics:

Is more than 1 aquifer present? No Yes (number): x Unknown (assume single aquifer)

Depth to water:
- Low value (ft bgs): 0
- High value (ft bgs): 15
- Unknown:

Flow direction: E

Horizontal hydraulic gradient (feet/foot):
- Measured using: Slug Test Laboratory Field data
  - Low: 1(10^-5) cm/sec
  - High: Unknown

Vertical hydraulic gradient (feet/foot):
- Measured using: Slug Test Laboratory Field data
  - Low: Unknown
  - High: Unknown

K range (ft/day):
- Measured using: Slug Test Laboratory Field data
  - Low: 1(10^-5) cm/sec
  - High: Unknown

Transmissivity (ft^2/day):
- Measured using: Slug Test Laboratory Field data
  - Low: Unknown
  - High: Unknown

Comments:

n~30%; moisture ~20%

Attachments:
**Thermal Treatment - Design**

**Thermal treatment:**
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
  - Steam
  - Steam + air
  - Steam + O2
- Other (describe)

**Type of Test:**
- Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone
- Both (Saturated and Vadose zones)

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:** 10/11/1997

**Hydraulic Control**
- Yes
- No

**Treatment Cell Design:**
- Size of target zone (ft2): 323
- Thickness of target zone (ft): 14
- Depth to top of target zone (ft bgs): 0.5
- Thickness of target zone below water table (ft): 0
- Number of energy delivery points: 12
- Number of extraction points: 12

**Temperature Profile:**
- Initial formation temperature (deg C): 49
- Maximum representative formation temperature (deg C): 410
- Time to reach maximum representative temperature (days): 35
- Duration of treatment at representative temperature (days): 323

**Mass of contaminant removed:**
- Via liquid pumping: __________ lb __________ kg Unknown
- In vapor stream: __________ lb __________ kg Unknown
- Total: __________ lb __________ kg Unknown

**Comments:**

**Attachments:**

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

- In Groundwater:

- In Soil:
  - PCBs > 2mg/kg by EPA regulations, but site specific at less than 1 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater:
  - Comment:

- In Soil:
  - Comment:

  yes all samples were below 10 ug/kg

General comments on the thermal application:


Lessons Learned


Energy

Total Energy Used: __________ kWh __________ kWh/m³ __________ kWh/yd³

- Total energy applied to treatment zone: __________ kWh/m³ __________ kWh/yd³

- Other energy: __________ kWh/m³ __________ kWh/yd³

  Please note other energy: ________________________________________________________

Cost

Total Project Cost:

- Consultant Cost: __________
- Thermal Vendor Cost: __________
- Energy Cost: __________ m³ __________ yd³
- Other Cost 1: __________
- Other Cost 2: __________
- Other Cost 3: __________

  Please note other cost: __________ Other Cost 1: __________

  Other Cost 2: __________

  Other Cost 3: __________
General Site Information

X File Analyzed By: JT PD ______ Date: ______
Type of treatment: ______ Conductive X Steam ______ ERH ______ Other: ______
Type of Contaminant: ______ Chlorinated Solvents X Petroleum Hydrocarbons ______ Pesticides ______ Wood Treating ______ Other: ______
Treatment Status: ______ Active X Post ______
Type of Test: ______ Pilot Test ______ Full Scale System ______
Start of Test: 5/14/1999 End of Test: 7/24/1999 Duration: 70 d
Type of Site: ______ Non-DOD X DoD ______

X Facility Name: NAS Alameda Point Site 5 Steam Pilot
Address: ____________________________________________
City, State, Zip Code: Alameda, CA
OU# or Site #: Site 5

X Primary point of contact: Steven Peck
Organization: Navy
Address: 1455 Frazee Rd., Ste. 900
City, State, Zip Code: San Diego, CA 92108
Phone #: 619-532-0756 email: steven.peck@navy.mil

___ Other contacts or vendors who worked on site: ______ None
Point of contact: ____________________________________________
Type: ______ Vendor, Consultant ______ Vendor, Technical Applications ______ Other ______
Organization: ____________________________________________
Address: ____________________________________________
City, State, Zip Code: ____________________________________________
Phone #: ____________________________________________ email: ____________________________________________

QA/QC

___ Characteristics of Interest
____ Good pre- and post-treatment groundwater data  ____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information  ____ Flux assessment
____ Groundwater elevations  ____ Geologic cross-section
____ Hydraulic Conductivity information
Impacted Zone:

- Length (parallel to flow direction)(ft.): 55
- Width (ft): 75
- Thickness (ft): Unknown

Impact zone as defined by documentation

- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

Monitor Wells:

- Number of relevant monitoring wells with groundwater data: None
- Number of wells relative to treatment zone: 42

Pre-treatment:
- Number of relevant monitoring wells with groundwater data: None
- Number of wells relative to treatment zone: 42

Post-treatment:
- Number of relevant monitoring wells with groundwater data: None
- Number of wells relative to treatment zone: 42

Soil Borings:

- Number of relevant soil borings with pre-treatment data: 9
- Number of relevant soil borings with post-treatment data: 9

Types of Contaminants:

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
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<td>Trichloroethene</td>
<td>Benzene</td>
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<td>None</td>
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<tr>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>50 mg/L, None</td>
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<td>10 mg/L, None</td>
<td>0.05 mg/L, 0.01 mg/kg</td>
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<tr>
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<td>cis-1,2-dichloroethene</td>
<td>Trichloroethene - 130</td>
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<td>0.1 mg/L, None</td>
<td>0.05 mg/L, 0.01 mg/kg</td>
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<td>0.05 mg/L, 0.01 mg/kg</td>
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<td>Ethylbenzene</td>
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<td>1,1, TCA - 78</td>
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Comments:

Chemicals of interest: Trichloroethene (TCE), Tetrachloroethene (PCE), 1,1-Trichloroethane (1,1 TCA), 1,1-Dichloroethane (1,1 DCA), cis 1,2-Dichloroethane (cis 1,2 DCA), Trimethylbenzene (TMB), and Naphthalene (Naph). All average post treatment soils concentrations were 0.005 mg/kg but were listed as 0.01 mg/kg due spreadsheet constraints.

Attachments:
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
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<td>Jet Fuel</td>
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### Comments:

Chemicals of interest: Trichloroethene (TCE), Tetrachloroethene (PCE), 1,1-Trichloroethene (1,1 TCA), 1,1-Dichloroethene (1,1 DCA), cis 1,2-Dichloroethane (cis 1,2 DCA), Trimethylbenzene (TMB), and Naphthalene (Naph). All average post treatment soils concentrations were 0.005 mg/kg but were listed as 0.01 mg/kg due spreadsheet constraints.
### Hydrogeologic Conceptual Model

#### Facility ID#:

0180

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<tbody>
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<td>Vadose Zone:</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
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<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: 0 ft amsl   Unknown

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): _____________
  - Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
<th>Flow direction</th>
<th>Horizontal hydraulic gradient (feet/foot):</th>
<th>Vertical hydraulic gradient (feet/foot):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low value (ft bgs):</td>
<td></td>
<td>0.004 to 0.006</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction**
  - Northeast

- **Horizontal hydraulic gradient (feet/foot):** 0.004 to 0.006
  - _____________
  - _____________
  - _____________
  - _____________
  - Unknown

- **Vertical hydraulic gradient (feet/foot):**
  - _____________
  - _____________
  - _____________
  - _____________
  - Unknown

- **K range (ft/day):**
  - Measured using: Slug Test, Laboratory, Field data
  - low: 0.737
  - high: 4.819

- **Transmissivity (ft²/day):**
  - Measured using: Slug Test, Laboratory, Field data
  - low: 158.4
  - high: _____________

**Comments:**

- n=30%

**Attachments:**

---------------------------------------------
---------------------------------------------
---------------------------------------------
---------------------------------------------
---------------------------------------------
---------------------------------------------
---------------------------------------------
---------------------------------------------
---------------------------------------------
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID#: 0180</th>
</tr>
</thead>
<tbody>
<tr>
<td>☒ Thermal treatment:</td>
<td></td>
</tr>
<tr>
<td>☒ Conductive</td>
<td></td>
</tr>
<tr>
<td>☒ Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td>☒ 3 phase</td>
<td>☒ 6 phase</td>
</tr>
<tr>
<td>☒ AC power</td>
<td>☒ DC power</td>
</tr>
<tr>
<td>☒ Steam</td>
<td></td>
</tr>
<tr>
<td>☒ Steam + air</td>
<td>☒ Steam + O2</td>
</tr>
<tr>
<td>☒ Other (describe)</td>
<td></td>
</tr>
<tr>
<td>☒ Type of Test:</td>
<td>Pilot test</td>
</tr>
<tr>
<td>☒ Full-scale System</td>
<td></td>
</tr>
<tr>
<td>☒ Geology of Treatment Zone:</td>
<td></td>
</tr>
<tr>
<td>☒ Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td>☒ Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td>☒ Largely permeable sediments with inter-bedded layers of lower permeability material</td>
<td></td>
</tr>
<tr>
<td>☒ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td>☒ Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td>☒ Weatherbedrock, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td>☒ Treatment Target Zone:</td>
<td>☒ Saturated only</td>
</tr>
<tr>
<td>☒ Vadose only</td>
<td>☒ Both (Saturated and Vadose zones)</td>
</tr>
<tr>
<td>☒ Start of Thermal Test:</td>
<td>5/14/1999</td>
</tr>
<tr>
<td>☒ Duration:</td>
<td>70 d</td>
</tr>
<tr>
<td>☒ Hydraulic Control</td>
<td>☒ Yes</td>
</tr>
<tr>
<td></td>
<td>☒ No</td>
</tr>
<tr>
<td>☒ Treatment Cell Design:</td>
<td></td>
</tr>
<tr>
<td>Size of target zone (ft2):</td>
<td>7500</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>10</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>0</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>12</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>12</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>3</td>
</tr>
<tr>
<td>☒ Temperature Profile:</td>
<td></td>
</tr>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>20</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>90</td>
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<tr>
<td>Time to reach maximum representative temperature (days):</td>
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<td>Duration of treatment at representative temperature (days):</td>
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<tr>
<td>☒ Date</td>
<td></td>
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<tr>
<td>☒ Temperature (deg C)</td>
<td></td>
</tr>
<tr>
<td>Formation temperature immediately post-treatment:</td>
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<td>Formation temperature post-treatment monitoring event 1:</td>
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</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
</tr>
<tr>
<td>☒ Mass of contaminant removed:</td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td></td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>1943 lb</td>
</tr>
<tr>
<td></td>
<td>x kg</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>☒ Comments:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>☒ Attachments:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Objective: Determine if steam is a cost effective in-situ remedial technology to remove chlorinated hydrocarbon in the identified NAPL zone.

Lessons Learned

<table>
<thead>
<tr>
<th>Energy</th>
<th>Total Energy Used:</th>
<th>kWh</th>
<th>kWh/m³</th>
<th>kWh/yd³</th>
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<tr>
<td></td>
<td>Total energy applied to treatment zone:</td>
<td>820,000 kw-hr</td>
<td>kWh/m³</td>
<td>kWh/yd³</td>
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<tr>
<td></td>
<td>Please note other energy:</td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Cost</th>
<th>Total Project Cost:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Consultant Cost:</td>
</tr>
<tr>
<td></td>
<td>Thermal Vendor Cost:</td>
</tr>
<tr>
<td></td>
<td>Energy Cost:</td>
</tr>
<tr>
<td></td>
<td>Other Cost 1:</td>
</tr>
<tr>
<td></td>
<td>Other Cost 2:</td>
</tr>
<tr>
<td></td>
<td>Other Cost 3:</td>
</tr>
<tr>
<td></td>
<td>Please note other cost:</td>
</tr>
</tbody>
</table>
General Site Information

File Analyzed By: JT PD ERH

Type of treatment: Conductive Steam ERH Other: __________

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: __________

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System


Type of Site: Non-DOD DoD

Facility Name: NAS Lemoore

City, State, Zip Code: Lemoore, CA

OU# or Site #: Site 17

Primary point of contact: Kent Udell

Organization: University of Utah

Address: 50 S Central Campus Dr. RM 2110 MEB

City, State, Zip Code: Salt Lake City, UT 84112

Phone #: 801-581-7934 email: udell@eng.utah.edu

Other contacts or vendors who worked on site: None

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information

Date: 11/3/2006
### General Site Assessment Data

**Facility ID:** 0190

<table>
<thead>
<tr>
<th>Impacted Zone</th>
<th>Length (parallel to flow direction)(ft.): 700</th>
<th>Width (ft):</th>
<th>Thickness (ft):</th>
<th>Unknown</th>
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<tbody>
<tr>
<td></td>
<td>Impacted zone as defined by documentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alternative method for determining size of impacted zone (See source zone definition attachments)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Map attachment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Monitor Wells

- Number of relevant monitoring wells with groundwater data: None
  - Pre-treatment: 1
  - Post-treatment: 1
  - Number of relevant monitoring wells with post-treatment data:
    - In: ______
    - Upgradient: ______
    - Downgradient: ______
    - Crossgradient: ______
  - Number of wells relative to treatment zone:
    - Pre-treatment: In: ______
      - Upgradient: ______
      - Downgradient: ______
      - Crossgradient: ______
    - Post-treatment: In: ______
      - Upgradient: ______
      - Downgradient: ______
      - Crossgradient: ______

#### Soil Borings

- Number of relevant soil borings with pre-treatment data: 4
  - Number of relevant soil borings with post-treatment data:
    - In: ______
    - Upgradient: ______
    - Downgradient: ______
    - Crossgradient: ______
  - Number inside treatment zone: ______
  - Number outside treatment zone: ______

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
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<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
<td>None</td>
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<tr>
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<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td></td>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
<td>JP-5</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethene</td>
<td>JP-5</td>
<td></td>
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<td>None</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- [Additional comments here]

**Attachments:**

- [Additional attachments here]
## Hydrogeologic Conceptual Model

### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- **Ground surface elevation based on wells in or adjacent to treatment zone:**
  - ft amsl
  - Unknown

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction**
  -   

- **Horizontal hydraulic gradient (feet/foot):**
  - Unknown

- **Vertical hydraulic gradient (feet/foot):**
  - Unknown

- **K range (ft/day)**
  - Measured using: Slug Test, Laboratory, Field data
  - Low: Unknown
  - High: 

- **Transmissivity (ft²/day):**
  - Measured using: Slug Test, Laboratory, Field data
  - Low: Unknown
  - High: 

### Comments:

- Shallow sandy silt permeability - 4e-12 m²
- Deeper sandy silt permeability - 14e-12 m²

### Attachments:

- [List of attachments]
- [Additional comments or data]
- [Additional information]
- [Contact information]
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance

- 3 phase  
- 6 phase  
- AC power  
- DC power

Steam  
- Steam  
- Steam + air  
- Steam + O2

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 7/5/1994  
- Duration:  80 days

Hydraulic Control  
- Yes  
- No

Treatment Cell Design:

Size of target zone (ft²):  48125  
- Unknown  
- ( 275 x 175 ft)

Thickness of target zone (ft):  20  
- Unknown

Depth to top of target zone (ft bgs):  5  
- Unknown

Thickness of target zone below water table (ft):  9  
- Unknown

Number of energy delivery points:  2  
- Unknown

Number of extraction points:  2  
- Unknown

Temperature Profile:

Initial formation temperature (deg C):  25  
- Unknown

Maximum representative formation temperature (deg C):  100  
- Unknown

Time to reach maximum representative temperature (days):  10  
- Unknown

Duration of treatment at representative temperature (days):  70  
- Unknown

Date  
- Temperature (deg C)

- 98

Formation temperature post-treatment monitoring event 1:  10/3/1994  
- 74

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

- Via liquid pumping:  75300 gal  
  - lb  
  - kg  
  - Unknown

- In vapor stream:  3179 gal  
  - lb  
  - kg  
  - Unknown

Total:  78479 gal  
- lb  
- kg  
- Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Performance

#### Remediation Goal:

- In Groundwater: ____________________________________________
  - Comment: ________________________________________________

- In Soil: ____________________________________________________
  - Comment: ________________________________________________

#### Was the Remediation Goal Achieved:

- In Groundwater: ____________________________________________
  - Comment: ________________________________________________

- In Soil: ____________________________________________________
  - Comment: ________________________________________________

**General comments on the thermal application:**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

**Lessons Learned**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

### Energy

#### Total Energy Used:

- __kWhr__ __kWhr/m³__ __kWhr/yd³__
- __Total energy applied to treatment zone:__ __kWhr/m³__ __kWhr/yd³__
- __Other energy:__ __kWhr/m³__ __kWhr/yd³__

Please note other energy: ________________________________________________

### Cost

#### Total Project Cost:

- __Consultant Cost:__ ____________________________________________
- __Thermal Vendor Cost:__ ________________________________________
- __Energy Cost:__ _____________________________________________
  - __m³__ __yd³__
- __Other Cost 1:__ _____________________________________________
- __Other Cost 2:__ _____________________________________________
- __Other Cost 3:__ _____________________________________________

Please note other cost: __Other Cost 1:__ ____________________________

__Other Cost 2:__ _____________________________________________

__Other Cost 3:__ _____________________________________________
General Site Information

Facility Name: NAS Alameda Point Site 5 ERH Pilot

Address: 1455 Frazee Rd., Ste. 900
City, State, Zip Code: Alameda, CA 92108

Phone #: 619-532-0786, email: steven.peck@navy.mil

Primary point of contact: Steven Peck
Organization: Navy

Secondary point of contact: John McGuire
Type: Vendor, Consultant
Organization: Shaw

Other contacts or vendors who worked on site: None

Type of treatment: Conductive, Steam, ERH Other: __________

Type of Contaminant: Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides
Wood Treating, Other: __________

Treatment Status: Active, Post

Type of Test: Pilot Test, Full Scale System

Duration: 197 d

Type of Site: Non-DOD, DoD

QA/QC

Characteristics of Interest:
- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
## General Site Assessment Data

### Impacted Zone:
- Length (parallel to flow direction)(ft.): 230
- Width (ft.): 150
- Thickness (ft.): 20

  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

### Monitor Wells:
- Number of wells relative to treatment zone:
  - Pre-treatment: 15
  - Post-treatment: 15

  - Number of relevant monitoring wells with groundwater data:
    - Pre-treatment: Unknown
    - Post-treatment: None

  - Number inside treatment zone: 15
  - Number outside treatment zone: None

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: 6
- Number of relevant soil borings with post-treatment data: 6
- Number inside treatment zone: 6
- Number outside treatment zone: 6

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
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<td>Tetrachloroethene</td>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>0.5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>0.05 mg/L</td>
<td>None</td>
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<tr>
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<td>1,1-dichloroethane</td>
<td>Ethylene</td>
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<td>5 mg/L</td>
<td>5 mg/L</td>
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<td>m/p-xylene</td>
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<td>0.05 mg/L</td>
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<tr>
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<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>0.05 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

- Chlorinated Solvents
- Petroleum Hydrocarbons
- Other

### Comments:

Attached sheet in file shows average concentrations for pre- and post-treatment at shallow, intermediate, and deep intervals. Only concentrations from shallow interval are shown in table. Pilot was within the source zone.

### Attachments:

- None
**Hydrogeologic Conceptual Model**

**Unconsolidated Sediments**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Vadose Zone:</th>
<th>Saturated Zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td>Largely permeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

**Geology:**

- Weathered bedrock, limestone, sandstone
- Competent, but fractured bedrock (i.e. crystalline rock)
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments

**Ground surface elevation based on wells in or adjacent to treatment zone:** 10 ft amsl

**Aquifer Characteristics:**

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Aquifer 1</td>
<td>Aquifer 2</td>
</tr>
<tr>
<td>Depth to water:</td>
<td>low value (ft bgs): 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs): 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flow direction:** North to northeast

**Horizontal hydraulic gradient (feet/foot):** 0.004 to 0.006

**Vertical hydraulic gradient (feet/foot):**

<table>
<thead>
<tr>
<th></th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**K range (ft/day):**

<table>
<thead>
<tr>
<th></th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Transmissivity (ft²/day):**

<table>
<thead>
<tr>
<th></th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**S=0.007**

**Facility ID#: 0200**

**Comments:**

**Attachments:**

- Additional data and information related to the hydrogeologic model.
**Thermal Treatment - Design**

**Facility ID#: 0200**

### Thermal treatment:
- **Conductive** 8
- **Electrical Resistance**
  - 3 phase
  - 6 phase
  - AC power
  - DC power
- **Steam**
  - Steam
  - Steam + air
  - Steam + O2
- **Other (describe)**

### Type of Test:
- **Pilot test**
- **Full-scale System**

### Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

### Start of Thermal Test:
- 6/21/2002
- Duration: 197 d

### Hydraulic Control:
- Yes
- No

### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>1520</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>30</td>
<td>Unknown</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>0</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>3</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>12</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>16</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### Temperature Profile:

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th>25</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>100</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>169</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>28</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### Date | Temperature (deg C)
--- | ---
--- | ---
--- | ---

| Formation temperature immediately post-treatment: | | |
| Formation temperature post-treatment monitoring event 1: | | |
| Duration of post-treatment monitoring (days): | | |

### Mass of contaminant removed:

- Via liquid pumping: ___________ lb ___________ kg
- In vapor stream: ___________ lb ___________ kg
- Total: 81 X ___________ lb ___________ kg

### Comments:

- Electrode spacing - 20 ft. Vapor extraction well spacing - 15 ft.

### Attachments:

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Performance

Remediation Goal:

- In Groundwater: 10,000 ug/L for contaminant.

- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater

- In Soil

Comment:

______________________
______________________
______________________
______________________
______________________
______________________
______________________

General comments on the thermal application:

Determine variability of SPH at site 5 and generate design parameters for full-scale treatment. On July 25, 2002, double-wye 3-phase power configuration was rewired to a true 6-phase configuration.

Lessons Learned

Double-wye 3-phase configuration on electrodes cause power application to go awry.

Energy

Total Energy Used: _____________________ kWhr __________________ kWhr/m³ __________________ kWhr/yd³

- Total energy applied to treatment zone: 428874 kw hour __________________ kWhr/m³ __________________ kWhr/yd³

- Other energy: __________________ kWhr/m³ __________________ kWhr/yd³

- Other cost: __________________ kWhr/m³ __________________ kWhr/yd³

Cost

Total Project Cost: ____________________

- Consultant Cost: ____________________

- Thermal Vendor Cost: ____________________

- Energy Cost: ____________________ m³ __________________ yd³

- Other Cost 1: ____________________

- Other Cost 2: ____________________

- Other Cost 3: ____________________

- Other cost: ____________________

- Other cost 1: ____________________

- Other cost 2: ____________________

- Other cost 3: ____________________
General Site Information

File Analyzed By: JT PD X Date: 11/6/2006

Type of treatment: X Conductive X Steam ERH Other: ____________

Type of Contaminant: X Chlorinated Solvents X Petroleum Hydrocarbons X Pesticides

Treatment Status: X Active X Post

Type of Test: X Pilot Test X Full Scale System


Type of Site: X Non-DOD X DoD

Facility Name: NAS Alameda Point Full Scale

City, State, Zip Code: Alameda, CA

OU# or Site #: Site 5, Plume 5-1

Primary point of contact: Steven Peck

Organization: Navy

Address: 1455 Frazee Rd., Ste. 900

City, State, Zip Code: San Diego, CA 92108

Phone #: 619-532-0786 email: steven.peck@navy.mil

Other contacts or vendors who worked on site: X None

Point of contact: John McGuire

Type: X Vendor, Consultant X Vendor, Technical Applications X Other ____________

Organization: Shaw

Address: ______________

City, State, Zip Code: ______________

Phone #: 925-288-2220 email: john.mcguire@shawgrp.com

QA/QC

Characteristics of Interest

X Good pre- and post-treatment groundwater data

X Good pre- and post-treatment soil data

X Good temperature profile vs. time information

X Flux assessment

X Groundwater elevations

X Geologic cross-section

X Hydraulic Conductivity information
General Site Assessment Data - Page 1

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: ___
  - Pre-treatment: __________
  - Post-treatment: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: ___
  - Uppgradient: ___
  - Downgradient: ___
  - Crossgradient: ___
  - Post-treatment: ___
  - Uppgradient: ___
  - Downgradient: ___
  - Crossgradient: ___

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: ___
- Number of relevant soil borings with post-treatment data: ___
- Number inside treatment zone: ___
- Number outside treatment zone: ___

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>X</td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>X</td>
<td></td>
<td></td>
<td>0.05 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>X</td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>X</td>
<td></td>
<td></td>
<td>0.05 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>X</td>
<td></td>
<td></td>
<td>0.05 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>X</td>
<td></td>
<td></td>
<td>0.05 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>X</td>
<td></td>
<td></td>
<td>0.05 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td>X</td>
<td></td>
<td></td>
<td>0.05 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>X</td>
<td></td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
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<td></td>
<td></td>
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<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>1,1,1-trichloroethene</td>
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<td></td>
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</tr>
<tr>
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<td>None</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

Attachments:
General Site Assessment Data - Page 2

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 230
- Width (ft.): 130
- Thickness (ft.): 20
- Impacted zone as defined by documentation: Unknown
- Alternative method for determining size of impacted zone (See source zone definition attachments): Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: None
- Number of wells relative to treatment zone:
  - Pre-treatment: 17
  - Post-treatment: 17
  - In: 17
  - Upgradient: None
  - Downgradient: None
  - Crossgradient: None

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: None
- Number of relevant soil borings with post-treatment data: None
- Number inside treatment zone: None
- Number outside treatment zone: None

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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</tr>
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<td>Trichloroethene</td>
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<tr>
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<tr>
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</tr>
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<td>1,2-dichloroethene</td>
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<tr>
<td>Vinyl Chloride</td>
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**Comments:**

- None

**Attachments:**

- None
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone: Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Saturated Zone: Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
</tbody>
</table>

- **X** Ground surface elevation based on wells in or adjacent to treatment zone: 10 ft amsl Unknown

- **X** Aquifer Characteristics:
  - Is more than 1 aquifer present? No Yes (number): X Unknown (assume single aquifer)
  - Depth to water:
    - low value (ft bgs): 507
    - high value (ft bgs):  
    - Unknown:  
  - Flow direction: N to NE
  - Horizontal hydraulic gradient (feet/foot): 0.004 to 0.006 Unknown
  - Vertical hydraulic gradient (feet/foot): Unknown
  - K range (ft/day):
    - Measured using: Slug Test Laboratory Field data
    - low 0.737  
    - Unknown  
    - high 4.819  
  - Transmissivity (ft²/day):
    - Measured using: Slug Test Laboratory Field data
    - low 158.4  
    - Unknown  
    - high  

- S=0.007

Attachments: 

- 
- 
- 
- 
-
### Thermal Treatment - Design

**Facility ID#:** 0215

<table>
<thead>
<tr>
<th><strong>Thermal treatment:</strong></th>
<th>____ Conductive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrical Resistance:</strong></td>
<td><strong>Steam</strong></td>
</tr>
<tr>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td>____ AC power</td>
<td>____ DC power</td>
</tr>
<tr>
<td><strong>Steam</strong></td>
<td><strong>Steam + air</strong></td>
</tr>
<tr>
<td>____ Steam</td>
<td>____ Steam + O2</td>
</tr>
<tr>
<td>____ Other (describe)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Type of Test:</strong></th>
<th>____ Pilot test</th>
<th><strong>Full-scale System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geology of Treatment Zone:</strong></td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Treatment Target Zone:</strong></th>
<th>____ Saturated only</th>
<th>____ Vadose only</th>
<th>____ Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Start of Thermal Test:</strong></td>
<td>7/8/2004</td>
<td><strong>Duration:</strong> 120 d</td>
<td></td>
</tr>
<tr>
<td><strong>Hydraulic Control</strong></td>
<td>____ Yes</td>
<td>____ No</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th><strong>Treatment Cell Design:</strong></th>
<th>____ No</th>
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</thead>
<tbody>
<tr>
<td><strong>Size of target zone (ft2):</strong></td>
<td>14520</td>
</tr>
<tr>
<td><strong>Thickness of target zone (ft):</strong></td>
<td>90</td>
</tr>
<tr>
<td><strong>Depth to top of target zone (ft bgs):</strong></td>
<td>0</td>
</tr>
<tr>
<td><strong>Thickness of target zone below water table (ft):</strong></td>
<td>13</td>
</tr>
<tr>
<td><strong>Number of energy delivery points:</strong></td>
<td>30 electrodes *</td>
</tr>
<tr>
<td><strong>Number of extraction points:</strong></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Temperature Profile:</strong></th>
<th>____ Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial formation temperature (deg C):</strong></td>
<td>220</td>
</tr>
<tr>
<td><strong>Maximum representative formation temperature (deg C):</strong></td>
<td>92</td>
</tr>
<tr>
<td><strong>Time to reach maximum representative temperature (days):</strong></td>
<td>90</td>
</tr>
<tr>
<td><strong>Duration of treatment at representative temperature (days):</strong></td>
<td>30</td>
</tr>
</tbody>
</table>

| **Formation temperature immediately post-treatment:** | **Unknown** |
| **Formation temperature post-treatment monitoring event 1:** | **Unknown** |
| **Duration of post-treatment monitoring (days):** | **Unknown** |

<table>
<thead>
<tr>
<th><strong>Mass of contaminant removed:</strong></th>
<th>____ Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Via liquid pumping:</strong></td>
<td>9.18 lb</td>
</tr>
<tr>
<td><strong>In vapor stream:</strong></td>
<td>3011.28 lb</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>3011.46 lb</td>
</tr>
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<table>
<thead>
<tr>
<th><strong>Comments:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>* 30 electrodes each with 4 sheet piles.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Attachments:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachments.</td>
</tr>
</tbody>
</table>

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

- In Groundwater:
  - Total concentrations of the COCs below 10,000 ppb.
- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment: yes
- In Soil
  - Comment:

General comments on the thermal application:

- Target temp of 92 deg C

Lessons Learned

- 
- 
- 
- 

Energy

Total Energy Used:

- Total energy applied to treatment zone: 1455923 kw-hr
- Other energy:
  - Please note other energy:

- 

Cost

Total Project Cost:

- Consultant Cost:
- Thermal Vendor Cost:
- Energy Cost:
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:

- Please note other cost:

- Other Cost 1:
- Other Cost 2:
- Other Cost 3:
Facility Name: NAS Alameda

Primary point of contact: John McGuire
Organization: Shaw

Other contacts or vendors who worked on site: None
Point of contact: Steven Peck
Type: Vendor, Consultant Vendor, Technical Applications Other

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### Impacted Zone
- Length (parallel to flow direction): 
- Width (ft): 
- Thickness (ft): 

### Monitor Wells
- Number of relevant monitoring wells with groundwater data: None

### Soil Borings
- Number of relevant soil borings with pre-treatment data: 
- Number of relevant soil borings with post-treatment data: 

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Cross</td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td>None None None None None</td>
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<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Naphthalene</td>
<td></td>
<td>None None None None None</td>
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<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
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<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None None None None None</td>
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<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td></td>
<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
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<td>None None None None None</td>
<td>None None None None None</td>
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<td>o-xylene</td>
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<td>Vinyl Chloride</td>
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### Comments:

### Attachments:
### Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Ground surface elevation based on wells in or adjacent to treatment zone: | Unknown |

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>Yes (number):</td>
</tr>
<tr>
<td>Depth to water:</td>
<td>Aquifer 1</td>
</tr>
<tr>
<td>low value (ft bgm):</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgm):</td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

| Horizontal hydraulic gradient (feet/foot): | Unknown |
| Vertical hydraulic gradient (feet/foot): | Unknown |

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Transmissivity (ft²/day):</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
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Comments:________________________________________________________________________

Attachments:______________________________________________________________________
<table>
<thead>
<tr>
<th>Thermal Treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
<th>3 phase</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
<th>Steam</th>
<th>Steam + air</th>
<th>Steam + O2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Test:</td>
<td>Pilot test</td>
<td>Full-scale System</td>
<td></td>
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<tr>
<td>Geology of Treatment Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Target Zone:</td>
<td>Saturated only</td>
<td>Vadose only</td>
<td>Both (Saturated and Vadose zones)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Start of Thermal Test:</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hydraulic Control:</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
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<tr>
<td>Size of target zone (ft²):</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Temperature Profile:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial formation temperature (deg C):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Time to reach maximum representative temperature (days):</td>
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<tr>
<td>Duration of treatment at representative temperature (days):</td>
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<tr>
<td>Formation temperature immediately post-treatment:</td>
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<td></td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mass of contaminant removed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>In vapor stream:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

  In Groundwater:

  In Soil:

Was the Remediation Goal Achieved:

  In Groundwater:

    Comment:

  In Soil:

    Comment:

General comments on the thermal application:


Lessons Learned


Energy

Total Energy Used:

  Total energy applied to treatment zone: ___ kWhr/m³ ___ kWhr/yd³

  Other energy: ___ kWhr/m³ ___ kWhr/yd³

  Please note other energy:

Cost

Total Project Cost:

  Consultant Cost: ___ m³ ___ yd³

  Thermal Vendor Cost:

  Energy Cost:

  Other Cost 1:

  Other Cost 2:

  Other Cost 3:

  Please note other cost: ___ Other Cost 1:

    ___ Other Cost 2:

    ___ Other Cost 3:
General Site Information

File Analyzed By: JT PD ERH Date: 10/26/2006

Type of treatment: Conductive Steam ERH Other: __________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Wood Treating Other: __________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: __________ End of Test: __________ Duration: __________
Type of Site: Non-DOD DoD

Facility Name: NAS Alameda
City, State, Zip Code: Alameda, CA
OU# or Site #: Site 4-2
Primary point of contact: John McGuire
Organization: Shaw
Phone #: 925-288-2220 email: john.mcguire@shawgrp.com

Other contacts or vendors who worked on site
Point of contact: Steven Peck
Type: Vendor, Consultant Vendor, Technical Applications Other __________
Organization: Navy
Address: 1455 Frazee Road, Suite 900
City, State, Zip Code: San Diego, CA 92108
Phone #: 619-532-0786 email: steven.peck@navy.mil

QA/QC

Characteristics of Interest
Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0215

<table>
<thead>
<tr>
<th><strong>Impacted Zone:</strong></th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

<table>
<thead>
<tr>
<th><strong>Monitor Wells:</strong></th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th></th>
<th>None</th>
</tr>
</thead>
</table>

- Number of wells relative to treatment zone:
  - Pre-treatment In: Upgradient: Downgradient: Crossgradient:  
  - Post-treatment In: Upgradient: Downgradient: Crossgradient:  

<table>
<thead>
<tr>
<th><strong>Soil Borings:</strong></th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th></th>
<th>Number outside treatment zone:</th>
</tr>
</thead>
</table>

- Number of relevant soil borings with post-treatment data:
  - Number inside treatment zone:  

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average Post-treatment Concentration per Chemical</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
</tbody>
</table>

#### Chlorinated Solvents

- Trichloroethene
- Tetrachloroethene
- 1,1-dichloroethene
- cis,1,2-dichloroethene
- trans-1,2-dichloroethene
- 1,1,2-trichloroethene
- 1,1,1-trichloroethane
- 1,2-dichloroethane
- 1,1-dichloroethane
- 1,2-dichloroethane
- 1,1,1,2-tetrachloroethane
- Vinyl Chloride
- 1,2-DCE

#### Petroleum Hydrocarbons

- Benzene
- Jet Fuel
- Napthalene
- Toluene
- Ethylbenzene
- m,p-xylene
- n-xylene

#### Other

- Creosote

#### Chemical Concentrations

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Average Pre-treatment Concentration</th>
<th>Average Post-treatment Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>100 mg/L</td>
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</tr>
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<td></td>
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<tr>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- Additional notes or observations.

### Attachments:

- Relevant documentation and reports.
<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>____</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
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<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>____</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>No</td>
<td>Yes (number):_________</td>
</tr>
<tr>
<td></td>
<td>Aquifer 1</td>
<td>Aquifer 2</td>
</tr>
<tr>
<td>Depth to water:</td>
<td>low value (ft bgs):</td>
<td>z</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
<td></td>
</tr>
<tr>
<td>Flow direction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Horizontal hydraulic gradient (feet/foot): | unknown |
- Vertical hydraulic gradient (feet/foot): | unknown |

- K range (ft/day): Measured using: ____ Slug Test ____ Laboratory ____ Field data
  low | high | | |
  | | | |

- Transmissivity (ft²/day): Measured using: ____ Slug Test ____ Laboratory ____ Field data
  low | high | | |
  | | | |

- Attachments: __________________________________________________________________________
  ______________________________________________________________________________________
  ______________________________________________________________________________________
  ______________________________________________________________________________________

- Comments: __________________________________________________________________________
  ______________________________________________________________________________________
  ______________________________________________________________________________________
  ______________________________________________________________________________________
  ______________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment:  
- Conductive

Electrical Resistance:  
- 3 phase
- 6 phase
- AC power
- DC power

Steam:  
- Steam
- Steam + air
- Steam + O2

Other (describe):

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded lenses of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
Duration:  

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft²):  
Thickness of target zone (ft):  
Depth to top of target zone (ft bgs):  
Thickness of target zone below water table (ft):  
Number of energy delivery points:  
Number of extraction points:  

Temperature Profile:

Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C):  
Time to reach maximum representative temperature (days):  
Duration of treatment at representative temperature (days):  
Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:
- Via liquid pumping:  
- In vapor stream:  
- Total:

Date  |  Temperature (deg C)
-----------------------------------

Comments:
Treating - 39800 yd³  
All information is based on the preliminary design.

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: [Screening analytes in groundwater to below 10 mg/L]

- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater

  Comment:

- In Soil

  Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ____________________ kWhr/yd³ ____________________ kWhr/m³ ____________________ kWhr/yd³

- Total energy applied to treatment zone: ____________________ kWhr/yd³ ____________________ kWhr/m³ ____________________ kWhr/yd³

- Other energy: ____________________ kWhr/yd³ ____________________ kWhr/m³ ____________________ kWhr/yd³

  Please note other energy: ____________________ kWhr/yd³ ____________________ kWhr/m³ ____________________ kWhr/yd³

Cost

Total Project Cost:

- Consultant Cost:

- Thermal Vendor Cost:

- Energy Cost: ____________________ m³ ____________________ yd³

- Other Cost 1:

- Other Cost 2:

- Other Cost 3:

  Please note other cost: ____________________ Other Cost 1:

  Other Cost 2:

  Other Cost 3:
Facility Name: Naval Facility Centerville Beach in Former Transformer Bldg #2
Address: Ferndale, CA
OU# or Site #: Site 6

Primary point of contact: Ralph Baker
Organization: TerraTherm
Address: 10 Stevens Rd.
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: rbaker@terratherm.com

Other contacts or vendors who worked on site: None

Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: 
Address: 
City, State, Zip Code: 
Phone #: 
email: 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
General Site Assessment Data

Impacted Zone: Length (parallel to flow direction)(ft.): __未知 Width (ft.): __ Thickness (ft.): __ 未知

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

Monitor Wells: Number of relevant monitoring wells with groundwater data:

Pre-treatment: Post-treatment: None

Number of wells relative to treatment zone:

Pre-treatment: In: _____ Upgradient: _____ Downgradient: _____ Crossgradient: _____
Post-treatment: In: _____ Upgradient: _____ Downgradient: _____ Crossgradient: _____

Soil Borings: Number of relevant soil borings with pre-treatment data: 15

Number of relevant soil borings with post-treatment data: 2

Number inside treatment zone: 14 Number outside treatment zone: __

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Avg Pre-treatment Concentration per Chemical</th>
<th>Avg Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
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<tr>
<td>1,1-dichloroethene</td>
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<td>cis-1,2-dichloroethene</td>
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<td>1,1,1-trichloroethane</td>
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<tr>
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<tr>
<td>Vinyl Chloride</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Impacted zone limited to 20 ft bgs

Attachments:
### Hydrogeologic Conceptual Model

**Unconsolidated Sediments**

<table>
<thead>
<tr>
<th>Geology</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

**Ground surface elevation based on wells in or adjacent to treatment zone:**

- **ft amsl**: ____________
- **Unknown**: 

**Aquifer Characteristics:**

- **Is more than 1 aquifer present?**
  - **No**: 
  - **Yes (number)**: ____________
  - **Unknown (assume single aquifer)**: 

<table>
<thead>
<tr>
<th>Aquifer Characteristics</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>99</td>
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<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction**: west

- **Horizontal hydraulic gradient (feet/foot)**: ____________
- **Vertical hydraulic gradient (feet/foot)**: ____________

- **K range (ft/day)**
  - Measured using: Slug Test, Laboratory, Field data
  - low: ____________
  - high: ____________
  - **Unknown**: 

- **Transmissivity (ft²/day)**
  - Measured using: Slug Test, Laboratory, Field data
  - low: ____________
  - high: ____________
  - **Unknown**: 

**Facility ID#:** 0230

**Comments:**

- ............................................................
- ............................................................

**Attachments:**

- ............................................................
- ............................................................
### Thermal Treatment - Design

**Facility ID:** 0230

<table>
<thead>
<tr>
<th><strong>Thermal Treatment Type</strong></th>
<th><strong>Treatment Cell Design</strong></th>
<th><strong>Geology of Treatment Zone</strong></th>
<th><strong>Type of Test</strong></th>
<th><strong>Start of Thermal Test</strong></th>
<th><strong>Duration of Treatment</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductive</td>
<td></td>
<td></td>
<td>Pilot test</td>
<td>Oct-98</td>
<td>4 months</td>
</tr>
<tr>
<td>Electrical Resistance</td>
<td></td>
<td></td>
<td>Full-scale System</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hydraulic Control:**
- Yes
- No

**Treatment Target Zone:**
- Saturated only
- vadose only
- Both (saturated and vadose zones)

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of higher permeability material
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Thermal Treatment Details:**
- **Size of Target Zone (ft²):** 1200
- **Thickness of Target Zone (ft):** 15
- **Depth to Top of Target Zone (ft bgs):** 3
- **Thickness of Target Zone Below Water Table (ft):** 0
- **Number of Energy Delivery Points:** 57
- **Number of Extraction Points:** 17

**Temperature Profile:**
- **Initial Formation Temperature (deg C):** Unknown
- **Maximum Representative Formation Temperature (deg C):** 360
- **Time to Reach Maximum Representative Temperature (days):** 120
- **Duration of Treatment at Representative Temperature (days):** Unknown

**Formation Temperature Immediately Post-Treatment:**
- **Formation Temperature Immediately Post-Treatment (deg C):** Unknown

**Formation Temperature Post-Treatment Monitoring Event 1:**
- **Formation Temperature Post-Treatment Monitoring Event 1 (deg C):** Unknown

**Duration of Post-Treatment Monitoring (days):** Unknown

**Mass of Contaminant Removed:**
- **Via Liquid Pumping:** Unknown
- **In Vapor Stream:** Unknown
- **Total:** 402

**Comments:**
- Minimal temperature data
- Heaters on 6 ft spacings; vacuum heater wells spacing = 10 ft

**Attachments:**
- Groundwater Services, Inc. freeware is attached.

---

**Note:** When applicable, mass flux measurements.
Remediation Goal:

In Groundwater: 

In Soil:
  1. Remove PCBs to at or below applicable regulator remedial goal. Remedial goal of less than 1.0 ppm or mg/kg DW, and 2. Dioxins and furans: 2,3,7,8-TCDD TEQ < 1.0 ppb

Was the Remediation Goal Achieved:

In Groundwater 

Comment: 

In Soil 

Comment: 

1.0 ppm or mg/kg DW was achieved in target treatment area

General comments on the thermal application:

Check for unidentified storm drains

Energy

Total Energy Used: ____kWhr ____kWhr/m³ ____kWhr/yd³

Total energy applied to treatment zone: ____kWhr/m³ ____kWhr/yd³

Other energy: ____kWhr/m³ ____kWhr/yd³

Please note other energy: 

Cost

Total Project Cost: 600,351

Consultant Cost: 

Thermal Vendor Cost: 600,351

Energy Cost: 

Other Cost 1: 

Other Cost 2: 

Other Cost 3: 

Please note other cost: Other Cost 1:

Other Cost 2: 

Other Cost 3: 

Lessons Learned

Site characterization $18,500; mobilization $30,000; Construction $210,124; Remediation $107,864; Site (general) $203,750; Demobilization $30,113 all at $284.15/ton

Other energy:

m³ yd³ kWhr/yd³ kWhr/m³ kWhr kWhr/
**General Site Information**

- **File Analyzed By:** JT
- **PD**
- **Date:** 10/31/2006

**Type of treatment:**
- Conductive
- Steam
- ERH
- Other:

**Type of Contaminant:**
- Chlorinated Solvents
- Petroleum Hydrocarbons
- Pesticides
- Wood Treating
- Other:

**Treatment Status:**
- Active
- Post

**Type of Test:**
- Pilot Test
- Full Scale System

**Start of Test:**
- End of Test:
- Duration:

**Type of Site:**
- Non-DOD
- DoD

---

**Facility Name:** Former Union Pacific Railroad

**Address:**

**City, State, Zip Code:** Long Beach, CA

**OU# or Site #:**

---

**Primary point of contact:** Jay Dablow

**Organization:** ERM

**Address:** 3 Hutton Centre, Suite 600

**City, State, Zip Code:** Santa Ana, CA 92707

**Phone #:** 714-430-1476

**email:** jay.dablow@erm.com

---

**Other contacts or vendors who worked on site:**
- None

**Point of contact:** Jim Levy

**Type:** Vendor, Consultant

**Vendor, Technical Applications**

**Organization:** Union Pacific Railroad Company

**Address:**

**City, State, Zip Code:** Rosedale, CA

**Phone #:**

**email:**

---

**QA/QC**

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
## General Site Assessment Data

### Chemicals of Concern

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
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<tr>
<td>1,1,2-trichloroethane</td>
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<td>Vinyl Chloride</td>
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<td>Ethylene</td>
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<td>Benzene</td>
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<td>Jet Fuel</td>
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</tr>
<tr>
<td>Transdichlorobenzene</td>
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</tr>
</tbody>
</table>

### Comments:

- Additional comments or notes related to the assessment data.

### Attachments:

- Any additional supporting documents or files related to the site assessment data.
## Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>■ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>■ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>■ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>■ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>■ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>■ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>■ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>■ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>■ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
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<td>■ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>■ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

---

**Ground surface elevation based on wells in or adjacent to treatment zone:** __________ ft amsl __________ Unknown

---

### Aquifer Characteristics:

**Is more than 1 aquifer present?**

- No
- Yes (number): __________
- Unknown (assume single aquifer)

**Depth to water:**

- low value (ft bgs): 10
- high value (ft bgs): __________
- Unknown: __________

**Flow direction:**

- __________

**Horizontal hydraulic gradient (feet/foot):**

- __________

**Vertical hydraulic gradient (feet/foot):**

- __________

**K range (ft/day):**

- measured using: ___ Slug Test ___ Laboratory ___ Field data
- low: __________
- high: __________

**Transmissivity (ft²/day):**

- measured using: ___ Slug Test ___ Laboratory ___ Field data
- low: __________
- high: __________

---

**Comments:**

---

**Attachments:**

---
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0235</th>
</tr>
</thead>
</table>

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power
- Steam  
- SVE enhanced steam injection
  - Steam
  - Steam + air
  - Steam + O2
- Other (describe)

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Competent, but fractured bedrock (i.e., crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test: __________________________

Duration of treatment at representative temperature (days): Unknown

Time to reach maximum representative temperature (days): Unknown

Maximum representative formation temperature (deg C): Unknown

Initial formation temperature (deg C): Unknown

Temperature Profile:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature immediately post-treatment: __________________________

Formation temperature post-treatment monitoring event 1: __________________________

Duration of post-treatment monitoring (days): __________________________

Mass of contaminant removed:  
- Via liquid pumping: __________________________  
  - lb  
  - kg  
  - Unknown
- In vapor stream: __________________________  
  - lb  
  - kg  
  - Unknown

Total: 60000  
- lb  
- kg  
- Unknown

Comments:  

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

Was the Remediation Goal Achieved:

General comments on the thermal application:

Lessons Learned:

Energy

Cost
General Site Information

File Analyzed By: JT PD

Type of treatment: x Conductive Steam ERH Other: __________

Type of Contaminant: x Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: __________

Treatment Status: Active x Post

Type of Test: Pilot Test x Full Scale System


Type of Site: x Non-DOD x DoD

Facility Name: Richmond, CA

Address: __________________________________________

City, State, Zip Code: Richmond, CA

OU# or Site #: Terminal 1 site

Primary point of contact: Ralph Baker

Organization: TerraTherm

Address: 10 Stevens Road

City, State, Zip Code: Fitchburg, MA 01420

Phone #: 978-343-0300 email: rbaker@terratherm.com

Other contacts or vendors who worked on site: None

Point of contact: Frank Szerdy

Type: x Vendor, Consultant __________ Vendor, Technical Applications __________ Other

Organization: Geomatrix Consultants, Inc

Address: 210 Webster St. 12th Fl.

City, State, Zip Code: Oakland, CA 94612

Phone #: 510-663-4100 email: Fserdy@geomatrix.com

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data

Good pre- and post-treatment soil data

Good temperature profile vs. time information

Flux assessment

Groundwater elevations

Geologic cross-section

Hydraulic Conductivity information
### General Site Assessment Data

<table>
<thead>
<tr>
<th>Types of Contaminants</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>2</td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>50 mg/kg</td>
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<tr>
<td>3</td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>cis,1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td>5</td>
<td>trans,1,2-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>1,1-dichloroethene</td>
<td>M/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>7</td>
<td>1,2-dichloroethene</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>8</td>
<td>1,1,1-trichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>9</td>
<td>1,1,2-trichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
</tbody>
</table>

### Comments:

- Additional relevant comments can be added here.

### Attachments:

- Map attachment
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<tr>
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<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
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<tr>
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<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: ~150 ft amsl

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th>Is more than 1 aquifer present?</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow direction:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal hydraulic gradient (feet/foot):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

K range (ft/day) measured using: Slug Test | Laboratory | Field data
low | 0.0003 |     |     |
high |         |     |     |

Transmissivity (ft²/day) measured using: Slug Test | Laboratory | Field data
low |     |     |     |
high |     |     |     |

Facility ID#: 0238

Comments:

Attachments:
Thermal Treatment - Design

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Thermal treatment:**
  - Conductive
  - In Situ Thermal Desorption
    - Electrical Resistance
      - 3 phase
      - 6 phase
      - AC power
      - DC power
      - Steam

- **Type of Test:**
  - Pilot test
  - Full-scale System

- **Geology of Treatment Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Treatment Target Zone:**
  - Saturated only
  - Vadose only
  - Both (Saturated and Vadose zones)

- **Start of Thermal Test:** 6/13/2005
- **Duration:** 116 d

- **Hydraulic Control:**
  - Yes

- **Treatment Cell Design:**
  - Size of target zone (ft²): 9450
  - Thickness of target zone (ft): 20
  - Depth to top of target zone (ft bgs): 0
  - Thickness of target zone below water table (ft): 18
  - Number of energy delivery points: 138
  - Number of extraction points: 12

- **Temperature Profile:**
  - Initial formation temperature (deg C): 17
  - Maximum representative formation temperature (deg C): 100
  - Time to reach maximum representative temperature (days): 110
  - Duration of treatment at representative temperature (days): 6

- **Formation temperature immediately post-treatment:**
  - Date: 10/8/2005
  - Temperature (deg C): 100

- **Formation temperature post-treatment monitoring event 1:**
  - Date: 10/8/2005
  - Temperature (deg C): 100

- **Duration of post-treatment monitoring (days):**
  - Date: 10/8/2005
  - Temperature (deg C): 100

- **Mass of contaminant removed:**
  - Via liquid pumping: __________ lb __________ kg __________ Unknown
  - In vapor stream: 6000 lb __________ kg __________ Unknown
  - Total: __________ lb __________ kg __________ Unknown

- **Comments:**

  12 ft spacing of heater wells

- **Attachments:**

  Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater:
- In Soil:

PCE = 2 mg/kg  TCE = 2 mg/kg  DCE = 17 mg/kg  VC = 0.23 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment:

PCE = 0.012 mg/kg  TCE = ND  DCE = 0.065 mg/kg  VC = 0.005 mg/kg

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: 2200000 kWh  kWh/m³  kWh/yd³

- Total energy applied to treatment zone:
- Other energy:
  - Please note other energy:

Cost

Total Project Cost:

- Consultant Cost:
- Thermal Vendor Cost: 1,770,000
- Energy Cost: 400,000 m³  $310 yd³
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:
  - Please note other cost:
  - Other Cost 1:
  - Other Cost 2:
  - Other Cost 3:
### General Site Information

- **File Analyzed By:** JT PD  
  **PD**  
  **Type of treatment:** Conductive Steam ERH Other:  
  **Type of Contaminant:** Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:  
  **Treatment Status:** Active Post  
  **Type of Test:** Pilot Test Full Scale System  
  **Start of Test:** 9/11/1999  
  **Type of Site:** Non-DOD DoD  
  **End of Test:** 4/14/2000  
  **Duration:** 113 days

- **Facility Name:** North Island NAS (Pilot)  
  **Address:**  
  **City, State, Zip Code:** Coronado, CA  
  **OU# or Site #:** IR Site 9 Area 1

- **Primary point of contact:** Michael Pound  
  **Organization:** Navy  
  **Address:**  
  **City, State, Zip Code:**  
  **Phone #:** 619-556-9901  
  **email:** michael.pound@navy.mil

- **Other contacts or vendors who worked on site:** None
  **Point of contact:** Richard Wong  
  **Type:** Vendor, Consultant Vendor, Technical Applications Other  
  **Organization:** Shaw  
  **Address:**  
  **City, State, Zip Code:**  
  **Phone #:** 619-437-6328 x314  
  **email:** richard.wong@shawgrp.com

### QA/QC

- **Characteristics of Interest**  
  - Good pre- and post-treatment groundwater data  
  - Good pre- and post-treatment soil data  
  - Good temperature profile vs. time information  
  - Flux assessment  
  - Groundwater elevations  
  - Geologic cross-section  
  - Hydraulic Conductivity information
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): 1000
- Width (ft): 500
- Thickness (ft): 13
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __
  - Pre-treatment: __
  - Post-treatment: __
  - Number of wells relative to treatment zone:
    - Pre-treatment: __ in: __
    - Upgradient: __
    - Downgradient: __
    - Crossgradient: __
    - Post-treatment: __ in: __
    - Upgradient: __
    - Downgradient: __
    - Crossgradient: __

Soil Borings:
- Number of relevant soil borings with pre-treatment data: __
  - Number of relevant soil borings with post-treatment data: __
  - Number inside treatment zone: __
  - Number outside treatment zone: __

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphtalene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
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<tr>
<td>1,1,2,2-tetrachloroethane</td>
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<td>None</td>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Attachments:
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
<th>Consolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
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<td></td>
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</tr>
</tbody>
</table>

#### Aquifer Characteristics:

- Ground surface elevation based on wells in or adjacent to treatment zone: 10 (aMLLW) ft amsl Unknown

- Is more than 1 aquifer present? Yes (number): ___ Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low value (ft bgs): 8</td>
<td>WNW</td>
</tr>
<tr>
<td>Aquifer 1</td>
<td>high value (ft bgs): 10</td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>Unknown:</td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Horizontal hydraulic gradient (feet/foot): 0.0004 to 0.0007

- Vertical hydraulic gradient (feet/foot): Unknown

- K range (ft/day) Measured using: Slug Test Laborator Field data

<table>
<thead>
<tr>
<th></th>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>k range</td>
<td>0.052</td>
<td>0.091</td>
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</tbody>
</table>

- Transmissivity (ft²/day): Measured using: Slug Test Laborator Field data

<table>
<thead>
<tr>
<th></th>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmissivity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Comments:

aMLLW - above mean low level sea water

- Attachments:
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
- 3 phase  
- 6 phase  
- AC power  
- DC power  
- Steam  
- Steam + air  
- Steam + O2  
- Other (describe)

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
9/11/1999  
Duration:  
113 days

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:  
Size of target zone (ft2):  
7853  
Thickness of target zone (ft):  
\( \_ \)  
Depth to top of target zone (ft bgs):  
\( \_ \)  
Thickness of target zone below water table (ft):  
\( \_ \)  
Number of energy delivery points:  
\( \_ \)  
Number of extraction points:  
\( \_ \)

Temperature Profile:  
Initial formation temperature (deg C):  
21  
Maximum representative formation temperature (deg C):  
104  
Time to reach maximum representative temperature (days):  
20  
Duration of treatment at representative temperature (days):  
49  
Formation temperature immediately post-treatment:  
Unknown  
Formation temperature post-treatment monitoring event 1:  
Unknown  
Duration of post-treatment monitoring (days):  
Unknown

Mass of contaminant removed:  
- Via liquid pumping:  
14600  
\( \_ \) lb  
\( \_ \) kg  
Unknown  
- In vapor stream:  
14000  
\( \_ \) lb  
\( \_ \) kg  
Unknown  
Total:  
28600  
\( \_ \) lb  
\( \_ \) kg  
Unknown

Comments:  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: __________
  See how long and if could reach 170F, the boiling point of TCE

- In Soil: __________

Was the Remediation Goal Achieved:

- In Groundwater: __________
  Comment: __________

- In Soil: __________
  Comment: __________

General comments on the thermal application:

_________________________________________________________________________________________________________
_________________________________________________________________________________________________________
_________________________________________________________________________________________________________
_________________________________________________________________________________________________________
_________________________________________________________________________________________________________
_________________________________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________________________________
_________________________________________________________________________________________________________
_________________________________________________________________________________________________________
_________________________________________________________________________________________________________
_________________________________________________________________________________________________________
_________________________________________________________________________________________________________

Energy

- Total Energy Used: __________ kWhr __________ kWhr/m3 __________ kWhr/yd3
- Total energy applied to treatment zone: __________ kWhr/m3 __________ kWhr/yd3
- Other energy: __________ kWhr/m3 __________ kWhr/yd3
  Please note other energy: __________

Cost

- Total Project Cost: __________
- Consultant Cost: __________
- Thermal Vendor Cost: __________
- Energy Cost: __________ m3 __________ yd3
- Other Cost 1: __________
- Other Cost 2: __________
- Other Cost 3: __________
  Please note other cost: __________
    Other Cost 1: __________
    Other Cost 2: __________
    Other Cost 3: __________
General Site Information

File Analyzed By: JT PD ERH Date: 9/22/2006
Type of treatment: Conductive Steam ERH Other: __________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: __________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 9/11/1999 End of Test: 4/14/2000 Duration: 113 days
Type of Site: Non-DOD DoD

Facility Name: North Island NAS
Organization: Navy
City, State, Zip Code: Coronado, CA
Phone #: 619-556-9901 email: michael.pound@navy.mil

Other contacts or vendors who worked on site: None
Type of Site: Non-DOD DoD
Organization: Shaw
City, State, Zip Code: Coronado, CA
Phone #: 619-437-6328 x314 email: richard.wong@shawgrp.com

QA/QC

Characteristics of Interest
Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data
Good temperature profile vs. time information Flux assessment
Groundwater elevations Geologic cross-section
Hydraulic Conductivity information
## General Site Assessment Data

### Impacted Zone:
- Length (parallel to flow direction)(ft.): 1000
- Width (ft): 100
- Thickness (ft): 1
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: ___
- Pre-treatment: ___
- Post-treatment: ___

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: 20
- Number of relevant soil borings with post-treatment data: 126
- Number inside treatment zone: 20/126
- Number outside treatment zone: 0

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethylene</td>
<td>5,000 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td>500 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>500 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Methylene</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>1,000 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>1,000 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Benzene</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>MTBE</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>MCUD</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>2,4-Dimethylpentane</td>
<td>1,000 mg/kg</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:
- See attached sheets for the numbers

### Attachments:
- Facility ID: 0245
- In: 20/126
- Number of wells relative to treatment zone:
  - Pre-treatment: ___
  - Post-treatment: ___
- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment: ___
  - Post-treatment: ___
- Number of relevant soil borings with pre-treatment data: 20
- Number of relevant soil borings with post-treatment data: 126
- Number inside treatment zone: 20/126
- Number outside treatment zone: 0

### Other
- Unknown
- Ancient method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Chemicals of Concern

- Trichloroethylene
- 1,1-Dichloroethene
- cis-1,2-Dichloroethene
- trans-1,2-Dichloroethene
- Ethylbenzene
- Methylene
- 1,1-Dichloroethane
- 1,2-Dichloroethane
- 1,1,1-Trichloroethane
- Vinyl Chloride
- Benzene
- MTBE
- Ethylbenzene
- MCUD
- 2,4-Dimethylpentane
- Total xenobase
Hydrogeologic Conceptual Model

Facility ID#: 0245

Unconsolidated Sediments

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: 10 (aMLLW) ft amsl

Is more than 1 aquifer present? No

Depth to water:
- Low value (ft bg): Unknown
- High value (ft bg): 10

Flow direction: WNW

Horizontal hydraulic gradient (feet/foot): 0.0004 to 0.0007

Vertical hydraulic gradient (feet/foot): Unknown

K range (ft/day)

- Low: 0.052
- High: 0.091

Transmissivity (ft²/day):

- Low: Unknown

Field data

slug test

Laboratory

aMLLW - above mean low level sea water

Comments:

Attachments:
Thermal Treatment - Design

Thermal treatment: ______ Conductive ______ Electrical Resistance

            ______ 3 phase ______ 6 phase ______ AC power ______ DC power

Steam: ______ Steam ______ Steam + air ______ Steam + O2

Type of Test: ______ Pilot test ______ Full-scale System

Geology of Treatment Zone:

- ______ Relatively homogeneous and permeable unconsolidated sediments
- ______ Relatively homogeneous and impermeable unconsolidated sediments
- ______ Largely permeable sediments with inter-bedded layers of lower permeability material
- ______ Largely impermeable sediments with inter-bedded layers of higher permeability material
- ______ Competent, but fractured bedrock (i.e. crystalline rock)
- ______ Weathered bedrock, limestone, sandstone

Treatment Target Zone:

- ______ Saturated only
- ______ Vadose only
- ______ Both (Saturated and Vadose zones)

Start of Thermal Test: 10/21/2002
Duration: 32 months

Hydraulic Control: ______ Yes ______ No

Treatment Cell Design:

Size of target zone (ft2): 595000
Thickness of target zone (ft): 10
Depth to top of target zone (ft bgs): 6
Thickness of target zone below water table (ft): 6
Number of energy delivery points: 24
Number of extraction points: 20

Temperature Profile:

Initial formation temperature (deg C): 21
Maximum representative formation temperature (deg C): 194
Time to reach maximum representative temperature (days): 20
Duration of treatment at representative temperature (days): 49

Formation temperature immediately post-treatment:

Date Temperature (deg C)

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Method</th>
<th>Mass Removed</th>
<th>Unit</th>
<th>Unit Conversion</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping</td>
<td>278223</td>
<td>lb</td>
<td>1 lb = 0.4535 kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>In vapor stream</td>
<td>86600</td>
<td>lb</td>
<td>1 lb = 0.4535 kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total</td>
<td>364823</td>
<td>lb</td>
<td>1 lb = 0.4535 kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Comments:

Total volume treated of 56,000yd³

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
General comments on the thermal application:

Please note other energy:

Lessons Learned

___ Energy

Total Energy Used:  

Total energy applied to treatment zone:  

Other energy:  

Please note other energy:

___ Cost

Total Project Cost:  

Consultant Cost:  

Thermal Vendor Cost:  

Energy Cost:  

Other Cost 1:  

Other Cost 2:  

Other Cost 3:  

Please note other cost:  

Other Cost 1:  

Other Cost 2:  

Other Cost 3:  

___ Performance

Remediation Goal:  

In Groundwater:  

In Soil:  Reduce VOC mass in shallow subsurface soils thereby reducing exposure risks to nearby human and ecological receptors

Was the Remediation Goal Achieved:  

In Groundwater:  

Comment:  

In Soil:  

Comment:  yes
General Site Information

File Analyzed By: JT

PD

Type of treatment: Conductive
Steam
ERH
Other:

Type of Contaminant: Chlorinated Solvents
Petroleum Hydrocarbons
Pesticides
Wood Treating
Other:

Treatment Status: Active
Post

Type of Test: Pilot Test
Full Scale System

Start of Test: Sep-91
End of Test: Sep-93
Duration: 746 days

Type of Site: Non-DOD
DoD

Facility Name: Rainbow Disposal

Address: ______________________________

City, State, Zip Code: Huntington Beach, CA

OU# or Site #: ______________________________

Primary point of contact: Paul de Percin

Organization: EPA SITE

Address: ______________________________

City, State, Zip Code: ______________________________

Phone #: ______________________________

email: ______________________________

Other contacts or vendors who worked on site

Point of contact: Nancy Olson Martin

Type: Vendor, Consultant
Vendor, Technical Applications
Other

Organization: ______________________________

Address: ______________________________

City, State, Zip Code: ______________________________

Phone #: 951-782-4497

email: ______________________________

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment: __________
  - Post-treatment: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>1,2,4-trichlorobenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
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<td></td>
<td></td>
<td></td>
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<td>None</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

70,000 to 135,000 gallons of diesel spilled

Impacted area of 2.3 acres

TPH pre-concentration - 3670 mg/kg, post - 3190 mg/kg

TRPH post concentration 2083 mg/kg

**Attachments:**

- Facility ID#: 0250
## Geology:

### Zone

**Vadose Zone:**
- ____ Relatively homogeneous and permeable unconsolidated sediments
- ____ Largely permeable sediments with inter-bedded lenses of lower permeability material
- ____ Largely impermeable sediments with inter-bedded layers of higher permeability material
- ____ Competent, but fractured bedrock (i.e. crystalline rock)
- ____ Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- ____ Relatively homogeneous and permeable unconsolidated sediments
- ____ Relatively homogeneous and impermeable unconsolidated sediments
- ____ Largely permeable sediments with inter-bedded lenses of lower permeability material
- ____ Largely impermeable sediments with inter-bedded layers of higher permeability material
- ____ Competent, but fractured bedrock (i.e. crystalline rock)
- ____ Weathered bedrock, limestone, sandstone

---

## Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>ft amsl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avi 1</td>
<td></td>
</tr>
<tr>
<td>Avi 2</td>
<td></td>
</tr>
<tr>
<td>Avi 3</td>
<td></td>
</tr>
</tbody>
</table>

---

## Aquifer Characteristics:

- ____ No
- ____ Yes (number): ________
- ____ Unknown (assume single aquifer)

### Depth to water:

- low value (ft bgs): 25
- high value (ft bgs): 40
- Unknown: ________

### Flow direction

- ________

### Horizontal hydraulic gradient (feet/foot):

- ________

### Vertical hydraulic gradient (feet/foot):

- ________

---

## K range (ft/day)

- low: ________
- high: ________

### Transmissivity (ft²/day):

- low: ________
- high: ________

---

## Comments:

- ________

---

## Attachments:

---
Thermal Treatment - Design

Thermal treatment:  
- Conductive 
- Electrical Resistance

Steam:  
- 3 phase 
- 6 phase 
- AC power 
- DC power

Type of Test:  
- Pilot test 
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only 
- Vadose only 
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- Sep-91

Duration: 746 days

Hydraulic Control:  
- Yes 
- No

Treatment Cell Design:

Size of target zone (ft²): 100188
Thicknes of target zone (ft): 24
Depth to top of target zone (ft bgs): 10
Thickness of target zone below water table (ft): 15
Number of energy delivery points: 35
Number of extraction points: 35

Temperature Profile:

Initial formation temperature (deg C): 18
Maximum representative formation temperature (deg C): 66
Time to reach maximum representative temperature (days): 380
Duration of treatment at representative temperature (days): 366

Formation temperature immediately post-treatment: (Unknown)
Formation temperature post-treatment monitoring event 1: (Unknown)
Duration of post-treatment monitoring (days): (Unknown)

Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Method</th>
<th>Quantity</th>
<th>Units</th>
<th>Units</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping</td>
<td>700 gal</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>In vapor stream</td>
<td>15400 gal</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total</td>
<td>16000 gal</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Comments:

Spacing - 45 ft with wells of opposite type and 60 ft for wells of same type

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance
Remediation Goal:

- In Groundwater:
- In Soil:

See if Technology could achieve the RWQCB requirement for soil = 1000 mg/kg TPH

Was the Remediation Goal Achieved:
- In Groundwater
- In Soil

Comment:

- No requirements were not met

General comments on the thermal application:

Cost - $46/yd3

See Cost sheet for complete details

Lessons Learned

Energy
Total Energy Used: _ _ _ kWh _ _ _ kWh/m3 _ _ _ kWh/yd3
- Total energy applied to treatment zone: _ _ _ kWh/m3 _ _ _ kWh/yd3
- Other energy: _ _ _ kWh/m3 _ _ _ kWh/yd3
- Please note other energy: _ _ _ kWh/m3 _ _ _ kWh/yd3

Cost
Total Project Cost: 4401120
- Consultant Cost: -
- Thermal Vendor Cost: -
- Energy Cost: 631470 _ _ _ m3 _ _ _ yd3
- Other Cost 1: -
- Other Cost 2: -
- Other Cost 3: -
- Please note other cost: -
- Other Cost 1: -
- Other Cost 2: -
- Other Cost 3: -
### Table 3-1. SUMMARY OF RESULTS OF THE ECONOMIC ANALYSIS

<table>
<thead>
<tr>
<th>Time To Remediate (Days)</th>
<th>Approx. Actual Costs for Rainbow Disposal Total ($)</th>
<th>Estimated Ideal Cost for Rainbow Disposal Total ($)</th>
<th>Estimated Cost for a Typical site of the same size Total ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>746</td>
<td>338,230 $9.56</td>
<td>325,960 $9.43</td>
<td>336,200 $9.54</td>
</tr>
</tbody>
</table>

#### Assumed off-Line Factor

<table>
<thead>
<tr>
<th>Site size (yd$^3$)</th>
<th>$50%$</th>
<th>$100%$</th>
<th>$75%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>90,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Approx. Actual Costs</th>
<th>Estimated Ideal Cost</th>
<th>Estimated Cost for a Typical site of the same size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Preparation Costs</td>
<td>$338,230 $9.56</td>
<td>325,960 $9.43</td>
<td>336,200 $9.54</td>
</tr>
<tr>
<td>Permitting and Regulatory Costs</td>
<td>$16,100 $0.17</td>
<td>11,100 $0.12</td>
<td>14,100 $0.15</td>
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<tr>
<td>Non-Depreciable Equipment Costs</td>
<td>$522,990 $5.51</td>
<td>522,490 $5.50</td>
<td>524,070 $5.52</td>
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<td>Startup and Fixed Costs</td>
<td>$758,800 $7.99</td>
<td>413,500 $4.35</td>
<td>435,700 $4.59</td>
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<tr>
<td>Labor Costs</td>
<td>$1,362,000 $14.34</td>
<td>775,600 $8.16</td>
<td>1,033,600 $10.88</td>
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<td>Consumables and Supplies Costs</td>
<td>$43,430 $0.46</td>
<td>24,320 $0.26</td>
<td>32,420 $0.34</td>
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<tr>
<td>Utilities Costs</td>
<td>$631,470 $6.65</td>
<td>280,190 $2.95</td>
<td>493,020 $5.19</td>
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<td>Effluent Treatment and Disposal Costs</td>
<td>$71,100 $0.75</td>
<td>35,600 $0.37</td>
<td>47,400 $0.50</td>
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<td>Residuals and Waste Handling and Disposal Costs</td>
<td>$67,200 $0.71</td>
<td>49,250 $0.52</td>
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<td>Sampling and Analytical Costs</td>
<td>$299,900 $3.16</td>
<td>195,900 $2.06</td>
<td>221,900 $2.34</td>
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<td>Facility Modification, Repair, and Replacement Costs</td>
<td>$150,700 $1.59</td>
<td>57,500 $0.61</td>
<td>77,600 $0.82</td>
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<td>Site Demobilization Costs</td>
<td>$139,200 $1.47</td>
<td>98,500 $1.04</td>
<td>98,500 $1.04</td>
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<td>TOTAL COSTS</td>
<td>$4,401,120 $46.33</td>
<td>$2,789,910 $29.37</td>
<td>$3,375,910 $35.54</td>
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</table>

* This table presents a summary of the detailed costs itemized in Table 3-2.

** For each cost category, costs per cubic yard are reported to the nearest cent.

Source:
File Analyzed By: JT x PD ______

Type of treatment: ______ Conductive ______ Steam ______ ERH x Other: Hot air

Type of Contaminant: ______ Chlorinated Solvents x Petroleum Hydrocarbons ______ Pesticides ______ Wood Treating ______ Other: __________________________

Treatment Status: ______ Active x Post

Type of Test: ______ Pilot Test x Full Scale System

Start of Test: 1991 End of Test: 1993 Duration: < 10 months

Type of Site: ______ Non-DOD ______ DoD

Facility Name: Service Station

Address: __________________________

City, State, Zip Code: San Francisco, CA

OU# or Site #: __________________________

Primary point of contact: Robert Dahl

Organization: TerraVac

Address: __________________________

City, State, Zip Code: __________________________

Phone #: 925-363-7322 email: rdahl@terravac.com

Other contacts or vendors who worked on site ______ None

Point of contact: TerraVac Website

Type: ______ Vendor, Consultant ______ Vendor, Technical Applications ______ Other ______

Organization: __________________________

Address: __________________________

City, State, Zip Code: __________________________

Phone #: __________________________ email: __________________________

QA/QC

Characteristics of Interest

____ Good pre- and post-treatment groundwater data

____ Good pre- and post-treatment soil data

____ Good temperature profile vs. time information

____ Flux assessment

____ Groundwater elevations

____ Geologic cross-section

____ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:**

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________  Width (ft.): __________  Thickness (ft.): __________  Unknown
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: __________
  - Number of wells relative to treatment zone:
    - Pre-treatment: _______  In: _______  Upgradient: _______  Downgradient: _______  Crossgradient: _______
    - Post-treatment: _______  In: _______  Upgradient: _______  Downgradient: _______  Crossgradient: _______

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: __________
  - Number of relevant soil borings with post-treatment data: __________
  - Number inside treatment zone: __________
  - Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
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<tbody>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>None</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
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<td></td>
<td>None</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- None

### Attachments:

- None
### Aquifer Characteristics:

- **Geology:**
  - Vadose Zone:
    - Low value (ft bgs): 
    - High value (ft bgs): 
    - Unknown:
  - Saturated Zone:
    - Low value (ft bgs): 
    - High value (ft bgs): 
    - Unknown:

- **Ground surface elevation based on wells in or adjacent to treatment zone:** 
  - Low value: 
  - High value: 
  - Unknown:

- **K range (ft/day):**
  - Measured using: Slug Test, Laboratory, Field data
  - Low: 
  - High: 
  - Unknown:

- **Transmissivity (ft²/day):**
  - Measured using: Slug Test, Laboratory, Field data
  - Low: 
  - High: 
  - Unknown:

- **Flow direction:**
  - 

- **Horizontal hydraulic gradient (feet/foot):**
  - 
  - 
  - 
  - Unknown:

- **Vertical hydraulic gradient (feet/foot):**
  - 
  - 
  - 
  - Unknown:

### Notes:

- Attachments:
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID#: 0260</th>
</tr>
</thead>
</table>

- **Thermal treatment:**
  - Conductive
  - Electrical Resistance
    - 3 phase
    - 6 phase
    - AC power
    - DC power
  - Steam
  - Steam + air
  - Steam + O2

- **Type of Test:**
  - Pilot test
  - Full-scale System

- **Geology of Treatment Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded layers of lower permeability material
  - Largely impermeable sediments with inter-bedded lenses of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Treatment Target Zone:**
  - Saturated only
  - Vadose only
  - Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - 1991
  - Duration: 2 years

- **Hydraulic Control:**
  - Yes
  - No

- **Temperature Profile:**
  - Initial formation temperature (deg C): unknown
  - Maximum representative formation temperature (deg C): unknown
  - Time to reach maximum representative temperature (days): unknown
  - Duration of treatment at representative temperature (days): unknown
  - Formation temperature immediately post-treatment: unknown
  - Formation temperature post-treatment monitoring event 1: unknown
  - Duration of post-treatment monitoring (days): unknown

- **Mass of contaminant removed:**
  - Via liquid pumping: unknown
  - In vapor stream: unknown
  - Total: 80000 lb kg unknown

- **Notes:**
  - When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater:

Comment:

In Soil:

Comment:

General comments on the thermal application:

Hot air increased extraction rated by up to a factor of three over those without hot air injection.

Lessons Learned

Energy

Total Energy Used: ___kWhr___kWhr/m³___kWhr/yd³

Total energy applied to treatment zone: ___kWhr/m³___kWhr/yd³

Other energy: ___kWhr/m³___kWhr/yd³

Please note other energy: ________________________________

Cost

Total Project Cost:

Consultant Cost: ________________________________

Thermal Vendor Cost: ________________________________

Energy Cost: ___m³___yd³

Other Cost 1: ________________________________

Other Cost 2: ________________________________

Other Cost 3: ________________________________

Please note other cost: Other Cost 1: ________________________________

Other Cost 2: ________________________________

Other Cost 3: ________________________________
## General Site Information

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<th>PD</th>
<th>Date:</th>
<th>9/26/2006</th>
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<td>Steam</td>
<td>ERH</td>
<td>Other:</td>
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<tr>
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<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
<td>Wood Treating</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Facility Name: Solvent Services

| Address: | 1021 Berryessa Rd |
| City, State, Zip Code: | San Jose, CA |

### Primary point of contact:

| Organization: | |
| City, State, Zip Code: | |
| Phone #: | email: |

### Other contacts or vendors who worked on site

| Point of contact: | None |
| Organization: | |
| City, State, Zip Code: | |
| Phone #: | email: |

### QA/QC

| Characteristics of Interest | |
| Good pre- and post-treatment groundwater data | Good pre- and post-treatment soil data |
| Good temperature profile vs. time information | Flux assessment |
| Groundwater elevations | Geologic cross-section | Hyd |
General Site Assessment Data

Impacted Zone: Length (parallel to flow direction)(ft.): Width (ft.): Thickness (ft.): Impacted zone as defined by documentation

-- Alternative method for determining size of impacted zone (See source zone definition attachments)

-- Map attachment

Monitor Wells: Number of relevant monitoring wells with groundwater data:

Pre-treatment: Post-treatment: None

Number of wells relative to treatment zone:

Pre-treatment: Upgradient: Downgradient: Crossgradient: Post-treatment: Upgradient: Downgradient: Crossgradient:

Soil Borings: Number of relevant soil borings with pre-treatment data:

Number outside treatment zone:

Chemicals of Concern

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr.</td>
<td>None</td>
<td>100 mg/kg None 50 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>100 mg/kg None 10 mg/kg</td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>0.5 mg/kg None 10 mg/kg</td>
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<tr>
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<tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

Comments:

41,000 yd³ contaminated at greater than 0.010 ppm

Concentrations from Table 1 for pre and Appendix C holes A1 and A2 averages

Attachments:
Hydrogeologic Conceptual Model

Facility ID#: 0270

Unconsolidated Sediments

Zone

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: 75 to 100 ft amsl

Is more than 1 aquifer present?
- No
- Yes (number): ________________

Depth to water:
- Low value (ft bgs): ________________
- High value (ft bgs): ________________
- Unknown: ________________

Flow direction:
- W

Horizontal hydraulic gradient (feet/foot):

Vertical hydraulic gradient (feet/foot):

K range (ft/day):

Transmissivity (ft²/day):

Measured using:
- Slug Test
- Laboratory
- Field data

Transmissivity = 200 gal per day per foot; Storativity = 0.22 both for aquifer

Flow direction from Figure 3 contours

Comments:

Attachments:
### Thermal Treatment - Design

**Facility ID#: 0270**

**Thermal treatment:**
- [x] Conductive
- [ ] Electrical Resistance
  - [ ] 3 phase
  - [ ] 6 phase
  - [ ] AC power
  - [ ] DC power
- [x] Steam

**Steam:**
- [x] Steam
- [ ] Steam + air
- [ ] Steam + O2

**Other (describe):**

**Type of Test:**
- [x] Pilot test
- [ ] Full-scale System

**Geology of Treatment Zone:**
- [x] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- [x] Saturated only
- [ ] Vadose only
- [ ] Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- [x] 8/17/1988
- [ ] Duration: 15 days

**Hydraulic Control:**
- [x] Yes
- [ ] No

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>169</th>
<th>[x] Unknown</th>
<th>(13 x 13 ft)</th>
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<tr>
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</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
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<td>Thickness of target zone below water table (ft):</td>
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<td>Number of energy delivery points:</td>
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<td>Number of extraction points:</td>
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<td>[x] Unknown</td>
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</tbody>
</table>

**Temperature Profile:**

| Initial formation temperature (deg C): | 26 | [x] Unknown |
| Maximum representative formation temperature (deg C): | 100 | [x] Unknown |
| Time to reach maximum representative temperature (days): | 1 | [x] Unknown |
| Duration of treatment at representative temperature (days): | >1 | [x] Unknown |

**Mass of contaminant removed:**

| Via liquid pumping: | 186.8 | lb | [x] kg | [x] Unknown |
| In vapor stream: | 548.3 | lb | [x] kg | [x] Unknown |
| Total: | 762.7 | lb | [x] kg | [x] Unknown |

**Notes:**
- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

Objectives: 1) demonstrate that control of the movement of the steam zone can be maintained; 2) identify controlling parameters and phenomena which characterize the use of steam for soil contamination remediation; 3) provide sufficient data on the operation and performance of the process to allow for an effective design of a full-scale cleanup process.

Lessons Learned


Energy

Total Energy Used: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

Total energy applied to treatment zone: ___________ kWh/m³ ___________ kWh/yd³

Other energy: ___________ kWh/m³ ___________ kWh/yd³

Please note other energy:

Cost

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost: ___________ m³ ___________ yd³

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost: Other Cost 1:

Other Cost 2:

Other Cost 3:
## General Site Information

<table>
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<tr>
<th>File Analyzed By</th>
<th>JT</th>
<th>PD</th>
<th>Date: 10/29/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment</td>
<td>____</td>
<td>Conductive</td>
<td>____</td>
</tr>
<tr>
<td>Type of Contaminant</td>
<td>____</td>
<td>Chlorinated Solvents</td>
<td>____</td>
</tr>
<tr>
<td>____</td>
<td>Wood Treating</td>
<td>____</td>
<td>Other: ____</td>
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<tr>
<td>Treatment Status</td>
<td>____</td>
<td>Active</td>
<td>____</td>
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<tr>
<td>Type of Test</td>
<td>____</td>
<td>Pilot Test</td>
<td>____</td>
</tr>
<tr>
<td>Start of Test</td>
<td>____</td>
<td>End of Test: ____</td>
<td>Duration: ____</td>
</tr>
<tr>
<td>Type of Site</td>
<td>____</td>
<td>Non-DOD</td>
<td>____</td>
</tr>
</tbody>
</table>

## Facility Name

- McClellan AFB Superfund Site

## Address

City, State, Zip Code: Sacramento, CA

OU# or Site #: ____________

## Primary point of contact

- Robert Dahl

## Organization

- TerraVac

## Address

City, State, Zip Code: ____________

Phone #: 925-363-7322
e-mail: rdahl@terravac.com

Other contacts or vendors who worked on site

- ____ None

Point of contact

- TerraVac Website

Type: _____ Vendor, Consultant _____ Vendor, Technical Applications _____ Other _____

Organization: ____________

Address: ____________

City, State, Zip Code: ____________

Phone #: ____________
e-mail: ____________

## QA/QC

- Characteristics of Interest

  ____ Good pre- and post-treatment groundwater data
  ____ Good pre- and post-treatment soil data
  ____ Good temperature profile vs. time information
  ____ Flux assessment
  ____ Groundwater elevations
  ____ Geologic cross-section
  ____ Hydraulic Conductivity information
### General Site Assessment Data

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetrachloroethene</td>
<td>Tetrachloroethene</td>
<td>Hexane</td>
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<tr>
<td>1,1-Dichloroethene</td>
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<td>None</td>
<td>None</td>
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<tr>
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</table>

### Comments:

- Additional comments on site assessment data.

### Attachments:

- Additional data sheets or reports related to site assessment.

---

**Facility ID#: 0275**
### Geology:

#### Zone

**Vadose Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Aquifer Characteristics:

**Is more than 1 aquifer present?**
- **No**
- **Yes** (number): __________
- Unknown (assume single aquifer)

**Depth to water:**
- **Pathway**
  - **low value (ft bgs):** __________
  - **high value (ft bgs):** __________
  - **Unknown:** __________

**Flow direction:**

**Horizontal hydraulic gradient (feet/foot):**

**Vertical hydraulic gradient (feet/foot):**

**K range (ft/day):**
- **Measured using:**
  - Slug Test
  - Laboratory
  - Field data
  - **low:** __________
  - **high:** __________

**Transmissivity (ft²/day):**
- **Measured using:**
  - Slug Test
  - Laboratory
  - Field data
  - **low:** __________
  - **high:** __________

### Ground surface elevation based on wells in or adjacent to treatment zone:
- __________ ft amsl
- Unknown

### Additional Information:

- **Comments:**
- **Attachments:**

---

**Facility ID#:** 0275

**Geology:** Unconsolidated Sediments

**Weathered bedrock, limestone, sandstone**

**Ground surface elevation based on wells in or adjacent to treatment zone:** __________ ft amsl

**Relatively homogeneous and permeable unconsolidated sediments**

**Largely permeable sediments with inter-bedded lenses of lower permeability material**

**Largely impermeable sediments with inter-bedded layers of higher permeability material**

**Competent, but fractured bedrock (i.e. crystalline rock)**

**Weathered bedrock, limestone, sandstone**

**Water table elevation:**

**Aquifer 1:**
- __________

**Aquifer 2:**
- __________

**Aquifer 3:**
- __________

**Water temperature:**
- __________

**Groundwater velocity:**
- __________

**Groundwater age:**
- __________

**Groundwater quality:**
- __________

**Groundwater recharge rate:**
- __________

**Groundwater recharge conditions:**
- __________

**Groundwater discharge rate:**
- __________

**Groundwater discharge conditions:**
- __________

---

**Facility ID#:** 0275

**Geology:** Unconsolidated Sediments

**Weathered bedrock, limestone, sandstone**

**Ground surface elevation based on wells in or adjacent to treatment zone:** __________ ft amsl

**Relatively homogeneous and permeable unconsolidated sediments**

**Largely permeable sediments with inter-bedded lenses of lower permeability material**

**Largely impermeable sediments with inter-bedded layers of higher permeability material**

**Competent, but fractured bedrock (i.e. crystalline rock)**

**Weathered bedrock, limestone, sandstone**

**Groundwater age:**
- __________

**Water temperature:**
- __________

**Water table elevation:**
- __________

**Water table elevation:**
- __________

**Flow direction:**

**Horizontal hydraulic gradient (feet/foot):**

**Vertical hydraulic gradient (feet/foot):**

**K range (ft/day):**
- **Measured using:**
  - Slug Test
  - Laboratory
  - Field data
  - **low:** __________
  - **high:** __________

**Transmissivity (ft²/day):**
- **Measured using:**
  - Slug Test
  - Laboratory
  - Field data
  - **low:** __________
  - **high:** __________
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
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<tr>
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<table>
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<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
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</table>

<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<tr>
<td>Weathered bedrock, limestone, sandstone</td>
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</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
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</thead>
<tbody>
<tr>
<td>Start of Thermal Test:</td>
<td></td>
<td></td>
<td>Duration:</td>
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</table>

<table>
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<tr>
<th>Hydraulic Control</th>
<th>Yes</th>
<th>No</th>
</tr>
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<table>
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<tr>
<th>Treatment Cell Design:</th>
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<tbody>
<tr>
<td>Size of target zone (ft²):</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
</tr>
<tr>
<td>Number of extraction points:</td>
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<table>
<thead>
<tr>
<th>Temperature Profile:</th>
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<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
</tr>
<tr>
<td>Formation temperature immediately post-treatment:</td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
</tr>
<tr>
<td>In vapor stream:</td>
</tr>
<tr>
<td>Total:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:

___ In Soil

Comment:

General comments on the thermal application:

__________________________________________

__________________________________________

__________________________________________

__________________________________________

__________________________________________

Lessons Learned

__________________________________________

__________________________________________

__________________________________________

__________________________________________

___ Energy

Total Energy Used: ___ kWhr ___ kWhr/m³ ___ kWhr/yd³

Total energy applied to treatment zone: ___ kWhr/m³ ___ kWhr/yd³

Other energy: ___ kWhr/m³ ___ kWhr/yd³

Please note other energy: __________________________________________

___ Cost

Total Project Cost: ___ Consultant Cost: ____________________________

___ Thermal Vendor Cost: ____________________________

___ Energy Cost: ____________________________ m³ ___ yd³

___ Other Cost 1: ____________________________

___ Other Cost 2: ____________________________

___ Other Cost 3: ____________________________

Please note other cost: ___ Other Cost 1: ____________________________

___ Other Cost 2: ____________________________

___ Other Cost 3: ____________________________

__________________________________________

__________________________________________
**General Site Information**

- **File Analyzed By:** JT  PD
- **Type of treatment:** ____ Conductive  x Steam  __ ERH  ____ Other:
- **Type of Contaminant:** ____ Chlorinated Solvents  ____ Petroleum Hydrocarbons  ____ Pesticides  __ Wood Treating  ____ Other:
- **Treatment Status:** ____ Active  x Post
- **Type of Test:** ____ Pilot Test  x Full Scale System
- **Start of Test:** May-97  **End of Test:** Jul-00  **Duration:** 37 months
- **Type of Site:** x  Non-DOD  ____ DoD

- **Facility Name:** Visalia Poleyard
- **Address:**
- **City, State, Zip Code:** CA
- **OU# or Site #:**

- **Primary point of contact:** Craig Eaker
- **Organization:** Southern California Edison
- **Address:** RP&A - EH&S, Quad 3A  2344 Walnut Grove Avenue
- **City, State, Zip Code:** Rosemead, CA 91770
- **Phone #:** 626-302-8531
- **email:**

- **Other contacts or vendors who worked on site:** ____ None
- **Point of contact:**
  - **Type:** ____ Vendor, Consultant  ____ Vendor, Technical Applications  ____ Other  ____
  - **Organization:**
  - **Address:**
  - **City, State, Zip Code:**
  - **Phone #:**
  - **email:**

**QA/QC**

- **Characteristics of Interest**
  - ____ Good pre- and post-treatment groundwater data
  - ____ Good pre- and post-treatment soil data
  - ____ Good temperature profile vs. time information
  - ____ Flux assessment
  - ____ Groundwater elevations
  - ____ Geologic cross-section
  - ____ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0280

**Impact Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft): __________
- Thickness (ft): __________
- Impacted zone as defined by documentation: __________
- Alternative method for determining size of impacted zone (See source zone definition attachments): __________
- Map attachment: __________

**Monitor Wells:**
- Number of relevant monitoring wells with pre-treatment data: __________
- Number of relevant monitoring wells with post-treatment data: __________
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________

**Soil Borings:**
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross-gradient</td>
<td>None</td>
<td>None</td>
<td>0.001 mg/L</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>PCE</td>
<td>None</td>
<td>None</td>
<td>0.001 mg/L</td>
<td>None</td>
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<tr>
<td>1,1-dichloroethene</td>
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<td>0.5 mg/L</td>
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<tr>
<td>1,1,1-trichloroethane</td>
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<td>Vinyl Chloride</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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</tr>
</tbody>
</table>

**Comments:**

NAPL Area: 525 ft by 150 ft; Impacted area 4.3 acres

Post-treatment data from June 2006 with Dioxins

= non-detect in ng/L

**Attachments:**

---

No attachments available.
## Hydrogeologic Conceptual Model

### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
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<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone: 0 ft amsl  x Unknown

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
<th>Aquifer 4</th>
<th>Aquifer 5</th>
<th>Aquifer 6</th>
<th>Aquifer 7</th>
<th>Aquifer 8</th>
<th>Aquifer 9</th>
<th>Aquifer 10</th>
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<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
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<td>Yes (number):</td>
<td>1</td>
<td>Unknown (assume single aquifer)</td>
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<td>75</td>
<td>120</td>
<td>low value (ft bgs):</td>
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<td>high value (ft bgs):</td>
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<td>high value (ft bgs):</td>
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### Horizontal hydraulic gradient (feet/foot):  x Unknown

### Vertical hydraulic gradient (feet/foot):  x Unknown

### K range (ft/day)

<table>
<thead>
<tr>
<th></th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>K range (ft/day)</th>
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<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>high</td>
<td></td>
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<td>high</td>
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### Transmissivity (ft²/day)

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<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Transmissivity (ft²/day)</th>
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</thead>
<tbody>
<tr>
<td>low</td>
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<td></td>
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<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>high</td>
</tr>
</tbody>
</table>

### Comments:

- If applicable, include any additional comments.

### Attachments:

- Include any relevant attachments.
**Thermal Treatment - Design**

**Facility ID#: 0280**

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3 phase</td>
</tr>
<tr>
<td></td>
<td>Steam</td>
<td>DUS/HPO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam</td>
</tr>
</tbody>
</table>

| Type of Test: | Pilot test | Full-scale System |

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Largely homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

| Start of Thermal Test: | 5/12/1997 | Duration: 37 months |

| Hydraulic Control | Yes | No |

**Treatment Cell Design:**
- Size of target zone (ft²): 154,800
- Thickness of target zone (ft): 85
- Depth to top of target zone (ft bgs): 20
- Thickness of target zone below water table (ft): 70
- Number of extraction points: 12
- Number of energy delivery points: 14
- Thickness of target zone below water table (ft): 70
- Depth to top of target zone (ft bgs): 20
- Thickness of target zone (ft): 85
- Number of extraction points: 12
- Number of energy delivery points: 14

**Temperature Profile:**
- Initial formation temperature (deg C): Unknown
- Maximum representative formation temperature (deg C): 130
- Time to reach maximum representative temperature (days): Unknown
- Duration of treatment at representative temperature (days): Unknown

**Formation temperature immediately post-treatment:**
- Unknown

**Formation temperature post-treatment monitoring event 1:**
- Unknown

**Duration of post-treatment monitoring (days):**
- Unknown

**Mass of contaminant removed:**
- Via liquid pumping: 199,500 lb, 37 months
- In vapor stream: 239,400 lb, 37 months
- Total: 1,330,000 lb, 37 months

**Mass removed:**
- 212,800 lb of in-situ oxidation and 678,300 lb of free product creosote

**Comments:**

**Attachments:**

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Performance

Remediation Goal:

☐ In Groundwater:

☐ In Soil:

Was the Remediation Goal Achieved:

☐ In Groundwater

Comment:

21 wells meet the criteria for PCP and 22 wells for TCDD and B(a)P - out of 25 wells

☐ In Soil

Comment:

General comments on the thermal application:

$57/cubic yard actually, but with lessons learned it would have been $38/cubic yard

Lessons Learned

Energy

Total Energy Used:

☐ Total energy applied to treatment zone: _______ kWh _______ kWh/m$^3$ _______ kWh/yd$^3$

☐ Other energy: _______ kWh/m$^3$ _______ kWh/yd$^3$

Please note other energy:

Cost

Total Project Cost: 21,500,000

☐ Consultant Cost:

☐ Thermal Vendor Cost:

☐ Energy Cost: _______ m$^3$ _______ yd$^3$

☐ Other Cost 1:

☐ Other Cost 2:

☐ Other Cost 3:

Please note other cost:

☐ Other Cost 1:

☐ Other Cost 2:

☐ Other Cost 3:
General Site Information

File Analyzed By: JT PD Date: 10/6/2006
Type of treatment: Conductive Steam ERH Other: ______________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: ______________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Type of Site: Non-DOD DoD

Facility Name: Lowry Landfill
Organization: EPA
Primary point of contact: Bonnie Lavelle
Phone #: 303-312-6579 email: __________________________

Other contacts or vendors who worked on site: None
Point of contact: Bill Plaehn
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: Parsons
Phone #: 303-764-8729 email: bill.a.plaehn@parsons.com

QA/QC

Characteristics of Interest
____________________  ____________
Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data
____________________  ____________
Good temperature profile vs. time information Flux assessment
____________________  ____________
Groundwater elevations Geologic cross-section
____________________  ______________________
Hydraulic Conductivity information
General Site Assessment Data

**Impacted Zone:**

- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): Unknown

  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)

  - Map attachment

**Monitor Wells:**

- Number of relevant monitoring wells with groundwater data: __________

  **Pre-treatment:**
  - In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

  **Post-treatment:**
  - In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

**Soil Borings:**

- Number of relevant soil borings with pre-treatment data: __________

  - Number inside treatment zone: __________
  - Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross-gradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>Methylene Chloride</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>Acetone</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td>2-butoxy</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Xylenes (perimeter)</td>
<td>10 mg/L</td>
<td>None</td>
<td>5 mg/L</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>Xylenes (in treat zone)</td>
<td>10,000 mg/L</td>
<td>500 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Total VOCs (perimeter)</td>
<td></td>
<td>1,000 mg/L</td>
<td>None</td>
<td>100 mg/L</td>
</tr>
<tr>
<td></td>
<td>Total VOCs (in treat zone)</td>
<td></td>
<td>10,000 mg/L</td>
<td>1,000 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,2-dichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Chemicals of Concern**

- Trichloroethene
- Tetrachloroethene
- 1,1-dichloroethene
- cis,1,2-dichloroethene
- trans,1,2-dichloroethene
- 1,1-dichloroethane
- 1,2-dichloroethane
- 1,1,1-trichloroethane
- 1,1,2-trichloroethane
- Vinyl Chloride
- Total VOCs (perimeter)
- Total VOCs (in treat zone)

**Comments:**

__________________________________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________________________________

Attachments:

See attached sheets for concentration data.
### Hydrogeologic Conceptual Model

**Geology:**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

**Aquifer Characteristics:**

- Is more than 1 aquifer present?  
  - No  
  - Yes (number):  
  - Unknown (assume single aquifer)  

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
</tr>
</tbody>
</table>

- Flow direction: NW

- Horizontal hydraulic gradient (feet/foot): 0.04 to 0.05

- Vertical hydraulic gradient (feet/foot):  
  - Measured using: Slug Test, Laboratory, Field data  
  - Unknown

- K range (ft/day)  
  - Measured using: Slug Test, Laboratory, Field data  
  - Unknown

- Transmissivity (ft²/day):  
  - Measured using: Slug Test, Laboratory, Field data  
  - Unknown

**Ground surface elevation based on wells in or adjacent to treatment zone:** 5760 ft amsl

**Horizonation hydraulic gradient during treatment was 0.05 to 0.06 ft/ft**

**Attachments:**

Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 phase AC power</td>
<td>Steam + O2</td>
<td>Steam + air</td>
</tr>
<tr>
<td>6 phase AC power</td>
<td>Steam</td>
<td>Steam + O2</td>
</tr>
<tr>
<td>DC power</td>
<td>Steam</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology of Treatment Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-beded lenses of lower permeability material</td>
<td>Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Thermal Test:</td>
<td>3/29/2002</td>
<td>Duration: 309 day</td>
<td></td>
</tr>
<tr>
<td>Hydraulic Control:</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

| Treatment Cell Design: | |
|------------------------|-----------------|-----------------|-----------------|-----------------|
| Size of target zone (ft²): | 35600 | (210 x 160 ft) |
| Thickness of target zone (ft): | 16 | Unknown |
| Depth to top of target zone (ft bgs): | 10 | Unknown |
| Thickness of target zone below water table (ft): | 6 | Unknown |
| Number of energy delivery points: | 120 | Unknown |
| Number of extraction points: | 7 | Unknown |

| Temperature Profile: | Initial formation temperature (deg C): | 16 | Unknown |
|----------------------| Maximum representative formation temperature (deg C): | 84 | Unknown |
| Time to reach maximum representative temperature (days): | 211 | Unknown |
| Duration of treatment at representative temperature (days): | 98 | Unknown |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/31/2003</td>
<td>86</td>
</tr>
<tr>
<td>4/25/2003</td>
<td>70</td>
</tr>
</tbody>
</table>

| Mass of contaminant removed: | |
|-----------------------------|-----------------|-----------------|-----------------|
| Via liquid pumping: | 751 lb | Unknown |
| In vapor stream: | 16375 lb | Unknown |
| Total: | 17127 lb | Unknown |

| Comments: | |
|-----------|-----------------|-----------------|-----------------|
| Attachments: | |

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

___ In Soil

General comments on the thermal application:

Goals: 1) Achieve 90% DRE of all chlorinated and non-chlorinated VOCs 2) Continuous and complete processing of VOC-laden off-gas during spikes in concentrations that can occur during heating

Regular electrode spacing was 18 feet, but in areas where new electrodes were installed the spacing went to 9 ft

Lessons Learned

1) They could never reach the goal of 90°C in some areas because of the metal debris. 2) Metal debris in high densities causes short-circuiting issues 3) Difficulty of heat a thin thermal barrier/hot floor just below the waste pits because of the metals above. 4) Closer electrode spacing can offset the effect of layered highly conductive materials.

Energy

Total Energy Used: 2475898 kWhr x kWhr/m³ kWhr/yd³

___ Total energy applied to treatment zone: ____________ kWhr/m³ ____________ kWhr/yd³

___ Other energy: ____________ kWhr/m³ ____________ kWhr/yd³

___ Please note other energy: ____________________________________________________________________

Cost

Total Project Cost:

___ Consultant Cost: ____________

___ Thermal Vendor Cost: ____________

___ Energy Cost: ____________ m³ ____________ yd³

___ Other Cost 1: ____________

___ Other Cost 2: ____________

___ Other Cost 3: ____________

___ Please note other cost: ___ Other Cost 1: ____________

___ Other Cost 2: ____________

___ Other Cost 3: ____________
Facility Name: Rocky Mountain Arsenal Basin F

City, State, Zip Code: Commerce, CO

OU# or Site #: ________________________________

Primary point of contact: Guggilam Sresty
Organization: ITT Research Institute
Address: 10 W. 35th Street
City, State, Zip Code: Chicago, IL 60616
Phone #: 312-567-4232

Other contacts or vendors who worked on site: None

Point of contact:
Type: Vendor, Consultant  Vendor, Technical Applications  Other
Organization: ________________________________
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: ________________________________
email: ________________________________

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
### Impacted Zone
- Length (parallel to flow direction)(ft.): 
- Width (ft.): 
- Thickness (ft.): 

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells
- Number of relevant monitoring wells with groundwater data: None
- Pre-treatment: 
- Post-treatment: 

- Number of wells relative to treatment zone:
  - Pre-treatment
    - In: 
    - Upgradient: 
    - Downgradient: 
    - Crossgradient: 
  - Post-treatment
    - In: 
    - Upgradient: 
    - Downgradient: 
    - Crossgradient: 

### Soil Borings
- Number of relevant soil borings with pre-treatment data: 
- Number of relevant soil borings with post-treatment data: 
- Number inside treatment zone: 
- Number outside treatment zone: 

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>M/p-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>n-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- 
- 
- 

### Attachments:

- 
- 
- 

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>___________________________________________</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>___________________________________________</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: ________ ft amsl ________ Unknown

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

Depth to water:
- low value (ft bgs): ________ ________ ________
- high value (ft bgs): ________ ________ ________
- Unknown: ________ ________ ________

Flow direction: ________ ________ ________

Horizontal hydraulic gradient (feet/foot): ________ ________ ________ Unknown
Vertical hydraulic gradient (feet/foot): ________ ________ ________ Unknown

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>________ ________</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>________ ________</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Transmissivity (ft2/day): Measured using: ________ ________ ________ Field data
- low: ________ ________ ________
- high: ________ ________ ________

Comments: __________________________________________________________
Attachments: ________________________________________________________
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID#: 0295</th>
</tr>
</thead>
<tbody>
<tr>
<td>x Thermal treatment:</td>
<td></td>
</tr>
<tr>
<td>Conductive</td>
<td></td>
</tr>
<tr>
<td>Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td>AC power</td>
<td>DC power</td>
</tr>
<tr>
<td>Steam</td>
<td>Steam + air</td>
</tr>
<tr>
<td>Steam + O2</td>
<td></td>
</tr>
<tr>
<td>x Type of Test:</td>
<td></td>
</tr>
<tr>
<td>Pilot test</td>
<td>Full-scale System</td>
</tr>
<tr>
<td>x Geology of Treatment Zone:</td>
<td></td>
</tr>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
</tr>
<tr>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td>x Treatment Target Zone:</td>
<td>Saturated only</td>
</tr>
<tr>
<td>Vadose only</td>
<td>Both (Saturated and Vadose zones)</td>
</tr>
<tr>
<td>x Start of Thermal Test:</td>
<td>1992</td>
</tr>
<tr>
<td>Duration:</td>
<td>1 month</td>
</tr>
<tr>
<td>x Hydraulic Control:</td>
<td>Yes</td>
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<td>No</td>
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<tr>
<td>x Treatment Cell Design:</td>
<td></td>
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<tr>
<td>Size of target zone (ft²):</td>
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<tr>
<td>Thickness of target zone (ft):</td>
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<tr>
<td>Depth to top of target zone (ft bgs):</td>
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<tr>
<td>Thickness of target zone below water table (ft):</td>
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<tr>
<td>Number of energy delivery points:</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of extraction points:</td>
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</tr>
<tr>
<td>Temperature Profile:</td>
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<tr>
<td>Initial formation temperature (deg C):</td>
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<tr>
<td>Maximum representative formation temperature (deg C):</td>
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<tr>
<td>Time to reach maximum representative temperature (days):</td>
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<tr>
<td>Duration of treatment at representative temperature (days):</td>
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<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Temperature (deg C)</td>
<td></td>
</tr>
<tr>
<td>x Mass of contaminant removed:</td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
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</tr>
<tr>
<td>In vapor stream:</td>
<td>Unknown</td>
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<tr>
<td>Total:</td>
<td>Unknown</td>
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<tr>
<td>x Notes:</td>
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<tr>
<td>When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.</td>
<td></td>
</tr>
</tbody>
</table>
Cost and Performance

Remediation Goal:

In Groundwater:________________________________________________________

In Soil:______________________________________________________________

Was the Remediation Goal Achieved:

In Groundwater:_________________________________________________________________________________

In Soil: 97 to 99% destruction in soils heated to 250°C or higher

Comment:_____________________________________________________________________________________

________________________________________

General comments on the thermal application:

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

Lessons Learned

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

Energy

Total Energy Used: ___________________________________________ kWhr kWhr/m³ kWhr/yd³

_ Total energy applied to treatment zone: ___________________________ kWhr/m³ kWhr/yd³

_ Other energy: _____________________________________________ kWhr/m³ kWhr/yd³

Please note other energy:_______________________________________________________________

Cost

Total Project Cost:______________________________________________

_ Consultant Cost:_____________________________________________

_ Thermal Vendor Cost:_________________________________________

_ Energy Cost:_________________________________________ m³ yd³

_ Other Cost 1:______________________________________________

_ Other Cost 2:______________________________________________

_ Other Cost 3:______________________________________________

Please note other cost:___________________________________________________________

_ Other Cost 1:______________________________________________

_ Other Cost 2:______________________________________________

_ Other Cost 3:______________________________________________
<table>
<thead>
<tr>
<th>General Site Information</th>
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</thead>
<tbody>
<tr>
<td>File Analyzed By: JT PD</td>
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<tr>
<td>Type of treatment: x Conductive</td>
</tr>
<tr>
<td>Type of Contaminant: x Chlorinated Solvents</td>
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<tr>
<td>x Wood Treating</td>
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<tr>
<td>Treatment Status:</td>
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<tr>
<td>Type of Test: x Pilot Test</td>
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<tr>
<td>Start of Test: 3/3/2002</td>
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<tr>
<td>Type of Site: x Non-DOD</td>
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| Facility Name: Rocky Mountain Arsenal |
| Address: |
| City, State, Zip Code: Commerce City, CO |
| OU# or Site #: Hex Pit |

| Primary point of contact: Ralph Baker |
| Organization: TerraTherm |
| Address: 356 Broad Street |
| City, State, Zip Code: Fitchburg, MA 01420 |
| Phone #: 978-343-0300 email: tbaker@terratherm.com |

| Other contacts or vendors who worked on site | x None |
| Point of contact: Kerry Guy |
| Type: x Vendor, Technical Applications | Other regulator |
| Organization: EPA Region 8 |
| Address: |
| City, State, Zip Code: |
| Phone #: 303-312-7288 email: guy.kerry@epa.gov |

| QA/QC |
| Characteristics of Interest |
| ____ Good pre- and post-treatment groundwater data |
| ____ Good pre- and post-treatment soil data |
| ____ Good temperature profile vs. time information |
| ____ Flux assessment |
| ____ Groundwater elevations |
| ____ Geologic cross-section |
| ____ Hydraulic Conductivity information |
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of relevant monitoring wells with groundwater data: __________
- Number of relevant monitoring wells with pre-treatment data: __________
- Number of relevant monitoring wells with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
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<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Chloroethene</td>
<td>Cross-gradient</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>naphthalene</td>
<td></td>
<td>None</td>
<td>100 mg/kg</td>
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<td>1,1-dichloroethene</td>
<td>xylene</td>
<td>toluene</td>
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<td>10,000 mg/kg</td>
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<td>cis,1,2-dichloroethene</td>
<td>benzene</td>
<td>chlorobenzene</td>
<td></td>
<td>None</td>
<td>100 mg/kg</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td>toluene</td>
<td>chlorobenzene</td>
<td></td>
<td>None</td>
<td>100 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>toluene</td>
<td></td>
<td>None</td>
<td>100 mg/kg</td>
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<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td>dibenzofluoranthene</td>
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<td>1,000 mg/kg</td>
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<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>hexachlorobenzene</td>
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<td>None</td>
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<td>1,1,2-trichloroethane</td>
<td>hexachlorobenzene</td>
<td>dieldrin</td>
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<td>None</td>
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<td>1,1,2,3-tetrachloroethane</td>
<td>hexachlorobenzene</td>
<td>aldrin</td>
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<td>Vinyl Chloride</td>
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<td></td>
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<td>None</td>
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<td>Carbon Tetrachloride</td>
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<td>Chloroform</td>
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<td></td>
<td></td>
<td>None</td>
<td>5 mg/kg</td>
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<tr>
<td>Tetrachloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
</tbody>
</table>

**Average Pre-treatment Concentration per Chemical:**
- Groundwater (mg/L) Soil (mg/kg)
- Groundwater (mg/L) Soil (mg/kg)

**Average Post-treatment Concentration per Chemical:**
- Groundwater (mg/L) Soil (mg/kg)
- Groundwater (mg/L) Soil (mg/kg)

**Comments:**
- Three stated impacted areas of 3200 yd³, 2550 yd³, and 2005 yd³

**Attachments:**
### Unconsolidated Sediments

#### Vadose Zone:
-  Relatively homogeneous and permeable unconsolidated sediments
-  Relatively homogeneous and impermeable unconsolidated sediments
-  Largely permeable sediments with inter-bedded lenses of lower permeability material
-  Largely impermeable sediments with inter-bedded layers of higher permeability material
-  Competent, but fractured bedrock (i.e. crystalline rock)
-  Weathered bedrock, limestone, sandstone

#### Saturated Zone:
-  Relatively homogeneous and permeable unconsolidated sediments
-  Relatively homogeneous and impermeable unconsolidated sediments
-  Largely permeable sediments with inter-bedded lenses of lower permeability material
-  Largely impermeable sediments with inter-bedded layers of higher permeability material
-  Competent, but fractured bedrock (i.e. crystalline rock)
-  Weathered bedrock, limestone, sandstone

#### Ground surface elevation based on wells in or adjacent to treatment zone:
-  5280 ft amsl
-  Unknown

#### Aquifer Characteristics:
- **Is more than 1 aquifer present?**
  - No
  - Yes (number): ___________
  - Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
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</thead>
<tbody>
<tr>
<td>Depth to water: low value (ft bgs):</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Flow direction
- NNE

#### Horizontal hydraulic gradient (feet/foot):
- 0.006
- Unknown

#### Vertical hydraulic gradient (feet/foot):
- | Unknown

#### K range (ft/day)

<table>
<thead>
<tr>
<th></th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
- Unknown

#### Transmissivity (ft²/day):

<table>
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<th></th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Unknown

### Comments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

### Attachments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment: [X] Conductive

Electrical Resistance

- [ ] 3 phase
- [ ] 6 phase
- [ ] AC power
- [ ] DC power
- [ ] Steam
- [ ] Steam + air
- [ ] Steam + O2
- [ ] Other (describe)

Type of Test: [X] Pilot test

Geology of Treatment Zone:

- [X] Full-scale System
- [ ] Relatively homogeneous and permeable consolidated sediments
- [ ] Relatively homogeneous and impermeable consolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

Treatment Targe Zone:

- [X] Saturated only
- [ ] Vadose only
- [ ] Both (Saturated and Vadose zones)

Start of Thermal Test: 3/3/2002

Duration: 12 days

Hydraulic Control

- [ ] Yes
- [X] No

Treatment Cell Design:

Size of target zone (ft²): 4512

Thickness of target zone (ft): 12

Depth to top of target zone (ft bgs): 2

Thickness of target zone below water table (ft): 0

Number of energy delivery points: 566

Number of extraction points: 56

Temperature Profile:

Initial formation temperature (deg C): 10

Maximum representative formation temperature (deg C): 213

Time to reach maximum representative temperature (days): 12

Duration of treatment at representative temperature (days): 1

Formation temperature immediately post-treatment:

Date | Temperature (deg C)
--- | ---

Formation temperature post-treatment monitoring event 1:

Date | Temperature (deg C)
--- | ---

Duration of post-treatment monitoring (days):

Date | Temperature (deg C)
--- | ---

Mass of contaminant removed:

- Via liquid pumping: _____________ lb __ kg __ Unknown
- In vapor stream: _____________ lb __ kg __ Unknown
- Total: _____________ lb __ kg __ Unknown

Comments:

6 ft spacing with borings completed at 12.5 ft bgs

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Soil: 90% DRE removal for each COC (hex, aldrin, dieldrin, endrin, isodrin, and chlorodane) and reduce mean concentrations of 6 COCs below the ROD HHE criteria

Was the Remediation Goal Achieved:

- In Groundwater
- In Soil

General comments on the thermal application:

1. Wanted also to see if ISTD could achieve RMA human health evaluation cleanup criteria for COCs.
2. Turned off after 12 days because of corrosion in pipes.
3. "Frac-outs" were seen from the horizontal well installation under the treatment zone.
4. 30 of 53 vapor tees were clogged and 40 of 56 flexible hoses had accumulation.

Lessons Learned

1. Never horizontally drill under a finished well field.
2. Include worst case-scenario design.
3. Perform pilot if treatable waste are qualitively different than previously encountered.
4. Insulate if abnormally cold weather could occur.
5. Do not assume 90% in-situ neutralization of acids.
6. Use magnetohelic gauge taps and ball valves at vapor tee to have ability to confirm flow.

Energy

Total Energy Used: ___________________________ kWhr  kWhr/m³  kWhr/yd³

- Total energy applied to treatment zone: ___________________________ kWhr/m³  kWhr/yd³
- Other energy: ___________________________ kWhr/m³  kWhr/yd³

Cost

Total Project Cost: ___________________________

- Consultant Cost: ___________________________
- Thermal Vendor Cost: ___________________________
- Energy Cost: ___________________________ m³  yd³
- Other Cost 1: 1954700
- Other Cost 2: 370000
- Other Cost 3: ___________________________

Please note other cost:

- Other Cost 1: design and construction
- Other Cost 2: horizontal dewatering well installation
- Other Cost 3: ___________________________
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By</th>
<th>JT</th>
<th>PD</th>
</tr>
</thead>
</table>

**Type of treatment:**
- [ ] Conductive
- [ ] Steam
- ERH
- [ ] Other: 

**Type of Contaminant:**
- [ ] Chlorinated Solvents
- [ ] Petroleum Hydrocarbons
- [ ] Pesticides
- [ ] Wood Treating
- [ ] Other: 

**Treatment Status:**
- [ ] Active
- [ ] Post

**Type of Test:**
- [ ] Pilot Test
- [ ] Full Scale System

**Type of Site:**
- [ ] Non-DOD
- [ ] DoD

---

**Facility Name:** Plating Facility
**Address:**
**City, State, Zip Code:** Danbury, CT
**OU# or Site #:**

---

**Primary point of contact:** Jay Dablow
**Organization:** ERM
**Address:** 3 Hutton Centre, Suite 600
**City, State, Zip Code:** Santa Ana, CA 92707
**Phone #:** 714-430-1476  
**email:** jay.dablow@erm.com

**Other contacts or vendors who worked on site:** None
**Point of contact:**
- [ ] Vendor, Consultant
- [ ] Vendor, Technical Applications
- [ ] Other

**Organization:**
**Address:**
**City, State, Zip Code:**
**Phone #:**
**email:**

---

**QA/QC**

**Characteristics of Interest**
- [ ] Good pre- and post-treatment groundwater data
- [ ] Good pre- and post-treatment soil data
- [ ] Good temperature profile vs. time information
- [ ] Flux assessment
- [ ] Groundwater elevations
- [ ] Geologic cross-section
- [ ] Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**  
Length (parallel to flow direction): __________  
Width: __________  
Thickness: __________  
Unknown  
Impacted zone as defined by documentation  
Alternative method for determining size of impacted zone (See source zone definition attachments)  
Map attachment

**Monitor Wells:**  
Number of relevant monitoring wells with groundwater data: __________  
Pre-treatment: __________  
Post-treatment: __________  
None  
Number of wells relative to treatment zone:  
Pre-treatment: In: __________  
Upgradient: __________  
Downgradient: __________  
Crossgradient: __________  
Post-treatment: In: __________  
Upgradient: __________  
Downgradient: __________  
Crossgradient: __________

**Soil Borings:**  
Number of relevant soil borings with pre-treatment data: __________  
Number inside treatment zone: __________  
Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical: Groundwater (mg/L)</th>
<th>Average Post-treatment Concentration per Chemical: Groundwater (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil (mg/kg)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
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<td>None</td>
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</tr>
<tr>
<td>Tetrachloroethene</td>
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<td>None</td>
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<td>1,1-dichloroethene</td>
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<tr>
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<td>1,1,2-trichloroethane</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Chemicals of Concern**  
- Trichloroethene  
- Tetrachloroethene  
- 1,1-dichloroethene  
- cis-1,2-dichloroethene  
- trans-1,2-dichloroethene  
- 1,1-dichloroethane  
- Ethylbenzene  
- 1,2-dichloroethane  
- 1,1,1-trichloroethane  
- 1,1,2-trichloroethane  
- Vinyl Chloride

**Comments:**  
________________________________________________________________________________________

**Attachments:**  
________________________________________________________________________________________
Hydrogeologic Conceptual Model

Geology: Zone  
Vadose Zone:  
  • Relatively homogeneous and permeable unconsolidated sediments  
  • Relatively homogeneous and impermeable unconsolidated sediments  
  • Largely permeable sediments with inter-bedded lenses of lower permeability material  
  • Largely impermeable sediments with inter-bedded layers of higher permeability material  
  • Competent, but fractured bedrock (i.e. crystalline rock)  
  • Weathered bedrock, limestone, sandstone  
Saturated Zone:  
  • Relatively homogeneous and permeable unconsolidated sediments  
  • Relatively homogeneous and impermeable unconsolidated sediments  
  • Largely permeable sediments with inter-bedded lenses of lower permeability material  
  • Largely impermeable sediments with inter-bedded layers of higher permeability material  
  • Competent, but fractured bedrock (i.e. crystalline rock)  
  • Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone:  

Aquifer Characteristics:

Is more than 1 aquifer present?  
No  
Yes (number):  
Unknown (assume single aquifer)

Depth to water:  
  • Low value (ft bgs):  
  • High value (ft bgs):  
  • Unknown:

Flow direction:

Horizontal hydraulic gradient (feet/foot):

Vertical hydraulic gradient (feet/foot):

K range (ft/day)  
Measured using:  
  • Slug Test  
  • Laboratory  
  • Field data

Transmissivity (ft2/day)  
Measured using:  
  • Slug Test  
  • Laboratory  
  • Field data

Comments:

Attachments:
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power

Steam  
- \( x \)  
- Steam + air  
- Steam + O2

Type of Test:  
- \( x \) Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
Duration:  
Hydraulic Control  
- Yes  
- No

Treatment Cell Design:
Size of target zone (ft\(^2\)):  
Thickness of target zone (ft):  
Depth to top of target zone (ft bgs):  
Thickness of target zone below water table (ft):  
Number of energy delivery points:  
Number of extraction points:  

Temperature Profile:
- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C):  
- Time to reach maximum representative temperature (days):  
- Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):

Mass of contaminant removed:
- Via liquid pumping:  
- In vapor stream:  
- Total:

Date  
Temperature (deg C)

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater:
- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater
- In Soil

General comments on the thermal application:

Lessons Learned

- Energy
  - Total Energy Used: ____kWhr ____kWhr/m³ ____kWhr/yd³
    - Total energy applied to treatment zone: ____kWhr/m³ ____kWhr/yd³
    - Other energy: ____kWhr/m³ ____kWhr/yd³

- Cost
  - Total Project Cost:
    - Consultant Cost: 
    - Thermal Vendor Cost: 
    - Energy Cost: ____m³ ____yd³
    - Other Cost 1: 
    - Other Cost 2: 
    - Other Cost 3: 

  - Please note other cost: 
    - Other Cost 1: 
    - Other Cost 2: 
    - Other Cost 3:
General Site Information

File Analyzed By: JT PD
Type of treatment: Conductive Steam ERH Other: 
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 2/7/1997 End of Test: 3/9/1997 Duration: 30 d
Type of Site: Non-DOD DoD

Facility Name: Dover Air Force Base
City, State, Zip Code: Dover, DE
OU# or Site #: 

Primary point of contact: Tim McHale
Organization: Dover National Test Site
Address: Bldg 909 Arnold Drive Ext
Phone #: 302-677-4103
email: timothy.mchale@dover.af.mil

Other contacts or vendors who worked on site: None

Type of Site: Non-DOD

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

*No contaminants of concern. They used two tracers that mimicked DNAPL, i.e. Perfluoromethylcyclohexane (PMCH) and perfluorotrimethycyclohexane (PTMCH).*
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vadose Zone:</strong></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td><strong>Saturated Zone:</strong></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone: Oct-35 ft amsl

#### Aquifer Characteristics:

- Is more than 1 aquifer present? **x** Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Flow direction: **NW**

- Horizontal hydraulic gradient (feet/foot): **x** Unknown

- Vertical hydraulic gradient (feet/foot): **x** Unknown

#### K range (ft/day)

- Measured using: **x** Slug Test, **x** Laboratory, **x** Field data

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>K range</td>
<td>8.5</td>
<td>27.8</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft²/day)

- Measured using: **x** Slug Test, **x** Laboratory, **x** Field data

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>x</strong> Unknown</td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

Attachments:  

____________________________________________________________________________________________

____________________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance

Type of Test:  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 2/7/1997
- Duration: 30 d

Treatment Cell Design:  
- Yes
- No

Size of target zone (ft²):  
- 900
- Unknown

Thickness of target zone (ft):  
- 15
- Unknown

Depth to top of target zone (ft bgs):  
- 20
- Unknown

Thickness of target zone below water table (ft):  
- 10
- Unknown

Number of energy delivery points:  
- 6
- Unknown

Number of extraction points:  
- 1
- Unknown

Temperature Profile:  
- Initial formation temperature (deg C): 14
- Maximum representative formation temperature (deg C): 100
- Time to reach maximum representative temperature (days): 17
- Duration of treatment at representative temperature (days): 13
- Formation temperature immediately post-treatment: Unknown
- Formation temperature post-treatment monitoring event 1: Unknown
- Duration of post-treatment monitoring (days): Unknown

Mass of contaminant removed:  
- Via liquid pumping: Unknown
- In vapor stream: Unknown
- Total: Unknown

Comments:  
- treated - 800 yd³ by the heat extending out from the array and steam rising upward

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Goal of the project was to see if SPH would remove DNAPL from the subsurface

Lessons Learned

Energy

Total Energy Used: 200000 kWhr

Cost

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
General Site Information

File Analyzed By: JT PD Date: 11/9/2006
Type of treatment: Conductive Steam ERH Other: 
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 
Treatment Status: Active Post 
Type of Test: Pilot Test Full Scale System 
Start of Test: 8/18/1999 End of Test: 7/12/2000 Duration: 203 d
Type of Site: Non-DOD DoD

Facility Name: Cape Canaveral
Address: ________________
City, State, Zip Code: Florida
OU# or Site #: LC34

Primary point of contact: Jackie Quinn
Organization: Kennedy Space Center
Address: ________________
City, State, Zip Code: ________________
Phone #: 321-867-8410 email: jacqueline.w.quinn@nasa.gov

Other contacts or vendors who worked on site None
Point of contact: Stephen Antonioli
Type: Vendor, Consultant Vendor, Technical Applications Other 
Organization: MSE Technology Application
Address: PO Box 4078 200 Technology Way
City, State, Zip Code: Butte, MT 59702
Phone #: ________________ email: 

QA/QC

Characteristics of Interest
Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data
Good temperature profile vs. time information Flux assessment
Groundwater elevations Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.):
- Width (ft.):
- Thickness (ft.):
- Unknown
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with pre-treatment data: None
  - Pre-treatment: 10
  - Post-treatment: 10
  - Number of relevant monitoring wells with groundwater data:
  - Upgradient: Pre-treatment: In: 6
  - Upgradient: Post-treatment: In: 6
  - DOWNGRADIENT: Pre-treatment: Unknown
  - DOWNGRADIENT: Post-treatment: Unknown
  - Crossgradient: Pre-treatment: Unknown
  - Crossgradient: Post-treatment: Unknown

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: None
  - Number inside treatment zone: None
  - Number outside treatment zone: None

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trichloroethene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

Area contained an estimated 11313 kg of TCE and vinyl chloride where all ND for pre-demo soil samples and for post-treatment trans (shallow) groundwater.

**Attachments:**

[Attachment Details]
### Hydrogeologic Conceptual Model

#### Geology:
- **Vadose Zone:**
  - Weathered bedrock, limestone, sandstone
- **Saturated Zone:**
  - Weathered bedrock, limestone, sandstone

#### Aquifer Characteristics:
- **Is more than 1 aquifer present?**
  - **No**
  - **Yes** (number): 2

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs):</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Flow direction

#### K range (ft/day)
- **Measured using:** Slug Test Laboratory Field data
  - **low**
  - **high**

#### Transmissivity (ft²/day)
- **Measured using:** Slug Test Laboratory Field data
  - **low**
  - **high**

#### Comments:
- **Upper sand unit**
  - $K = 0.14$ to $13.7$ ft/day average $9.7$ ft/day
- **Middle fine-grained unit**
  - $K = 2.1$ to $4.9$ ft/day average $3.2$ ft/day
- **Lower Sand unit**
  - $K = 2.7$ to $3.3$ ft/day average $1.6$ ft/day

#### Attachments:
### Thermal Treatment: Design

**Thermal treatment:**
- [ ] Conductive
- [x] Electrical Resistance

**Type of Test:**
- [x] Pilot test

**Geology of Treatment Zone:**
- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [x] Largely permeable sediments with inter-bedded layers of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- [ ] Saturated only
- [x] Vadose only
- [x] Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- 9/18/1999
- Duration: 203 d

**Hydraulic Control**
- [ ] Yes
- [ ] No

**Treatment Cell Design:**
- Size of target zone (ft²): 1750
- Thickness of target zone (ft): 42
- Depth to top of target zone (ft bgs): 3
- Thickness of target zone below water table (ft): 41
- Number of extraction points: 12
- Number of energy delivery points: 12

**Temperature Profile:**
- Initial formation temperature (deg C): 26
- Maximum representative formation temperature (deg C): Unknown
- Time to reach maximum representative temperature (days): Unknown
- Duration of treatment at representative temperature (days): Unknown

**Formation temperature immediately post-treatment:**

**Formation temperature post-treatment monitoring event 1:**

**Duration of post-treatment monitoring (days):**

**Mass of contaminant removed:**
- Via liquid pumping: Unknown lb kg
- In vapor stream: Unknown lb kg
- Total: 2150 lb kg

**Notes:**
- 2 conductive intervals of 23 to 30 ft bgs and 38 to 45 ft bgs.

**Attachments:**

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- **In Groundwater**: FL cleanup of GW of 3 ug/L of TCE
- **In Soil**: Reach FL cleanup goal for TCE in soil of 30 ug/kg

Was the Remediation Goal Achieved:

- **In Groundwater**: 
  - Comment:
- **In Soil**: 
  - Comment:

General comments on the thermal application:

**Objective**: 1) Remove 90% of TCE mass in saturated zone  
2) State of FL cleanup goals  
3) Clean silt and clay stringers  
4) Remove DNAPL pools from depressions in clay aquitard  
5) Avoid mobilization

**Lessons Learned**


**Energy**

Total Energy Used:  
- Total energy applied to treatment zone: 1725000 kWhr  
- Other energy: 
  - Please note other energy:


**Cost**

Total Project Cost: 568742

- Consultant Cost:  
- Thermal Vendor Cost:  
- Energy Cost: 72484
  - Other Cost 1:  
  - Other Cost 2:  
  - Other Cost 3: 
  - Please note other cost:
Facility Name: Cape Canaveral
Organization: Kennedy Space Center

Primary point of contact: Jackie Quinn
Phone #: 321-867-8410
email: jacqueline.w.quinn@nasa.gov

Other contacts or vendors who worked on site
Type: Vendor, Consultant
Organization: IWR

Characteristics of Interest
- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

**X**  Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

- Impacted as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**X**  Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>In: __________</td>
<td>_____________</td>
</tr>
<tr>
<td>Upgradient: __________</td>
<td>__________</td>
</tr>
<tr>
<td>Downgradient: __________</td>
<td>__________</td>
</tr>
<tr>
<td>Crossgradient: __________</td>
<td>__________</td>
</tr>
</tbody>
</table>

**X**  Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________

| Number inside treatment zone: __________ | Number outside treatment zone: __________ |

**X**  Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>X</td>
<td>TCE - Shallow</td>
<td>500 mg/L</td>
<td>50 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>X</td>
<td>TCE - Mid</td>
<td>100 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>X</td>
<td>TCE - Deep</td>
<td>500 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>X</td>
<td>cis-12 DCE - Shallow</td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>X</td>
<td>cis-12 DCE - Mid</td>
<td>100 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>X</td>
<td>cis-12 DCE - Deep</td>
<td>50 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>X</td>
<td>Trans-12 DCE</td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>X</td>
<td>Trans-12 DCE</td>
<td>5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>X</td>
<td>Trans-12 DCE</td>
<td>50 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>X</td>
<td>VC - Shallow</td>
<td>50 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>X</td>
<td>VC - Mid</td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-12-DCE</td>
<td>X</td>
<td>VC - Deep</td>
<td>100 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

Shallow treatment zone from 18 to 24 ft; Intermediate treatment zone from 25 to 28 ft; Deep from 41 to 44 ft

Soil Samples from cis-12-DCE, trans-12-DCE, and vinyl chloride where all ND for pre-demo sample

**Attachments:**

None
## Hydrogeologic Conceptual Model

### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded layers of lower permeability material</td>
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<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

#### Is more than 1 aquifer present?

- **No**
- **Yes** (number): 2
- Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs):</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Horizontal hydraulic gradient (feet/foot):

- Measured using: Slug Test, Laboratory, Field data
- low: Unknown
- high: 0.00005 to 0.0008

#### Vertical hydraulic gradient (feet/foot):

- Measured using: Slug Test, Laboratory, Field data
- low: Unknown
- high: Unknown

### K range (ft/day):

- Measured using: Slug Test, Laboratory, Field data
- low: Unknown
- high: 0.000009 to 0.0007

### Transmissivity (ft²/day):

- Measured using: Slug Test, Laboratory, Field data
- low: Unknown
- high: 0.000005 to 0.0008

### Ground surface elevation based on wells in or adjacent to treatment zone:

- 5 ft amsl
- Unknown

### Attachments:

- Upper sand unit: K = 0.14 to 13.7 ft/day, average 9.7 ft/day
- Middle fine-grained unit: K = 2.1 to 4.9 ft/day, average 3.2 ft/day
- Lower Sand unit: K = 2.7 to 3.3 ft/day, average 1.6 ft/day
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Type:</td>
<td>Conductive</td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot test</td>
</tr>
<tr>
<td>Geology of Treatment Zone:</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Start of Thermal Test:</td>
<td>7/19/2001</td>
</tr>
<tr>
<td>Duration:</td>
<td>160 d</td>
</tr>
<tr>
<td>Size of target zone (ft^2):</td>
<td>1750</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>40</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>6</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>40</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>4</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>18</td>
</tr>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Formation temperature immediately post-treatment:</td>
<td>Unknown</td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Mass of contaminant removed:</td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td>16400 lb</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>16400 kg</td>
</tr>
</tbody>
</table>
| Notes:                                                                  | When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
General comments on the thermal application:

Primary criterion for success was defined as the ability to cost effectively remove TCE DNAPL. Site Characterization cost were not included, but were estimated to be $255,000.

Lessons Learned

Energy

Total Energy Used: _____ kWhr/yd³ _____ kWhr/m³ _____ kWhr/yd³

Total energy applied to treatment zone: _____ kWhr/yd³ _____ kWhr/m³

Other energy: _____ kWhr/yd³ _____ kWhr/m³

Please note other energy: __________________________________________________________________________________________

Cost

Total Project Cost: 1201175

Consultant Cost: _________________________

Thermal Vendor Cost: _________________________

Energy Cost: 13902 m³ yd³

Other Cost 1: _________________________

Other Cost 2: _________________________

Other Cost 3: _________________________

Please note other cost: Other Cost 1: _________________________

Other Cost 2: _________________________

Other Cost 3: _________________________
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT PD</th>
<th>Date:</th>
<th>x File Analyzed By: JT PD</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam</td>
<td>ERH</td>
<td>Other:</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
<td>Other:</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>x Post</td>
<td>x Pilot Test</td>
<td>Full Scale System</td>
</tr>
<tr>
<td>Start of Test:</td>
<td>27-Dec</td>
<td>End of Test:</td>
<td>10-Oct</td>
<td>Duration: 250 days</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>x Non-DOD</td>
<td>DoD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>FDOT Greensboro Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code: Greensboro, FL</td>
<td></td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary point of contact:</th>
<th>Jimmy Bailey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>Florida Department of Transportation</td>
</tr>
<tr>
<td>Address:</td>
<td>PO Box 607</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Chipley, Florida 32428-0607</td>
</tr>
<tr>
<td>Phone #:</td>
<td>850-531-9860</td>
</tr>
<tr>
<td>email:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other contacts or vendors who worked on site:</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of contact:</td>
<td>David Rountree</td>
</tr>
<tr>
<td>Type:</td>
<td>Vendor, Consultant</td>
</tr>
<tr>
<td>Organization:</td>
<td>WRS Infrastructure &amp; Environment, Inc.</td>
</tr>
<tr>
<td>Address:</td>
<td>625 East Tennessee Street, Suite 100</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Tallahassee, FL 32308-4939</td>
</tr>
<tr>
<td>Phone #:</td>
<td>850-531-9860</td>
</tr>
<tr>
<td>email:</td>
<td></td>
</tr>
</tbody>
</table>

### QA/QC

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Good pre- and post-treatment groundwater data</td>
<td>Good pre- and post-treatment soil data</td>
</tr>
<tr>
<td>Good temperature profile vs. time information</td>
<td>Flux assessment</td>
</tr>
<tr>
<td>Groundwater elevations</td>
<td>Geologic cross-section</td>
</tr>
<tr>
<td>Hydraulic Conductivity information</td>
<td></td>
</tr>
</tbody>
</table>
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): 40
- Width (ft.): 40
- Thickness (ft.): Unknown
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

Monitor Wells:
- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment: 12
  - Post-treatment: 12
  - None
  - Number of relevant monitoring wells with post-treatment data:
  - Upgradient: None
  - Downgradient: None
  - Crossgradient: None

Soil Borings:
- Number of relevant soil borings with pre-treatment data:
  - Number of relevant soil borings with post-treatment data:
  - Number of soil borings with post-treatment data:
  - Number inside treatment zone: None
  - Number outside treatment zone: None

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benene</td>
<td>Crossdr</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>Diesel</td>
<td>5,000 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethene</td>
<td>Naphthalene</td>
<td>Gasoline (BTEX)</td>
<td>5,000 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis,1,2-Dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>50 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-Dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>1,2-Dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-Trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-Trichloroethane</td>
<td>Total xylenes</td>
<td></td>
<td>5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>MTBE</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
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<td>None</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

All COCs were nondetect in post treatment samples but they did not give the detection limit.

Attachments:
### Hydrogeologic Conceptual Model

#### Facility ID:
0343

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
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<td></td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone:
255 ft amsl

#### Aquifer Characteristics:

**Is more than 1 aquifer present?**
- **No**
- **Yes (number):** 1

**Depth to water:**
- **Low value (ft bgs):** 10
- **High value (ft bgs):**
- **Unknown:**

**Flow direction:**
- **N-NE**

**Horizontal hydraulic gradient (feet/foot):**
- 0.005752

**Vertical hydraulic gradient (feet/foot):**
- Unknown

**K range (ft/day):**
- **Measured using:** Slug Test, Laboratory, Field data
  - **Low:** 1.91
  - **High:** 2.19

**Transmissivity (ft²/day):**
- **Measured using:** Slug Test, Laboratory, Field data
  - **Low:**
  - **High:** Unknown

#### Comments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

#### Attachments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
  - Steam
  - Steam + air
  - Steam + O2
  - Other (describe)

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 2-Jan

Duration of post-treatment monitoring (days):  
- 250 days

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft2):  
- 4305

Thickness of target zone (ft):  
- 23

Depth to top of target zone (ft bgs):  
- 10

Thickness of target zone below water table (ft):  
- 13

Number of energy delivery points:  
- 9

Number of extraction points:  
- 16

Temperature Profile:

Initial formation temperature (deg C):  
- 15

Maximum representative formation temperature (deg C):  
- 60

Time to reach maximum representative temperature (days):  
- 170

Duration of treatment at representative temperature (days):  
- 80

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping:  
- \( \text{lb} \)  
- \( \text{kg} \)  
- Unknown

In vapor stream:  
- \( \text{lb} \)  
- \( \text{kg} \)  
- Unknown

Total:  
- \( \text{lb} \)  
- \( \text{kg} \)  
- Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: Source Reduction
- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater: Y
  Comment: Total VOA /BTEX compounds went from >100,000 ug/L to <200 ug/L.

- In Soil:

General comments on the thermal application:

Very effective at removing contamination from the ground - contaminant removal rates went up by an order of magnitude. Knowledge of extent of source material is critical to proper design. Target temperature of 70 to 80°C.

Lessons Learned:

The remediation worked very well where it was implemented. More detailed knowledge of the contaminant distribution would have resulted in a wider application of the thermal technology. High temperatures of recovered groundwater plus high contaminant concentrations led to chemical compatibility issues not normally seen on petroleum sites.

Energy:

- Total Energy Used: 291 kWh, kWh/m³, kWh/yd³
  - Total energy applied to treatment zone: kWh/m³, kWh/yd³
  - Other energy: kWh/m³, kWh/yd³
  - Please note other energy: ________________

Cost:

- Total Project Cost: ________________
  - Consultant Cost: ________________
  - Thermal Vendor Cost: ________________
  - Energy Cost: m³, yd³
  - Other Cost 1: ________________
  - Other Cost 2: ________________
  - Other Cost 3: ________________
  - Please note other cost: ________________
General Site Information

Facility Name: Confidential Europe
Address: ________________________________
City, State, Zip Code: Europe
OU# or Site #: ________________________________

Primary point of contact: James Baldock
Organization: ERM
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: 01865 384 800 email: James.baldock@erm.com

Other contacts or vendors who worked on site: None
Point of contact: Ross Pollock
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: Churngold Remediation Ltd
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: 0117 916 0510 email: ross.pollock@churngold.com

QA/QC

Characteristics of Interest
___ Good pre- and post-treatment groundwater data
___ Good pre- and post-treatment soil data
___ Good temperature profile vs. time information
___ Flux assessment
___ Groundwater elevations
___ Geologic cross-section
___ Hydraulic Conductivity information
General Site Assessment Data

Facility ID: 0347

Impacted Zone: Length (parallel to flow direction)(ft.): ___________ Width (ft.): ___________ Thickness (ft.): ___________ Unknown

Impacted zone as defined by documentation
Alternative method for determining size of impacted zone (See source zone definition attachments)
Map attachment

Monitor Wells: Number of relevant monitoring wells with groundwater data: ___________ None

Number of wells relative to treatment zone:
Pre-treatment: In: ___________ Upgradient: ___________ Downgradient: ___________ Crossgradient: ___________
Post-treatment: In: ___________ Upgradient: ___________ Downgradient: ___________ Crossgradient: ___________

Soil Borings: Number of relevant soil borings with pre-treatment data: ___________
Number of relevant soil borings with post-treatment data: ___________
Number inside treatment zone: ___________
Number outside treatment zone: ___________

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>trichloroethene</td>
<td>toluene</td>
<td>water</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>tetrachloroethene</td>
<td>jet fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
<td>total xylenes</td>
<td></td>
<td>None</td>
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<td></td>
<td>1,1,2,2-tetrachloroethene</td>
<td>ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>vinyl chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:
______________________________________________________________________________________________________________________________
______________________________________________________________________________________________________________________________
______________________________________________________________________________________________________________________________
______________________________________________________________________________________________________________________________
Attachments:
______________________________________________________________________________________________________________________________
### Hydrogeologic Conceptual Model

#### Geology:

**Zone** | Unconsolidated Sediments
---|---
Vadose Zone: | Relatively homogeneous and permeable unconsolidated sediments
| Relatively homogeneous and impermeable unconsolidated sediments
| Largely permeable sediments with inter-bedded lenses of lower permeability material
| Largely impermeable sediments with inter-bedded layers of higher permeability material
| Competent, but fractured bedrock (i.e. crystalline rock)
| Weathered bedrock, limestone, sandstone

Saturated Zone: | Relatively homogeneous and permeable unconsolidated sediments
| Relatively homogeneous and impermeable unconsolidated sediments
| Largely permeable sediments with inter-bedded lenses of lower permeability material
| Largely impermeable sediments with inter-bedded layers of higher permeability material
| Competent, but fractured bedrock (i.e. crystalline rock)
| Weathered bedrock, limestone, sandstone

#### Ground surface elevation based on wells in or adjacent to treatment zone:

| | ft
---|---
Unknown

#### Aquifer Characteristics:

| Is more than 1 aquifer present? | No | Yes (number): | Unknown (assume single aquifer)
---|---|---|---

| Depth to water | Aquifer 1 | Aquifer 2 | Aquifer 3
---|---|---|---
low value (ft bgs): |
high value (ft bgs): |
Unknown: |

| Flow direction |
---|

| Horizontal hydraulic gradient (feet/foot): |
---|

| Vertical hydraulic gradient (feet/foot): |
---|

| K range (ft/day) | Measured using: | Slug Test | Laboratory | Field data
---|---|---|---|---
low |
high |

| Transmissivity (ft²/day): | Measured using: | Slug Test | Laboratory | Field data
---|---|---|---|---
low |
high |

#### Comments:

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

#### Attachments:

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  

Steam:  
- Steam  
- Steam + air  
- Steam + O2  
- Other (describe)

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded layers of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
2/21/2005  
Duration: 85 d

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>17222</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>23</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>23</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Temperature Profile:

- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C):  
- Time to reach maximum representative temperature (days):  
- Duration of treatment at representative temperature (days):  

- Date  
- Temperature (deg C)

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

- Via liquid pumping:  
- In vapor stream:  
- Total: 2000 lb  

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: ____________ kWhr ____________ kWhr/m³ ____________ kWhr/yd³

Total energy applied to treatment zone: ____________ kWhr/m³ ____________ kWhr/yd³

Other energy: ____________ kWhr/m³ ____________ kWhr/yd³

Please note other energy:

Cost

Total Project Cost: ____________

Consultant Cost: ____________

Thermal Vendor Cost: ____________

Energy Cost: ____________ m³ ____________ yd³

Other Cost 1: ____________

Other Cost 2: ____________

Other Cost 3: ____________

Please note other cost:

Other Cost 1: ____________

Other Cost 2: ____________

Other Cost 3: ____________
File Analyzed By: JT PD

Type of treatment: Conductive Steam ERH Other: ____________________________

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: ____________________________

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System


Type of Site: Non-DOD DoD

Facility Name: Young Rainey Star Center

City, State, Zip Code: Largo, FL

OU# or Site #: Northeast Site Area A

Primary point of contact: Joe Daniel

Organization: SM Stoller Corporation

Address: 7887 Bryan Dairy Rd, Suite 260

City, State, Zip Code: Largo, FL 33777

Phone #: 727-549-0603 email: joe.daniel@gjo.doe.gov

Other contacts or vendors who worked on site: None

Type of contact: Jack Craig

Type: Vendor, Consultant Vendor, Technical Applications Other

Organization: Department of Energy

Address: 7887 Bryan Dairy Road, Suite 195

City, State, Zip Code: Largo, FL 33777

Phone #: 412-386-4754 email: jack.craig@ln.doe.gov

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data

Good temperature profile vs. time information

Groundwater elevations

Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0050

| Impacted Zone: | Length (parallel to flow direction)(ft.): | Width (ft.): | Thickness (ft.): | Unknown
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Impacted zone as defined by documentation</td>
<td>Alternative method for determining size of impacted zone (See source zone definition attachments)</td>
<td>Map attachment</td>
<td>—</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitor Wells:</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-treatment: 6</td>
</tr>
<tr>
<td>Number of wells relative to treatment zone:</td>
<td></td>
</tr>
<tr>
<td>Pre-treatment</td>
<td>In: 6</td>
</tr>
<tr>
<td>Post-treatment</td>
<td>In: 16</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>26</td>
</tr>
<tr>
<td>Number of relevant soil borings with post-treatment data:</td>
<td></td>
</tr>
<tr>
<td>Number inside treatment zone:</td>
<td>40</td>
</tr>
<tr>
<td>Number outside treatment zone:</td>
<td>16</td>
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</tbody>
</table>

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Jet Fuel</td>
<td>Crossdr</td>
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<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
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<td>Ethylbenzene</td>
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<td>m/p-xylene</td>
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<td>None</td>
<td>None</td>
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<td>1,1,1-trichloroethene</td>
<td></td>
<td>o-xylene</td>
<td></td>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
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</tr>
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<td>Methylen Chloride</td>
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**Comments:**

- Text not visible

**Attachments:**

- Text not visible
## Hydrogeologic Conceptual Model

### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number)</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>1</td>
<td>(Average 5)</td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
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</table>

### Flow direction

- ESE

### Horizontal hydraulic gradient (feet/foot): 0.002

### Vertical hydraulic gradient (feet/foot): Unknown

### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>0.99</td>
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</tr>
<tr>
<td>high</td>
<td>7.1</td>
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</tbody>
</table>

### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Measured using</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone: 17 ft amsl

### Vertical K = 1.06e-6 to 1.06e-4 cm/s

Average with Darcys - 1 ft/day and n=0.3 for 20 ft/yr

### Comments

- Vertical K = 1.06e-6 to 1.06e-4 cm/s
- Average with Darcys - 1 ft/day and n=0.3 for 20 ft/yr

### Attachments
Thermal Treatment - Design

Thermal treatment: 
- Conductive

Type of Test: 
- Pilot test 
- Full-scale System

Geology of Treatment Zone: 
- Relatively homogeneous and permeable unconsolidated sediments 
- Largely permeable sediments with inter-bedded layers of higher permeability material 
- Weathered bedrock, limestone, sandstone

Treatment Target Zone: 
- Saturated only 
- Vadose only 
- Both (Saturated and Vadose zones)

Start of Thermal Test: 10/3/2002
Duration: 136d

Hydraulic Control: 
- Yes 
- No

Treatment Cell Design:
- Size of target zone (ft2): 10000
- Thickness of target zone (ft): 35
- Depth to top of target zone (ft bgs): 0
- Thickness of target zone below water table (ft): 30
- Number of energy delivery points: 78
- Number of extraction points: 78

Temperature Profile:
- Initial formation temperature (deg C): 28
- Maximum representative formation temperature (deg C): 100
- Time to reach maximum representative temperature (days): 68
- Duration of treatment at representative temperature (days): 70

Formation temperature immediately post-treatment: 2/19/2003
Duration of post-treatment monitoring (days): 

Maximum representative formation temperature (deg C):
- Date: 2/19/2003
- Temperature: 105
- Date: 4/23/2003
- Temperature: 85

Mass of contaminant removed:
- Via liquid pumping: ___ lb ___ kg ___ Unknown
- In vapor stream: ___ lb ___ kg ___ Unknown
- Total: 9920 or 3880 ___ lb ___ kg ___ Unknown

Comments: Mass removed provides the high and low calculations

Volume treated:
- floor 10/3/02 to 10/22/02 and steam+ERH 10/23/02 to 2/17/03
- 10000 yd3 (1816000 ft3)

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:  

- In Groundwater:
  - ug/L - TCE - 11000; cis-1,2-DCE - 50000; methylene chloride - 20000; Toluene - 55000; TPH - 50000

- In Soil:
  - mg/kg - TCE - 20.4; cis-1,2-DCE - 70; methylene chloride -227; Toluene - 15; TPH - 2500

Was the Remediation Goal Achieved:  

- In Groundwater
  - Comment: yes

- In Soil
  - Comment: yes

General comments on the thermal application:

- Target temperature of 84C

Lessons Learned

1) Pressure cycling is effective technique for maximizing mass removal

____ Energy

- Total Energy Used: 10 E9 BTU
- kWh
- kWh/m^3
- kWh/yd^3

- Total energy applied to treatment zone: ____________ kWh/m^3 ____________ kWh/yd^3
- Other energy: ____________ kWh/m^3 ____________ kWh/yd^3
- Please note other energy: ________________________________

____ Cost

- Total Project Cost: 3800000
- Consultant Cost: ________________________________
- Thermal Vendor Cost: ________________________________
- Energy Cost: ________________________________ m^3 ____________ yd^3
- Other Cost 1: ________________________________
- Other Cost 2: ________________________________
- Other Cost 3: ________________________________
- Please note other cost: ________________________________
  - Other Cost 1: ________________________________
  - Other Cost 2: ________________________________
  - Other Cost 3: ________________________________
General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th>11/15/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam</td>
<td>ERH</td>
<td>Other:</td>
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<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
<td>Wood Treating</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
<td></td>
<td></td>
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<tr>
<td>Start of Test:</td>
<td></td>
<td>End of Test: 5/15/2006</td>
<td>Duration:</td>
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</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Facility Name: Young Rainey Star Center
Address: ______________________________
City, State, Zip Code: Largo, FL
OU# or Site #: Northeast Site Area B

Primary point of contact: Paul Darr
Organization: SM Stoller Corporation
Address: 2597 B 314 Rd
City, State, Zip Code: Grand Junction, CO 81503
Phone #: 970-248-7666 email: paul.darr@ejo.doe.gov

Other contacts or vendors who worked on site
Point of contact: Jack Craig
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: Department of Energy
Address: ______________________________
City, State, Zip Code: ______________________________
Phone #: ______________________________ email: ______________________________

QA/QC

**Characteristics of Interest**

- [X] Good pre- and post-treatment groundwater data
- [X] Good pre- and post-treatment soil data
- [X] Good temperature profile vs. time information
- [X] Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
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<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
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<td>cis-1,2-dichloroethene</td>
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<td>None</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Methylene Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

---

**Attachments:**

---
**Hydrogeologic Conceptual Model**

**Facility ID#: 0360**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

**Ground surface elevation based on wells in or adjacent to treatment zone:** __________ ft amsl  
Unknown

**Aquifer Characteristics:**

- Is more than 1 aquifer present?  
  - No  
  - Yes (number): __________  
  - Unknown (assume single aquifer)

- Depth to water:  
  - low value (ft bgs): __________  
  - high value (ft bgs): __________  
  - Unknown: __________

- Flow direction: __________

- Horizontal hydraulic gradient (feet/foot): __________  
  - Unknown: __________

- Vertical hydraulic gradient (feet/foot): __________  
  - Unknown: __________

- K range (ft/day):  
  - Measured using: __________ Slug Test  
  - Laboratory  
  - Field data  
  - low: __________  
  - high: __________  
  - Unknown: __________

- Transmissivity (ft^2/day):  
  - Measured using: __________ Slug Test  
  - Laboratory  
  - Field data  
  - low: __________  
  - high: __________  
  - Unknown: __________

**Notes:**  
- **Vertical K = 1.06e-6 to 1.06e-4 cm/s**
- Average with Darcys - 1 ft/day and n=0.3 for 20 ft/yr

**Attachments:**

- 
  -
  -
  -
  -
  -
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0360</th>
</tr>
</thead>
</table>

#### Thermal treatment:
- [x] Conductive
- [x] Electrical Resistance ETDRP

#### Type of Test:
- [ ] Pilot test
- [x] Full-scale System

#### Geology of Treatment Zone:
- [x] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Largely homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-beded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-beded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

#### Treatment Target Zone:
- [ ] Saturated only
- [ ] Vadose only
- [x] Both (Saturated and Vadose zones)

#### Start of Thermal Test:
- [ ] No
- [x] Yes

#### Treatment Cell Design:
- [ ] Yes
- [x] No

#### Temperature Profile:

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum representative formation temperature (deg C)</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days)</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days)</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### Date

<table>
<thead>
<tr>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

#### Formation temperature immediately post-treatment:

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

#### Formation temperature post-treatment monitoring event 1:

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

#### Duration of post-treatment monitoring (days):

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

#### Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Method</th>
<th>Mass (lb)</th>
<th>Mass (kg)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping</td>
<td>4000</td>
<td>x</td>
<td>_______</td>
</tr>
<tr>
<td>In vapor stream</td>
<td>14000</td>
<td>x</td>
<td>_______</td>
</tr>
<tr>
<td>Total</td>
<td>18000</td>
<td>x</td>
<td>_______</td>
</tr>
</tbody>
</table>

#### Heating cycles - ERH only for hot

```
floor 10/3/02 to 10/22/02 and steam+ERH 10/23/02 to 2/17/03
10000 yd^3 (1816000 ft^3)
```

#### Volume treated

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

#### Comments:
- Mass removed provides the high and low calculations

#### Attachments:

```
Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
```
Cost and Performance

Facility ID#: 0360

Performance

Remediation Goal:

___ In Groundwater: _____________________________

___ In Soil: _____________________________

Was the Remediation Goal Achieved:

___ In Groundwater: _____________________________

Comment: _____________________________

___ In Soil: _____________________________

Comment: _____________________________

General comments on the thermal application:

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

Lessons Learned

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

Energy

Total Energy Used: _____________________________ kWhr _____________________________ kWhr/m³ _____________________________ kWhr/yd³

___ Total energy applied to treatment zone: _____________________________ kWhr/m³ _____________________________ kWhr/yd³

___ Other energy: _____________________________ kWhr/m³ _____________________________ kWhr/yd³

Please note other energy: _____________________________

Cost

Total Project Cost:

___ Consultant Cost: _____________________________

___ Thermal Vendor Cost: _____________________________

___ Energy Cost: _____________________________ m³ _____________________________ yd³

___ Other Cost 1: _____________________________

___ Other Cost 2: _____________________________

___ Other Cost 3: _____________________________

Please note other cost: _____________________________

___ Other Cost 1: _____________________________

___ Other Cost 2: _____________________________

___ Other Cost 3: _____________________________
Facility Name: Cape Canaveral AF Station SLC 15 Pilot
Address: 2216 South Bentley Ave. #14
City, State, Zip Code: Los Angeles, CA 90064
Phone #: 310-445-9851
email: plamori@bemsys.com

Other contacts or vendors who worked on site

Point of contact:
Type: Vendor, Consultant
Vendor, Technical Applications
Other
Organization:
Address:
City, State, Zip Code:
Phone #:
email:

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good temperature profile vs. time information
Groundwater elevations
Hydraulic Conductivity information
### General Site Assessment Data

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________
  - Width (ft.): __________
  - Thickness (ft.): __________
- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: __________
- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: __________
  - Number of relevant soil borings with post-treatment data: __________
- **Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td></td>
<td>500 mg/L</td>
<td>500 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Hexane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Freon 113</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Total VOC's</td>
<td></td>
<td></td>
<td></td>
<td>500 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
</tbody>
</table>

**Notes:**
- Source was considered to be anywhere with dissolved TCE above 10 parts per million (1% solubility). Estimated 582 kg TCE mass.

### Comments:

Comments:

Source was considered to be anywhere with dissolved TCE above 10 parts per million (1% solubility). Estimated 582 kg TCE mass.

### Attachments:

- Attachments:
<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: 10 ft amsl

Is more than 1 aquifer present? No X Yes (number): 2

Depth to water: low value (ft bgs): 5
                      high value (ft bgs): 100
                      Unknown: __________________________

Flow direction: North (usually) sometimes East

Horizontal hydraulic gradient (feet/foot): 10^-3 to 10^-4

Vertical hydraulic gradient (feet/foot): __________________________

K range (ft/day) measured using: Slug Test Laboratory Field data

low 10
high 10

Transmissivity (ft^2/day): measured using: Slug Test Laboratory Field data

low
high

Vertical K in clay 0.0001 ft/day
K's - sand 1 - 30 ft/day, sand 2 - 0.5 ft/day, sand 3 - 0.1 ft/day, sand 4 - 5 ft/day
K's - clay 1 - 0.001 ft/day, clay 2 - 1(10^-4) ft/day, clay 3 - 1(10^-4) ft/day, clay 4 - 0.002 ft/day
### Thermal Treatment - Design

#### Thermal Treatment:
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
- Steam
  - Steam
  - Steam + air
  - Steam + O2
- Other (describe): In situ mixing with steam

#### Type of Test:
- Pilot test
- Full-scale System

#### Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Compacted, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Relatively homogeneous and impermeable unconsolidated sediments
- Competent, but fractured bedrock (i.e. crystalline rock)
- Both (Saturated and Vadose zones)

#### Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

#### Start of Thermal Test:
- Jan-03
- Duration: 6 months

#### Hydraulic Control:
- Yes
- No

#### Treatment Cell Design:
<table>
<thead>
<tr>
<th>Size of target zone (ft²)</th>
<th>2764</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft)</td>
<td>35</td>
<td>Unknown</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs)</td>
<td>20</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft)</td>
<td>35</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points</td>
<td>1 per cell</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of extraction points</td>
<td>1 per cell</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### Temperature Profile:
- Initial formation temperature (deg C): Unknown
- Maximum representative formation temperature (deg C): Unknown
- Time to reach maximum representative temperature (days): Unknown
- Duration of treatment at representative temperature (days): Unknown

#### Date | Temperature (deg C)
--- | ---

#### Formation temperature immediately post-treatment:

#### Formation temperature post-treatment monitoring event 1:

#### Duration of post-treatment monitoring (days):

#### Mass of contaminant removed:
- Via liquid pumping: Unknown lb kg
- In vapor stream: Unknown lb kg
- Total: Unknown lb kg

#### Comments:
- Pilot has 32 test cells from 20 to 55 ft

#### Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Cost and Performance

#### Facility ID#: 0362

<table>
<thead>
<tr>
<th><strong>x</strong></th>
<th><strong>Performance</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Remediation Goal:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>x</strong></td>
<td>In Groundwater:</td>
</tr>
<tr>
<td></td>
<td>80% removal</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>In Soil:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Was the Remediation Goal Achieved:

<table>
<thead>
<tr>
<th><strong>x</strong></th>
<th>In Groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Comment:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>x</strong></td>
<td>In Soil</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Comment:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### General comments on the thermal application:

Goal: reduce the identifiable source area mass by at least 80% or more to meet the objective of reaching GW cleanup target levels (GCTL).

### Lessons Learned

- |
- |
- |
- |
- |
- |
- |
- |
- |

### **Energy**

<table>
<thead>
<tr>
<th><strong>Total Energy Used:</strong></th>
<th>kWhr</th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total energy applied to treatment zone:</strong></td>
<td>kWhr/m³</td>
<td>kWhr/yd³</td>
<td></td>
</tr>
<tr>
<td><strong>Other energy:</strong></td>
<td>kWhr/m³</td>
<td>kWhr/yd³</td>
<td></td>
</tr>
<tr>
<td><strong>Please note other energy:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### **Cost**

| **Total Project Cost:** | |
|-------------------------| |
| **Consultant Cost:** | |
| **Thermal Vendor Cost:** | |
| **Energy Cost:** | m³ | yd³ |
| **Other Cost 1:** | |
| **Other Cost 2:** | |
| **Other Cost 3:** | |
| **Please note other cost:** | **Other Cost 1:** | |
| | **Other Cost 2:** | |
| | **Other Cost 3:** | |
General Site Information

File Analyzed By: JT PD
Type of treatment: Conductive Steam ERH Other: in situ soil mixing w/steam
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: Mar-04 End of Test: Aug-04 Duration: 6 months
Type of Site: Non-DOD DoD

Facility Name: Cape Canaveral AF Station SLC 15 Full-scale
Address: Cape Canaveral, FL
OU# or Site #: Space Launch Complex 15, Solid Waste Management Unite (SMWU C030)

Primary point of contact: Phil La Mori
Organization: BEM Systems
Address: 2216 South Bentley Ave. #14
City, State, Zip Code: Los Angeles, CA 90064
Phone #: 310-445-9851 email: plamori@bemsys.com

Other contacts or vendors who worked on site: None

Point of contact:
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization:
Address:
City, State, Zip Code:
Phone #: email:

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________
  - Width (ft.): __________
  - Thickness (ft.): __________
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

- **Number of wells relative to treatment zone:**
  - Pre-treatment: 16
  - Post-treatment: 16
  - Number of relevant soil borings with pre-treatment data: 16
  - Number of relevant soil borings with post-treatment data: 16
  - Number inside treatment zone: 16/16
  - Number outside treatment zone: 

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross-gradient</td>
<td></td>
<td>500 mg/L</td>
<td>500 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
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<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Total VOCs</strong></td>
<td></td>
<td></td>
<td></td>
<td>500 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
</tbody>
</table>

**Comments:**

Source was considered to be anywhere with dissolved TCE above 10 parts per million (1% solubility). Estimated 582 kg TCE mass.

**Attachments:**

---


### Geology:

**Vadose Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-beded lenses of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Aquifer Characteristics:

- Is more than 1 aquifer present? **Yes** (number): 2
- Depth to water:
  - Low value (ft bgs): 5 feet
  - High value (ft bgs): 100 feet
  - Unknown: ________________

- Flow direction:
  - North (usually)
  - Sometimes East

- Horizontal hydraulic gradient (feet/foot):
- Vertical hydraulic gradient (feet/foot):

- K range (ft/day):
  - Measured using: **Slug Test**
  - Low value: 10 ft/day
  - High value: ________________
  - Field data

- Transmissivity (ft2/day):
  - Measured using: **Slug Test**
  - Low value: ________________
  - High value: ________________

### Comments:

- Vertical K in clay 0.0001 ft/day
  - K's - sand 1 - 30 ft/day, sand 2 - 0.5 ft/day, sand 3 - 0.1 ft/day, sand 4 - 5 ft/day
  - K's - clay 1 - 0.001 ft/day, clay 2 - 1(10^-4) ft/day, clay 3 - 1(10^-4) ft/day, clay 4 - 0.002 ft/day

### Additional Information:

- Ground surface elevation based on wells in or adjacent to treatment zone: **10 ft amsl**
- Unknown:

- Facility ID#: 0363
Thermal Treatment - Design

- **Thermal treatment:**
  - Conductive
  - Electrical Resistance
    - 3 phase
    - 6 phase
    - AC power
    - DC power
  - Steam
    - Steam
    - Steam + air
    - Steam + O2

- **Type of Test:**
  - Pilot test
  - Full-scale System

- **Geology of Treatment Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Treatment Target Zone:**
  - Saturated only
  - Vadose only
  - Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - Mar-04
  - Duration: 6 months

- **Hydraulic Control:**
  - Yes
  - No

- **TREATMENT CELL DESIGN:**

  **Size of target zone (ft²):** 27900
  **Thickness of target zone (ft):** 25
  **Depth to top of target zone (ft bgs):** 10
  **Thickness of target zone below water table (ft):** 15
  **Number of energy delivery points:** 1 per cell
  **Number of extraction points:** 1 per cell

  **Hydraulic Control:**
  - Yes
  - No

  **Temperature Profile:**

  **Initial formation temperature (deg C):**
  **Maximum representative formation temperature (deg C):**
  **Time to reach maximum representative temperature (days):**
  **Duration of treatment at representative temperature (days):**

  **Formation temperature immediately post-treatment:**
  **Formation temperature post-treatment monitoring event 1:**
  **Duration of post-treatment monitoring (days):**

- **Mass of contaminant removed:**
  - Via liquid pumping: ___ lb ___ kg Unknown
  - In vapor stream: ___ lb ___ kg Unknown
  - Total: 13272 ___ lb ___ kg Unknown

- **Comments:**

  TCE only - 4234 lb. Treated 48,000 yd³ including the deluge based (10 to 45 ft bgs) and 323 cells

- **Attachments:**

  ________________________________

  Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater: ____________________________ 80% removal

In Soil: ____________________________________________

Was the Remediation Goal Achieved:

In Groundwater

Comment: __________________________________________

In Soil

Comment: __________________________________________

General comments on the thermal application:

Goal: reduce the identifiable source area mass by at least 80% or more to meet the objective of reaching GW cleanup target levels (GCTL)

Lessons Learned

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

Energy

Total Energy Used: ____________________________ kWhr/m^3 kWhr/yd^3

Total energy applied to treatment zone: ____________________________ kWhr/m^3 kWhr/yd^3

Other energy: ____________________________ kWhr/m^3 kWhr/yd^3

Please note other energy: ____________________________________________

Cost

Total Project Cost: ____________________________ Total Project Cost: ____________________________

Consultant Cost: ____________________________ Thermal Vendor Cost: ____________________________

Energy Cost: ____________________________ m^3 yd^3

Other Cost 1: ____________________________

Other Cost 2: ____________________________

Other Cost 3: ____________________________

Please note other cost: ____________________________

Other Cost 1: ____________________________

Other Cost 2: ____________________________

Other Cost 3: ____________________________
General Site Information

File Analyzed By: JT PD
Date: 1/9/2007
Type of treatment: ___ Conductive ___ Steam ___ ERH ___ Other: in situ soil mixing w/steam
Type of Contaminant: ___ Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides
___ Wood Treating ___ Other: ______________________
Treatment Status: ___ Active ___ Post
Type of Test: ___ Pilot Test ___ Full Scale System
Start of Test: Oct-04 End of Test: Jan-06 Duration: 4 months
Type of Site: ___ Non-DOD ___ DoD

Facility Name: Cape Canaveral AF Station Deluge Basin
Address: ________________________________________________________________
City, State, Zip Code: Cape Canaveral, FL
OU# or Site #: Space Launch Complex 15, Solid Waste Management Unite (SMU C030)

Primary point of contact: Phil La Mori
Organization: BEM Systems
Address: 2216 South Bentley Ave. #14
City, State, Zip Code: Los Angeles, CA 90064
Phone #: 310-445-9851 email: plamori@bemsys.com

Other contacts or vendors who worked on site: None
Point of contact: ____________________________________________________
Type: ___ Vendor, Consultant ___ Vendor, Technical Applications ___ Other ___
Organization: ______________________________________________________
Address: __________________________________________________________
City, State, Zip Code: ______________________________________________
Phone #: __________________________________________________________ email: ____________________________

QA/QC

Characteristics of Interest
___ Good pre- and post-treatment groundwater data
___ Good pre- and post-treatment soil data
___ Good temperature profile vs. time information
___ Flux assessment
___ Groundwater elevations
___ Geologic cross-section
___ Hydraulic Conductivity information
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________

- Pre-treatment: __________
- Post-treatment: __________

- Number of wells relative to treatment zone:
  - Pre-treatment: In: __________, Upgradient: __________, Downgradient: __________, Crossgradient: __________
  - Post-treatment: In: __________, Upgradient: __________, Downgradient: __________, Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________

- Number of relevant soil borings with post-treatment data: __________

- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
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<tr>
<td></td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossd</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>1,1,2,2-tetrachloroethane</td>
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<td>Total VOCs</td>
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<td></td>
<td>500 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
</tbody>
</table>

**Comments:**

Source was Considered to be anywhere with dissolved TCE above 10 parts per million (1% solubility). Estimated 272 kg TCE mass.

**Attachments:**

...
### Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th><strong>Geology:</strong></th>
<th><strong>Zone</strong></th>
<th><strong>Unconsolidated Sediments</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>x</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>x</td>
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<td></td>
<td>x</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>x</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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</tr>
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<td></td>
<td>x</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- **Ground surface elevation based on wells in or adjacent to treatment zone:** 10 ft amsl
- **Unknown**

- **Is more than 1 aquifer present?**
  - **No**
  - **Yes (number):** 2
- **Aquifer Characteristics:**
- **Unknown (assume single aquifer)**

<table>
<thead>
<tr>
<th><strong>Aquifer</strong></th>
<th><strong>Depth to water (ft bgs):</strong></th>
<th><strong>K range (ft/day):</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>low</td>
<td>10^-3 to 10^-4</td>
</tr>
<tr>
<td></td>
<td>high</td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high</td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td>low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high</td>
<td></td>
</tr>
</tbody>
</table>

- **Horizontal hydraulic gradient (feet/foot):** 10^-3 to 10^-4
- **Vertical hydraulic gradient (feet/foot):**
- **Unknown**

- **Flow direction:**
  - North (usually)
  - Sometimes East

- **Vertical K in clay 0.0001 ft/day**
  - K's - sand 1 - 30 ft/day, sand 2 - 0.5 ft/day, sand 3 - 0.1 ft/day, sand 4 - 5 ft/day
  - K's - clay 1 - 0.001 ft/day, clay 2 - 1(10^-4) ft/day, clay 3 - 1(10^-4) ft/day, clay 4 - 0.002 ft/day

- **Attachments:**

- **Comments:**
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
- Steam
  - Steam
  - Steam + air
  - Steam + O2

Other (describe): In situ mixing with steam

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: Oct-04
Duration: 4 months

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft²): 17825
Thickness of target zone (ft): Unknown
Depth to top of target zone (ft bgs): 20
Thickness of target zone below water table (ft): 15
Number of energy delivery points: 1 per cell
Number of extraction points: 1 per cell

Temperature Profile:

Initial formation temperature (deg C): Unknown
Maximum representative formation temperature (deg C): Unknown
Time to reach maximum representative temperature (days): Unknown
Duration of treatment at representative temperature (days): Unknown

Formation temperature immediately post-treatment:
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping: Unknown
In vapor stream: Unknown
Total: 13272

Comments:

Treated 48,000 yd³ including the deluge based (20 to 55 ft bgs) and 261 cells

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: □ 80% removal
- In Soil: □

Was the Remediation Goal Achieved:

- In Groundwater: □
  - Comment: □
- In Soil: □
  - Comment: □

General comments on the thermal application:

Goal: reduce the identifiable source area mass by at least 80% or more to meet the objective of reaching GW cleanup target levels (GCTL)

Lessons Learned:

- □
- □
- □
- □
- □
- □
- □
- □
- □
- □

Energy

Total Energy Used:

□ Total energy applied to treatment zone: □ kWhr □ kWhr/m³ □ kWhr/yd³

□ Other energy: □ kWhr/m³ □ kWhr/yd³

□ Please note other energy: □

Cost

Total Project Cost: □ 7,163,447 (includes deluge basin ($149/yd³))

□ Consultant Cost: □
□ Thermal Vendor Cost: □
□ Energy Cost: □ m³ □ yd³
□ Other Cost 1: □
□ Other Cost 2: □
□ Other Cost 3: □

□ Please note other cost: □ Other Cost 1: □
□ Other Cost 2: □
□ Other Cost 3: □
General Site Information

File Analyzed By: JT × PD ___ Date: 10/26/2006

Type of treatment: ___ Conductive × Steam _____ ERH _____ Other: __________

Type of Contaminant: ___ Chlorinated Solvents × Petroleum Hydrocarbons _____ Pesticides

Treatment Status: ___ Active × Post

Type of Test: ___ Pilot Test × Full Scale System

Start of Test: _______________ End of Test: _______________ Duration: __________

Type of Site: × Non-DOD ___ DoD

Facility Name: Gulf Power / Southern Companies

Address: ____________________________________________________________

City, State, Zip Code: Panama City, FL

OU# or Site #: ______________

Primary point of contact: Jay Dablow

Organization: ERM

Address: 3 Hutton Centre, Suite 600

City, State, Zip Code: Santa Ana, CA 92707

Phone #: 714-430-1476 email: jay.dablow@erm.com

Other contacts or vendors who worked on site

Point of contact: Victor Holstrand

Type: ___ Vendor, Consultant ___ Vendor, Technical Applications × Other __________

Organization: FL EPA

Address: ____________________________________________________________

City, State, Zip Code: _______________________________________________

Phone #: 850-595-8360 x 1212 email: _________________________________

QA/QC

Characteristics of Interest

___ Good pre- and post-treatment groundwater data

___ Good pre- and post-treatment soil data

___ Good temperature profile vs. time information

___ Flux assessment

___ Groundwater elevations

___ Geologic cross-section

___ Hydraulic Conductivity information
### General Site Assessment Data

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</tbody>
</table>

### Comments:

- Soil Borings:
  - Number of relevant soil borings:
  - Number of relevant soil borings with pre-treatment data:
  - Number of relevant soil borings with post-treatment data:
  - Number inside treatment zone:
  - Number outside treatment zone:

### Types of Contaminants

- Monitor Wells:
  - Number of relevant monitoring wells:
  - Pre-treatment:
  - Post-treatment:

- Impacted Zone:
  - Length (parallel to flow direction): ____________
  - Width (ft): ____________
  - Thickness (ft): ____________

- Soil Borings:
  - Number of relevant soil borings:
  - Number of relevant soil borings with pre-treatment data:
  - Number of relevant soil borings with post-treatment data:

- Unknown
**Hydrogeologic Conceptual Model**

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<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

Is more than 1 aquifer present? No Yes (number): _____________ Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction

Horizontal hydraulic gradient (feet/foot): ___________ ___________ ___________ Unknown

Vertical hydraulic gradient (feet/foot): ___________ ___________ ___________ Unknown

K range (ft/day)

Measured using: Slug Test Laboratory Field data

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Transmissivity (ft²/day)

Measured using: Slug Test Laboratory Field data

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments: ____________________________________________________________

Attachments: _________________________________________________________
Thermal Treatment - Design

Facility ID: 0365

Thermal treatment: [ ] Conductive [ ] Electrical Resistance

- [ ] 3 phase
- [ ] 6 phase
- [ ] AC power
- [ ] DC power

Steam: [ ] Steam [ ] Steam + air [ ] Steam + O2

Other (describe): __________________________________________________________________________

Type of Test: [ ] Pilot test [ ] Full-scale System

- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

Geology of Treatment Zone: __________________________________________________________________

Treatment Target Zone: [ ] Saturated only [ ] Vadose only [ ] Both (Saturated and Vadose zones)

Start of Thermal Test: _______________________________________________________________________

Duration: _______________________________________________________________________________

Hydraulic Control: [ ] Yes [ ] No

Treatment Cell Design:

- Size of target zone (ft2): ___________ Unknown (___ x ___ ft)
- Thickness of target zone (ft): ___________ Unknown
- Depth to top of target zone (ft bgs): ___________ Unknown
- Thickness of target zone below water table (ft): ___________ Unknown
- Number of energy delivery points: ___________ Unknown
- Number of extraction points: ___________ Unknown

Temperature Profile:

- Initial formation temperature (deg C): ___________ Unknown
- Maximum representative formation temperature (deg C): ___________ Unknown
- Time to reach maximum representative temperature (days): ___________ Unknown
- Duration of treatment at representative temperature (days): ___________ Unknown

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature immediately post-treatment: __________________________________________________________________

Formation temperature post-treatment monitoring event 1: __________________________________________________________________

Duration of post-treatment monitoring (days): _______________________________________________________________________

Mass of contaminant removed:

- Via liquid pumping: ___________ lb ___________ kg ___________ Unknown
- In vapor stream: ___________ lb ___________ kg ___________ Unknown
- Total: ___________ lb ___________ kg ___________ Unknown

Comments:

________________________________________________________________________________________

Attachments:

________________________________________________________________________________________

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

___ In Groundwater: ________________________________________________

___ In Soil: ________________________________________________

Was the Remediation Goal Achieved:

___ In Groundwater: ________________________________________________

Comment: ________________________________________________

___ In Soil: ________________________________________________

Comment: ________________________________________________

General comments on the thermal application:

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

Lessons Learned

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

Energy

Total Energy Used: ________________________________________________

___ Total energy applied to treatment zone: ________________________________________________

___ Other energy: ________________________________________________

Please note other energy: ________________________________________________

Cost

Total Project Cost: ________________________________________________

___ Consultant Cost: ________________________________________________

___ Thermal Vendor Cost: ________________________________________________

___ Energy Cost: ________________________________________________

___ Other Cost 1: ________________________________________________

___ Other Cost 2: ________________________________________________

___ Other Cost 3: ________________________________________________

Please note other cost: ________________________________________________

___ Other Cost 1: ________________________________________________

___ Other Cost 2: ________________________________________________

___ Other Cost 3: ________________________________________________
General Site Information

File Analyzed By: JT  PD  ERH  Date: 11/1/2006

Type of treatment:  ___ Conductive  ___ Steam  x  ERH  ___ Other:  ________________

Type of Contaminant:  ____ Chlorinated Solvents  ____ Petroleum Hydrocarbons  ____ Pesticides

____ Wood Treating  ____ Other:  ________________

Treatment Status:  ____ Active  x  Post

Type of Test:  ____ Pilot Test  x  Full Scale System

Start of Test:  ________________  End of Test:  ________________  Duration:  ________________

Type of Site:  ___ Non-DOD  ____ DoD

Facility Name:    Confidential, Tampa, FL

Address:  _______________________________________________________________________

City, State, Zip Code:  Tampa, FL

OU# or Site #:  ___________________________________________________________________

Primary point of contact:  Horge Rameriz

Organization:  BBL

Address:  _______________________________________________________________________

City, State, Zip Code:  ___________________________________________________________________

Phone #:  813-933-0697 ext 19  email:  ___________________________________________________________________

Other contacts or vendors who worked on site  ___ None

Point of contact:  Dacre Bush

Type:  ___ Vendor, Consultant  ___ Vendor, Technical Applications  ___ Other  ________________

Organization:  McMillian-McGee

Address:  _______________________________________________________________________

City, State, Zip Code:  ___________________________________________________________________

Phone #:  805-295-9071  email:  dacre.bush@mcmillan-mcghee.com

QA/QC

___ Characteristics of Interest

___ Good pre- and post-treatment groundwater data

___ Good pre- and post-treatment soil data

___ Good temperature profile vs. time information

___ Flux assessment

___ Groundwater elevations

___ Geologic cross-section

___ Hydraulic Conductivity information
### General Site Assessment Data

#### Impacted Zone
- Length (parallel to flow direction)(ft.): ________
- Width (ft): ________
- Thickness (ft): ________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells
- Number of relevant monitoring wells with groundwater data: ________
  - Pre-treatment: ________
  - Post-treatment: ________
- Number of wells relative to treatment zone:
  - Pre-treatment: ________
  - Upgradient: ________
  - Downgradient: ________
  - Crossgradient: ________
  - Post-treatment: ________
  - Upgradient: ________
  - Downgradient: ________
  - Crossgradient: ________

#### Soil Borings
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number inside treatment zone: ________
- Number outside treatment zone: ________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical (mg/L)</th>
<th>Average Post-treatment Concentration per Chemical (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossd</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>1,2-dichloroethene</td>
<td>1,1,1-trichloroethene</td>
<td>1,1,2-trichloroethene</td>
<td>Tetrachloroethene</td>
</tr>
<tr>
<td></td>
<td>Jet Fuel</td>
<td>m/p-xylene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Naphthalene</td>
<td>o-xylene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Benzene</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ethylbenzene</td>
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<td>Napthalene</td>
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</tr>
<tr>
<td></td>
<td>Ethylbenzene</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>None</td>
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<td>1,1,2-dichloroethane</td>
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<td>Napthalene</td>
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<td></td>
<td>Ethylbenzene</td>
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<td></td>
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<tr>
<td></td>
<td>None</td>
<td>None</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Notes

- Facility ID: 0368

### Comments:

- None

### Attachments:

- None
### Geology:

**Vadose Zone:**
- **Relatively homogeneous and permeable unconsolidated sediments**
- **Relatively homogeneous and impermeable unconsolidated sediments**
- **Largely permeable sediments with inter-bedded lenses of lower permeability material**
- **Largely impermeable sediments with inter-bedded layers of higher permeability material**
- **Competent, but fractured bedrock (i.e. crystalline rock)**
- **Weathered bedrock, limestone, sandstone**

**Saturated Zone:**
- **Relatively homogeneous and permeable unconsolidated sediments**
- **Relatively homogeneous and impermeable unconsolidated sediments**
- **Largely permeable sediments with inter-bedded lenses of lower permeability material**
- **Largely impermeable sediments with inter-bedded layers of higher permeability material**
- **Competent, but fractured bedrock (i.e. crystalline rock)**
- **Weathered bedrock, limestone, sandstone**

### Aquifer Characteristics:

**Is more than 1 aquifer present?**
- **No**
- **Yes (number):**
  - **Aquifer 1**
  - **Aquifer 2**
  - **Aquifer 3**

**Ground surface elevation based on wells in or adjacent to treatment zone:**
- **ft amsl**
- **Unknown**

**Depth to water:**
- **low value (ft bgs):**
- **high value (ft bgs):**
- **Unknown:**

**Flow direction:**

**Horizontal hydraulic gradient (feet/foot):**
- **Unknown**

**Vertical hydraulic gradient (feet/foot):**
- **Unknown**

**K range (ft/day):**
- Measured using:
  - **Slug Test**
  - **Laboratory**
  - **Field data**
  - **Unknown**

**Transmissivity (ft²/day):**
- Measured using:
  - **Slug Test**
  - **Laboratory**
  - **Field data**
  - **Unknown**

**Comments:**

**Attachments:**

---
**Thermal Treatment - Design**

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>____ Conductive</th>
<th>____ Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>____ Pilot test</th>
<th>x Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>____ Saturated only</th>
<th>____ Vadose only</th>
<th>____ Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>Duration:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydraulic Control</th>
<th>____ Yes</th>
<th>____ No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Cell Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²):</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
</tr>
<tr>
<td>Number of extraction points:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Formation temperature immediately post-treatment: | |
| Formation temperature post-treatment monitoring event 1: | |
| Duration of post-treatment monitoring (days): | |

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
</tr>
<tr>
<td>In vapor stream:</td>
</tr>
<tr>
<td>Total:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater:
- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater
- In Soil

General comments on the thermal application:


Lessons Learned


Energy

Total Energy Used: _________ kWhr _____ kWhr/m^3 _____ kWhr/yd^3

- Total energy applied to treatment zone: _________ kWhr/m^3 _____ kWhr/yd^3

- Other energy: _________ kWhr/m^3 _____ kWhr/yd^3

- Please note other energy: __________________________________________________________

Cost

Total Project Cost:

- Consultant Cost: ___________________________________________
- Thermal Vendor Cost: _______________________________________
- Energy Cost: _____________ m^3 _____________ yd^3
- Other Cost 1: ___________________________________________
- Other Cost 2: ___________________________________________
- Other Cost 3: ___________________________________________

- Please note other cost: _____________ Other Cost 1: ___________________________
- Other Cost 2: ___________________________________________
- Other Cost 3: ___________________________________________

Other energy:

- Energy Cost: ___________________________________________
- Total Project Cost: _______________________________________
- Consultant Cost: _______________________________________
- Thermal Vendor Cost: ____________________________________
- Energy Cost: _____________ m^3 _____________ yd^3

Other Cost 1: ___________________________________________
- Other Cost 2: ___________________________________________
- Other Cost 3: ___________________________________________

- Please note other cost: _____________ Other Cost 1: ___________________________
- Other Cost 2: ___________________________________________
- Other Cost 3: ___________________________________________
General Site Information

File Analyzed By: JT PD ERH Date: 10/11/2006

Type of treatment: Conductive Steam ERH Other: ____________

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides

Wood Treating Other: kerosene like specialty fuel

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System

Start of Test: 5/27/1999 End of Test: 12/10/1999 Duration: 198 days

Type of Site: Non-DOD DoD

Facility Name: Confidential Manufacturing Plant

Address: Doraville GA

OU# or Site #: ____________

Primary point of contact: Trish Reifenberger

Organization: Brown and Caldwell

Address: 990 Hammond Drive, Suite 400

City, State, Zip Code: Atlanta, GA 30328

Phone #: 770-673-3630 email: treifenberger@brncald.com

Other contacts or vendors who worked on site None

Point of contact: Greg Beyke (White paper)

Type: Vendor, Consultant Vendor, Technical Applications Other

Organization: TRS

Address: 4137 Jensome Lane

City, State, Zip Code: Franklin, TN

Phone #: 615-791-5772 email: g beyke@thermalrs.com

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information


## General Site Assessment Data

**Facility ID:** 0770

### Impacted Zone

- **Length (parallel to flow direction)(ft.):**
- **Width (ft.):**
- **Thickness (ft.):**
  - **Unknown**
  - **Impact zone as defined by documentation**
  - **Alternative method for determining size of impacted zone (See source zone definition attachments)**
  - **Map attachment**

### Monitor Wells

- **Number of relevant monitoring wells with groundwater data:**
  - **None**

### Soil Borings

- **Number of relevant soil borings with pre-treatment data:**
  - **None**
- **Number of relevant soil borings with post-treatment data:**
  - **None**
- **Number inside treatment zone:**
  - **None**
- **Number outside treatment zone:**
  - **None**

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>Napthlene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>m/p-xylene</td>
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</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
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<td>None</td>
<td>Specialty fuel</td>
<td>None</td>
<td>None</td>
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<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>Specialty fuel</td>
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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>Specialty fuel</td>
<td>None</td>
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</tr>
</tbody>
</table>

**Comments:**

- The impacted zone was 4,900 ft² up to a 10 ft thick
- The specialty fuel has a boiling point of 228°C and a viscosity of 2 mm²/s
### Hydrogeologic Conceptual Model

#### Zone

**Vadose Zone:**
- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

#### Geology:

- Aquifer Characteristics:
  - Is more than 1 aquifer present? [X] Unknown (assume single aquifer)
  - Depth to water:
    - Low value (ft bgs): 23
    - High value (ft bgs): 27
    - Unknown: 23
  - Flow direction: no significant flow
  - Horizontal hydraulic gradient (feet/foot): \( < 0.01 \)
  - Vertical hydraulic gradient (feet/foot): \( < 0.01 \)

#### Facility ID:

- Facility ID: 0370

#### Ground surface elevation based on wells in or adjacent to treatment zone:

- 1050 ft amsl
- Unknown

#### Other Measurements:

- Average depth to water was 24 feet
- Attachments:
  - Measured using: Slug Test, Laboratory, Field data

---

**Vadose Zone:**
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Weathered bedrock, limestone, sandstone
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

---

**Unconsolidated Sediments**

- Geology:
  - Weathered bedrock, limestone, sandstone
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

---

**Aquifer Characteristics**

- Is more than 1 aquifer present? [X] Unknown (assume single aquifer)
- Depth to water:
  - Low value (ft bgs): 23
  - High value (ft bgs): 27
  - Unknown: 23
- Flow direction: no significant flow
- Horizontal hydraulic gradient (feet/foot): \( < 0.01 \)
- Vertical hydraulic gradient (feet/foot): \( < 0.01 \)
- K range (ft/day)
  - Measured using: Slug Test, Laboratory, Field data
    - Low: unknown
    - High: unknown
- Transmissivity (ft²/day)
  - Measured using: Slug Test, Laboratory, Field data
    - Low: unknown
    - High: unknown

---

**Average depth to water was 24 feet**
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID#: 0370</th>
</tr>
</thead>
<tbody>
<tr>
<td>x Thermal treatment:</td>
<td>Conductive</td>
</tr>
<tr>
<td>x Electrical Resistance</td>
<td>6 phase AC power</td>
</tr>
<tr>
<td>x 3 phase Steam</td>
<td>Steam + air</td>
</tr>
<tr>
<td>x Steam + O2</td>
<td>Other (describe)</td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot test</td>
</tr>
<tr>
<td>x Full-scale System</td>
<td></td>
</tr>
<tr>
<td>Geology of Treatment Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td>x Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td>x Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
</tr>
<tr>
<td>x Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td>x Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td>x Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td>Treatment Target Zone:</td>
<td>Saturated only</td>
</tr>
<tr>
<td>x Vadose only</td>
<td>Both (Saturated and Vadose zones)</td>
</tr>
<tr>
<td>Start of Thermal Test:</td>
<td>5/27/1999</td>
</tr>
<tr>
<td>Duration:</td>
<td>198 days</td>
</tr>
<tr>
<td>Hydraulic Control:</td>
<td>Yes</td>
</tr>
<tr>
<td>x No</td>
<td></td>
</tr>
<tr>
<td>Treatment Cell Design:</td>
<td></td>
</tr>
<tr>
<td>Size of target zone (ft²):</td>
<td>4000</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>10</td>
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<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>20</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>6</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>30</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>50</td>
</tr>
<tr>
<td>Temperature Profile:</td>
<td></td>
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<tr>
<td>Initial formation temperature (deg C):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Date</td>
<td>Temperature (deg C)</td>
</tr>
<tr>
<td>Formatting temperature immediately post-treatment:</td>
<td></td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
<td></td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
</tr>
<tr>
<td>x Mass of contaminant removed:</td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td></td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td></td>
</tr>
<tr>
<td>lb</td>
<td>kg</td>
</tr>
</tbody>
</table>

Notes: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Facility ID#: 0370

Remediation Goal:

- In Groundwater: To reduce LNAPL thickness to less than 1/8 inch
- In Soil: To reduce LNAPL thickness to less than 1/8 inch

Was the Remediation Goal Achieved:

- In Groundwater
  Comment: Yes, LNAPL was reduced
- In Soil
  Comment: Yes, LNAPL was reduced

General comments on the thermal application:

Used combination wells of extraction/monitoring and ERH electrode. Goal was only to reduce LNAPL thickness

Lessons Learned


___ Energy

Total Energy Used: ___________ kWhr ___________ kWhr/m³ ___________ kWhr/yd³

Total energy applied to treatment zone: ___________ kWhr/m³ ___________ kWhr/yd³

Other energy: ___________ kWhr/m³ ___________ kWhr/yd³

Please note other energy: __________________________________________

___ Cost

Total Project Cost: ___________

Consultant Cost: ___________

Thermal Vendor Cost: ___________

Energy Cost: ___________ m³ ___________ yd³

Other Cost 1: ___________

Other Cost 2: ___________

Other Cost 3: ___________

Please note other cost: ___________

Other Cost 1: ___________

Other Cost 2: ___________

Other Cost 3: ___________
General Site Information

File Analyzed By: JT PD ERH
Date: 10/30/2006
Type of treatment: ___ Conductive ___ Steam ___ ERH ___ Other: _______________
Type of Contaminant: ___ Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides ___ Wood Treating ___ Other: _______________
Treatment Status: ___ Active ___ Post
Type of Test: ___ Pilot Test ___ Full Scale System
Start of Test: 2006
End of Test: _______________
Duration: _______________
Type of Site: ___ Non-DOD ___ DoD ___ Non-DOD ___ DoD

Facility Name: Cartersville, GA
Address: ____________________________
City, State, Zip Code: Cartersville, GA
OU# or Site #: ____________________________

Primary point of contact: David Fleming
Organization: TRS
Address: 7421-A Warren SE
City, State, Zip Code: Snoqualmie, WA 98065
Phone #: 425-396-4266 email: dfleming@thermalrs.com

Other contacts or vendors who worked on site
Point of contact: Dave Smoak
Type: ___ Vendor, Consultant ___ Vendor, Technical Applications ___ Other _______________
Organization: Mactec
Address: ____________________________
City, State, Zip Code: Snoqualmie, WA 98065
Phone #: 770-421-3400 email: desmoak@mactec.com

QA/QC

Characteristics of Interest
___ Good pre- and post-treatment groundwater data
___ Good pre- and post-treatment soil data
___ Good temperature profile vs. time information
___ Flux assessment
___ Groundwater elevations
___ Geologic cross-section
___ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** (177)

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor Wells:</td>
<td>Number of relevant monitoring wells with groundwater data:</td>
<td>Pre-treatment:</td>
<td>Post-treatment:</td>
<td>None</td>
</tr>
<tr>
<td>Soil Borings:</td>
<td>Number of relevant soil borings with post-treatment data:</td>
<td>Number inside treatment zone:</td>
<td>Number outside treatment zone:</td>
<td></td>
</tr>
</tbody>
</table>

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
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<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2,2-trichloroethane</td>
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<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>Methylene chloride</td>
<td>None</td>
<td></td>
<td>None</td>
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**Comments:**

```

```

**Attachments:**

```

```
### Hydrogeologic Conceptual Model

#### Facility ID#: 0113

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone: ________ ft amsl ________ Unknown

#### Aquifer Characteristics:

- Is more than 1 aquifer present? Yes (number): ___________ Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>high (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
</tr>
</tbody>
</table>

- Flow direction

- Horizontal hydraulic gradient (feet/foot): ________ Unknown

- Vertical hydraulic gradient (feet/foot): ________ Unknown

- K range (ft/day): Measured using: Slug Test Laboratory Field data
  - low: ___________ Unknown
  - high: ___________

- Transmissivity (ft²/day): Measured using: Slug Test Laboratory Field data
  - low: ___________ Unknown
  - high: ___________

#### Comments:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

Attachments: ______________________________________________________________________________

____________________________________________________________________________________________
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID#: 0373</th>
</tr>
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<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td></td>
</tr>
<tr>
<td>Conductive</td>
<td></td>
</tr>
<tr>
<td>Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td>3 phase</td>
<td>x</td>
</tr>
<tr>
<td>6 phase</td>
<td></td>
</tr>
<tr>
<td>AC power</td>
<td></td>
</tr>
<tr>
<td>DC power</td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td></td>
</tr>
<tr>
<td>Steam + air</td>
<td></td>
</tr>
<tr>
<td>Steam + O2</td>
<td></td>
</tr>
<tr>
<td>Other (describe)</td>
<td></td>
</tr>
<tr>
<td><strong>Type of Test:</strong></td>
<td></td>
</tr>
<tr>
<td>Pilot test</td>
<td>x</td>
</tr>
<tr>
<td>Full-scale System</td>
<td></td>
</tr>
<tr>
<td><strong>Geology of Treatment Zone:</strong></td>
<td></td>
</tr>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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</tr>
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<tr>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<tr>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<tr>
<td>Weathered bedrock, limestone, sandstone</td>
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<tr>
<td><strong>Treatment Target Zone:</strong></td>
<td></td>
</tr>
<tr>
<td>Saturated only</td>
<td>x</td>
</tr>
<tr>
<td>Vadose only</td>
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<tr>
<td>Both (Saturated and Vadose zones)</td>
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</tr>
<tr>
<td><strong>Start of Thermal Test:</strong></td>
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<td>2006</td>
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<tr>
<td><strong>Duration:</strong></td>
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</tr>
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<td><strong>Hydraulic Control:</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>x</td>
</tr>
<tr>
<td>No</td>
<td></td>
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<td>Size of target zone (ft²):</td>
<td>12130</td>
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<td>Thickness of target zone (ft):</td>
<td>25</td>
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<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>5</td>
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<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>15</td>
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<tr>
<td>Number of energy delivery points:</td>
<td>50</td>
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<tr>
<td>Number of extraction points:</td>
<td>50</td>
</tr>
<tr>
<td><strong>Temperature Profile:</strong></td>
<td></td>
</tr>
<tr>
<td>Initial formation temperature (deg C):</td>
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</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
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</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Formation temperature immediately post-treatment:** | |
| **Formation temperature post-treatment monitoring event 1:** | |
| **Duration of post-treatment monitoring (days):** | |
|      |                     |
|      |                     |
|      |                     |

| **Mass of contaminant removed:** | |
| Via liquid pumping: |                    |
| In vapor stream: |                    |
| Total: |                    |
|      | lb                  |
|      | kg                  |
|      | Unknown             |

| **Comments:** | |
|              | |
|              | |
|              | |

| **Attachments:** | |
|                  | |
|                  | |
|                  | |

*Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.*
Performance

Remediation Goal:

___ In Groundwater: ______________________________________________________________

___ In Soil: ______________________________________________________________

Was the Remediation Goal Achieved:

___ In Groundwater

Comment: ____________________________________________________________________

___ In Soil

Comment: ____________________________________________________________________

General comments on the thermal application:

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

Lessons Learned

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

Energy

Total Energy Used: ______ kWh  ______ kWh/m³  ______ kWh/yd³

___ Total energy applied to treatment zone: ______ kWh/m³  ______ kWh/yd³

___ Other energy: ______ kWh/m³  ______ kWh/yd³

___ Please note other energy: ____________________________________________________________________

Cost

Total Project Cost:

___ Consultant Cost: ____________________________

___ Thermal Vendor Cost: ____________________________

___ Energy Cost: ____________________________ ______ m³  ______ yd³

___ Other Cost 1: ____________________________

___ Other Cost 2: ____________________________

___ Other Cost 3: ____________________________

___ Please note other cost: ____________________________

___ Other Cost 1: ____________________________

___ Other Cost 2: ____________________________

___ Other Cost 3: ____________________________
General Site Information

File Analyzed By: JT PD Erh Date: 10/30/2006

Type of treatment: Conductive Steam ERH Other: 

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Other: 

Treatment Status: Active Post 

Type of Test: Pilot Test Full Scale System 

Start of Test: 2006 

End of Test: Duration: 

Type of Site: Non-DOD DoD 

Facility Name: Siemens Energy and Automation Facility 

Address: 2037 Weems Road 

City, State, Zip Code: Tucker, GA 

OU# or Site #: 

Primary point of contact: David Fleming 

Organization: TRS 

Address: 7421-A Warren SE 

City, State, Zip Code: Snoqualmie, WA 98065 

Phone #: 425-396-4266 email: dfleming@thermalrs.com 

Other contacts or vendors who worked on site None 

Point of contact: Kevin Sweeney 

Type: Vendor, Consultant Vendor, Technical Applications Other 

Organization: 

Address: 

City, State, Zip Code: 

Phone #: 770-751-2346 email: kevin.sweeney@siemens.com 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data 

Good temperature profile vs. time information Flux assessment 

Groundwater elevations Geologic cross-section 

Hydraulic Conductivity information
### General Site Assessment Data

#### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- None
- Number of wells relative to treatment zone:
  - Pre-treatment:
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________
  - Post-treatment:
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>None</td>
<td>1 mg/kg</td>
<td>None</td>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
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<td>None</td>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>Ethylbenzene</td>
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<td>None</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>5 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>Methylene chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>100 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>DCE</td>
<td></td>
<td></td>
<td>None</td>
<td>5 mg/kg</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:

- __________________________________________________________
- __________________________________________________________
- __________________________________________________________
- __________________________________________________________

#### Attachments:

- __________________________________________________________
- __________________________________________________________
## Geology

### Vadose Zone
- **Weathered bedrock, limestone, sandstone**
- **Competent, but fractured bedrock (i.e. crystalline rock)**

### Saturated Zone
- **Relatively homogeneous and permeable unconsolidated sediments**
- **Largely permeable sediments with inter-bedded lenses of lower permeability material**
- **Competent, but fractured bedrock (i.e. crystalline rock)**
- **Weathered bedrock, limestone, sandstone**

---

### Aquifer Characteristics

#### Ground surface elevation based on wells in or adjacent to treatment zone:
- **Unknown ft amsl**

#### Aquifer Characteristics:
- **Is more than 1 aquifer present?**
  - No
  - Yes (number):
  - Unknown (assume single aquifer)

- **Depth to water**:
  - **low value (ft bgs):**
  - **high value (ft bgs):**
  - **Unknown:**

- **Flow direction**

- **Horizontal hydraulic gradient (feet/foot):**

- **Vertical hydraulic gradient (feet/foot):**

- **K range (ft/day):**
  - **Measured using:**
  - **slug test**
  - **laboratory**
  - **field data**

- **Transmissivity (ft²/day):**
  - **Measured using:**
  - **slug test**
  - **laboratory**
  - **field data**

---

### Comments:

---

### Attachments:

---
### Thermal Treatment - Design

**Facility ID#: 0375**

<table>
<thead>
<tr>
<th>Option</th>
<th>Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td>x</td>
</tr>
<tr>
<td>- Conductive</td>
<td></td>
</tr>
<tr>
<td>- Electrical Resistance</td>
<td>x</td>
</tr>
<tr>
<td>- 3 phase</td>
<td></td>
</tr>
<tr>
<td>- 6 phase</td>
<td></td>
</tr>
<tr>
<td>- AC power</td>
<td></td>
</tr>
<tr>
<td>- DC power</td>
<td></td>
</tr>
<tr>
<td>- Steam</td>
<td></td>
</tr>
<tr>
<td>- Steam + air</td>
<td></td>
</tr>
<tr>
<td>- Steam + O₂</td>
<td></td>
</tr>
<tr>
<td>- Other (describe)</td>
<td></td>
</tr>
</tbody>
</table>

**Type of Test:**
- Pilot test  
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- 2006

**Hydraulic Control:**
- Yes  
- No

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²)</td>
<td>16357</td>
</tr>
<tr>
<td>Thickness of target zone (ft)</td>
<td>20</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs)</td>
<td>0</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft)</td>
<td>0</td>
</tr>
<tr>
<td>Number of energy delivery points</td>
<td>65</td>
</tr>
<tr>
<td>Number of extraction points</td>
<td>65</td>
</tr>
</tbody>
</table>

**Temperature Profile:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C)</td>
<td>Unknown</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C)</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days)</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days)</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Formation temperature immediately post-treatment:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Formation temperature post-treatment monitoring event 1:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Duration of post-treatment monitoring (days):**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Method</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping</td>
<td>lb</td>
</tr>
<tr>
<td>In vapor stream</td>
<td>lb</td>
</tr>
<tr>
<td>Total</td>
<td>lb</td>
</tr>
</tbody>
</table>

**Comments:**

17 foot electrode spacing

**Attachments:**

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- **In Groundwater:**
  - **Comment:**

- **In Soil:**
  - **methylene Chloride - 0.08; PCE - 0.08; TCE - 0.13; DCE - 0.53; VC - 0.04 mg/kg**
  - **Comment:**

Was the Remediation Goal Achieved:

- **In Groundwater**
  - **Comment:**

- **In Soil**
  - **Comment:**

General comments on the thermal application:

- ____________________________
- ____________________________
- ____________________________
- ____________________________

Lessons Learned

- ____________________________
- ____________________________
- ____________________________
- ____________________________

**Energy**

- **Total Energy Used:**
  - **kWhr**
  - **kWhr/m³**
  - **kWhr/yd³**
  - **Total energy applied to treatment zone:**
    - **kWhr/m³**
    - **kWhr/yd³**
  - **Other energy:**
    - **kWhr/m³**
    - **kWhr/yd³**
  - **Please note other energy:**

**Cost**

- **Total Project Cost:**
  - **Consultant Cost:**
  - **Thermal Vendor Cost:**
  - **Energy Cost:**
    - **m³**
    - **yd³**
  - **Other Cost 1:**
  - **Other Cost 2:**
  - **Other Cost 3:**
  - **Please note other cost:**
    - **Other Cost 1:**
    - **Other Cost 2:**
    - **Other Cost 3:**
General Site Information

File Analyzed By: JT  PD  Date: 11/9/2006
Type of treatment:  Conductive  Steam  ERH  Other:  
Type of Contaminant:  Chlorinated Solvents  x Petroleum Hydrocarbons  Pesticides
Wood Treating  Other:  PAHs
Treatment Status:  Active  Post
Type of Test:  Pilot Test  Full Scale System
Start of Test:  4/5/2002  End of Test:  8/5/2002  Duration: 120 d
Type of Site:  Non-DOD  DoD

Facility Name: Hunter Army Airfield, GA
Address: 
City, State, Zip Code: Savannah, GA
OU# or Site #: Former Pumphouse #2

Primary point of contact: Ana Vergara
Organization: US Army Corps of Engineers (USACE)
Address: 100 West Oglethorpe Avenue
City, State, Zip Code: Savannah, GA 1401
Phone #: 912-652-5835  email: ana.vergara@us.army.mil

Other contacts or vendors who worked on site  None
Point of contact: Patty Stoll
Type: x Vendor, Consultant  Vendor, Technical Applications  Other  
Organization: Science Applications International Corporation
Address: 151 Lafayette Drive, PO Box 2501
City, State, Zip Code: Oak Ridge, TN 37831
Phone #: 865-481-4600  email: 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
**General Site Assessment Data**

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft): __________
- Thickness (ft): __________

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Post-treatment: __________

**Soil Borings:**
- Number of relevant soil borings with post-treatment data: __________
  - Number inside treatment zone: __________
  - Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Groundwater (mg/L)</strong></td>
<td><strong>Soil (mg/kg)</strong></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>0.5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Hexane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Pentane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Isopropyl Alcohol</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Butyl Alcohol</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Toluene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>xylenes</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Other</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphtalene</td>
<td>Naphthalene</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>2-methylnaphthalene</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>3-methylnaphthalene</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylene</td>
<td>Benzene</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>n-p-xylene</td>
<td>benzene</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
<td>Benzene</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td>xylene</td>
<td>benzene</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>benzo(a)pyrene</td>
<td>naphthalene</td>
</tr>
<tr>
<td>Benzene</td>
<td>benzo(a)pyrene</td>
<td>Fluorene</td>
</tr>
<tr>
<td>Toluene</td>
<td>benzo(a)pyrene</td>
<td>Fluorene</td>
</tr>
<tr>
<td>xylenes</td>
<td>None</td>
<td>Fluorene</td>
</tr>
<tr>
<td>Indeno(1,2,3-cd)pyrene</td>
<td>None</td>
<td>Indeno(1,2,3-cd)pyrene</td>
</tr>
<tr>
<td>Creosote</td>
<td>None</td>
<td>Vinyl Chloride</td>
</tr>
</tbody>
</table>

**Comments:**
Benzene impacted area of 55,000 ft² (above 5 mg/L) in January 2002. After treatment it was 12,500 ft² in July of 2005.

Soil concentrations (mg/kg) for ethylbenzene was 0.005 and for benzene, toluene, and xylenes it was 0.001.

**Attachments:**

---

Facility ID #: 1080
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>None</td>
<td>Phenanthrene</td>
<td>0.01 mg/L</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>None</td>
<td>None</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-Dichloroethene</td>
<td>None</td>
<td>None</td>
<td>1,1,1-Trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans,1,2-Dichloroethene</td>
<td>None</td>
<td>None</td>
<td>1,2-Dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>None</td>
<td>None</td>
<td>1,2-Dichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>None</td>
<td>None</td>
<td>1,2,3-Trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>1,1,2,2-Tetrachloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Hexane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Jet Fuel</td>
<td>None</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Methanol</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Methanol</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Methanol</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- Impacted Zone:
  - Length (parallel to flow direction)(ft.): below
  - Width (ft.): thickness
  - Thickness (ft.): unknown
  - Impacted zone as defined by documentation
  - Map attachment
  - Alternative method for determining size of impacted zone (See source zone definition attachments)

- Monitor Wells:
  - Number of relevant monitoring wells with groundwater data: none
  - Pre-treatment: 12
  - Post-treatment: 12
  - Number of wells relative to treatment zone:
    - Pre-treatment:
      - In: 12
      - Upgradient: unknown
      - Downgradient: unknown
      - Crossgradient: unknown
    - Post-treatment:
      - In: 12
      - Upgradient: unknown
      - Downgradient: unknown
      - Crossgradient: unknown

- Soil Borings:
  - Number of relevant soil borings with post-treatment data: 4
  - Number inside treatment zone: 1
  - Number outside treatment zone: 3

- General Site Assessment Data:
  - Facility ID: 0380
  - Chemical of Concern:
    - Chlorinated Solvents:
      - Trichloroethene
      - Tetrachloroethene
      - 1,1-Dichloroethene
      - cis,1,2-Dichloroethene
      - trans,1,2-Dichloroethene
      - 1,1-Dichloroethane
      - 1,2-Dichloroethane
      - 1,1,1-Trichloroethane
      - 1,1,2,2-Tetrachloroethane
      - Vinyl Chloride
    - Petroleum Hydrocarbons:
      - Benzene
      - Jet Fuel
      - Ethylene
      - Methanol
    - Other:
      - Cross
      - Phenanthrene
      - Toluene
      - 1,1,1-Trichloroethene
      - 1,2-Dichloroethene
      - 1,2,3-Trichloroethene
      - 1,1,2,2-Tetrachloroethane

### Attachments:

- Map attachment
- Impacted Zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
**Hydrogeologic Conceptual Model**

### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>X Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>_ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>_ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>_ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>_ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>X Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>_ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>_ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>_ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>_ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - No
  - X Yes (number): 2
  - Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs):</th>
<th>Vertical hydraulic gradient (feet/foot):</th>
<th>Horizontal hydraulic gradient (feet/foot):</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>0.0072 (ave)</td>
<td>0.0072 (ave)</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction**
  - SW

- **K range (ft/day)**
  - Measured using: Slug Test Laboratory Field data
  - Low: 34.3
  - High: Unknown

- **Transmissivity (ft²/day)**
  - Measured using: Slug Test Laboratory Field data
  - Low: Unknown
  - High: Unknown

### Ground surface elevation based on wells in or adjacent to treatment zone:

- f amsl
  - Unknown

### Flow direction

- SW

### Horizontal hydraulic gradient baried from 0.0026 to 0.0091. 

### K range (ft/day)

- Measured using: Slug Test Laboratory Field data
  - Low: 34.3
  - High: Unknown

### Transmissivity (ft²/day)

- Measured using: Slug Test Laboratory Field data
  - Low: Unknown
  - High: Unknown

### Comments:

- Horizontal hydraulic gradient baried from 0.0026 to 0.0091. 
  - K=0.0121 cm/sec

### Attachments:

- Horizontally hydraulic gradient baried from 0.0026 to 0.0091.
- K=0.0121 cm/sec

- Additional comments and notes for the hydrogeologic conceptual model.

- Facility ID#: 0180
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3 phase 6 phase AC power DC power</td>
</tr>
<tr>
<td></td>
<td>Steam</td>
<td>Steam + air Steam + O2</td>
</tr>
<tr>
<td></td>
<td>Other (describe)</td>
<td></td>
</tr>
</tbody>
</table>

Type of Test: Pilot test Full-scale System

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone: Saturated only Vadose only Both (Saturated and Vadose zones)

Start of Thermal Test: 4/5/2002 Duration: 120d

Hydraulic Control: Yes No

Treatment Cell Design:
- Size of target zone (ft2): 10000 Unknown
- Thickness of target zone (ft): 8 Unknown
- Depth to top of target zone (ft bgs): 8 Unknown
- Thickness of target zone below water table (ft): 4 Unknown
- Number of energy delivery points: 111 Unknown
- Number of extraction points: 41 Unknown

Temperature Profile:
- Initial formation temperature (deg C): 20 Unknown
- Maximum representative formation temperature (deg C): 90 Unknown
- Time to reach maximum representative temperature (days): 110 Unknown
- Duration of treatment at representative temperature (days): 10 Unknown
- Date: Temperature (deg C):

Formation temperature immediately post-treatment: 
Formation temperature post-treatment monitoring event 1: 
Duration of post-treatment monitoring (days): 24 months

Mass of contaminant removed:
- Via liquid pumping: ____________ lb kg Unknown
- In vapor stream: ____________ lb kg Unknown
- Total: 44000 x lb kg Unknown

Comments:
Electrode spacing of 18 ft; vapor recovery wells spacing of 40 ft; 23 vapor and 18 dural phase extraction wells.

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater: Cleanup in ug/L - Benzene-469, Benzo(a)pyrene-2, benzo(b)fluoranthene-2, chrysene-2, naphthalene-428, Toluene-1516000

In Soil: Cleanup in mg/kg - benzene-0.44, benzo(a)pyrene-6.8, benzo(b)fluoranthene-24.0, chrysene-10, ethylbenzene-389, indeno(1,2,3-cd)pyrene-0.66, Toluene-2050, total xylenes-700

Was the Remediation Goal Achieved:

In Groundwater
Comment:
yes, except for a benzene at 733 ug/L

In Soil
Comment:
yes

General comments on the thermal application:
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________

Lessons Learned
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________

Energy

Total Energy Used: 1678000 kWhr

kWhr kWhr/m³ kWhr/yd³
3 Total energy applied to treatment zone: ________________ kWhr/m³ ________________ kWhr/yd³
3 Other energy: ________________ kWhr/m³ ________________ kWhr/yd³

Please note other energy:
_____________________________________________________________________________________________________

Cost

Total Project Cost: 1301169

Consultant Cost:

Thermal Vendor Cost:

Energy Cost: 259000 m³ yd³

Other Cost 1: 1042169

Other Cost 2:

Other Cost 3:

Please note other cost:
Other Cost 1: ERH system operation and maintenance

Other Cost 2:

Other Cost 3:
General Site Information

File Analyzed By: JT PD ERH Other: 
Type of treatment: Conductive Steam ERH Other: 
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 
Treatment Status: Active Post 
Type of Test: Pilot Test Full Scale System 
Start of Test: Dec-95 End of Test: 1-Sep Duration: 5.5 years 
Type of Site: Non-DOD DoD 

Facility Name: AG Communications 
Address: 400 North Wolfe Rd 
City, State, Zip Code: North Lake, IL 
OU# or Site #: 

Primary point of contact: 
Organization: 
Address: 
City, State, Zip Code: 
Phone #: email: 

Other contacts or vendors who worked on site: None 

Point of contact: 
Type: Vendor, Consultant Vendor, Technical Applications Other 
Organization: 
Address: 
City, State, Zip Code: 
Phone #: email: 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data 
Good temperature profile vs. time information Flux assessment 
Groundwater elevations Geologic cross-section 
Hydraulic Conductivity information
**General Site Assessment Data**

**Facility ID:** 100

---

### Impacted Zone:
- **Length (parallel to flow direction)(ft.):** __________
- **Width (ft):** __________
- **Thickness (ft):** __________
- **Impacted zone as defined by documentation:** __________
- **Alternative method for determining size of impacted zone (See source zone definition attachments):** __________
- **Map attachment:** __________

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: In: __________, Upgradient: __________, Downgradient: __________, Crossgradient: __________
  - Post-treatment: In: __________, Upgradient: __________, Downgradient: __________, Crossgradient: __________

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

---

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>10 mg/L</td>
<td>0.1 mg/L</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
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<td>None</td>
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<td>Vinyl Chloride</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichlorobenzene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,3-dichlorobenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>2,2-dichlorobenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

Impacted 160,000 ft² total with VOC impacting 11,000 ft²

**Attachments:**

Figure 3-1
Hydrogeologic Conceptual Model

Facility ID#: 0390

Geology: Zone
Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: 660 ft amsl

Aquifer Characteristics:
- Is more than 1 aquifer present? Yes (number): Unknown
- Depth to water: low value (ft bgs): 17
  high value (ft bgs): 480
- Flow direction: ESE

Horizontal hydraulic gradient (feet/foot): Unknown
Vertical hydraulic gradient (feet/foot): Unknown

K range (ft/day): Measured using: Slug Test Laboratory Field data
  low see comments
  high
  Unknown

Transmissivity (ft²/day): Measured using: Slug Test Laboratory Field data
  low
  high
  Unknown

Comments:

See attached map (Figure 1-4)

Attachments:

Figure 1-4
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
- Steam  
- Steam + air  
- Steam + O2  
- Other (describe)  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
- Dec-95  
Duration:  
- 5.5 years  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  
- Size of target zone (ft2): 30800  
- Thickness of target zone (ft):  
- Depth to top of target zone (ft bgs): 37  
- Thickness of target zone below water table (ft):  
- Number of energy delivery points: 57  
- Number of extraction points: 282  

Temperature Profile:  
- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C):  
- Time to reach maximum representative temperature (days):  
- Duration of treatment at representative temperature (days):  
- Formation temperature immediately post-treatment:  
- Formation temperature post-treatment monitoring event 1:  
- Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
- Via liquid pumping:  
- In vapor stream:  
- Total: 40,000  

Comments:  
- Injection wells - 31 at 48 feet and 26 at 39 feet  
- Extraction Wells - 205  
- vapor only, 75 GW/Vapor, and 2 GW only  
- Hydraulic control - sheet pile  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:

___ In Soil

Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

___ Energy

Total Energy Used: ___ kWhr ___ kWhr/m³ ___ kWhr/yd³

___ Total energy applied to treatment zone: ___ kWhr/m³ ___ kWhr/yd³

___ Other energy: ___ kWhr/m³ ___ kWhr/yd³

Please note other energy: ___________________________________________________________

___ Cost

Total Project Cost: 5,600,000 (includes pilot)

___ Consultant Cost: ___________________________

___ Thermal Vendor Cost: ___________________________

___ Energy Cost: ___ m³ ___ yd³

___ Other Cost 1: ___________________________

___ Other Cost 2: ___________________________

___ Other Cost 3: ___________________________

Please note other cost: ___ Other Cost 1: ___________________________

___ Other Cost 2: ___________________________

___ Other Cost 3: ___________________________
### General Site Information

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>AG Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td>400 North Wolfe Rd</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>North Lake, IL</td>
</tr>
</tbody>
</table>

**Primary point of contact:**

- Organization: 
- Address: 
- Phone #: 
- Email: 

**Other contacts or vendors who worked on site:** None

<table>
<thead>
<tr>
<th>Point of contact:</th>
</tr>
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<tbody>
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<td>Type: Vendor, Consultant Vendor, Technical Applications Other</td>
</tr>
<tr>
<td>Organization:</td>
</tr>
<tr>
<td>Address:</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
</tr>
<tr>
<td>Phone #:</td>
</tr>
<tr>
<td>Email:</td>
</tr>
</tbody>
</table>

### QA/QC

**Characteristics of Interest**

- [ ] Good pre- and post-treatment groundwater data
- [ ] Good pre- and post-treatment soil data
- [ ] Good temperature profile vs. time information
- [ ] Flux assessment
- [ ] Groundwater elevations
- [x] Geologic cross-section
- [x] Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation: __________
- Alternative method for determining size of impacted zone (See source zone definition attachments): __________
- Map attachment: __________

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
  - Pre-treatment: __________
  - Post-treatment: __________
  - None
- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________
- Post-treatment: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
  - None
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossdr</td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>None</td>
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<td>m/p-xylene</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
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<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

Impacted 160,000 ft² total with VOC impacting 11,000 ft²

**Attachments:**

Figure 3-1
### Hydrogeologic Conceptual Model

**Facility ID#: 0391**

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td></td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td></td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Largely permeable sediments with inter-bedded layers of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- **Ground surface elevation based on wells in or adjacent to treatment zone:** 660 ft amsl  
  Unknown

- **Aquifer Characteristics:**
  - Is more than 1 aquifer present? **Yes (number):**
  - **Unknown (assume single aquifer)**
  - **Aquifer 1**
  - **Aquifer 2**
  - **Aquifer 3**
  - **Depth to water:**
    - Low value (ft bg): 37
    - High value (ft bg): 440
  - **Flow direction**: ESE

- **Horizontal hydraulic gradient (feet/foot):**
  Unknown

- **Vertical hydraulic gradient (feet/foot):**
  Unknown

- **K range (ft/day):**
  - **Measured using:** Slug Test Laboratory Field data
  - **Low:**
    - **Unknown**
  - **High:**
    - **Unknown**

- **Transmissivity (ft²/day):**
  - **Measured using:** Slug Test Laboratory Field data
  - **Low:**
    - **Unknown**
  - **High:**
    - **Unknown**

**Comments:**

- See attached x-section
## Thermal Treatment - Design

### Facility ID:
- 0391

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td>Steam</td>
<td>Steam</td>
<td>Steam + air</td>
</tr>
</tbody>
</table>

### Type of Test:
- Pilot test
- Full-scale System

### Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

### Start of Thermal Test:
- 1993
- Duration:

### Hydraulic Control:
- Yes
- No

### Treatment Cell Design:
- Size of target zone (ft^2):
- Thickness of target zone (ft):
- Depth to top of target zone (ft bgs):
- Thickness of target zone below water table (ft):
- Number of energy delivery points:
- Number of extraction points:

### Temperature Profile:
- Initial formation temperature (deg C):
- Maximum representative formation temperature (deg C):
- Time to reach maximum representative temperature (days):
- Duration of treatment at representative temperature (days):

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Mass of contaminant removed:
- Via liquid pumping:
- In vapor stream:
- Total: 500 lb, kg

### Notes:
- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater: __________________________________________________________
- In Soil: ________________________________________________________________

Was the Remediation Goal Achieved:

- In Groundwater: ________________________________________________________
  Comment: __________________________________________________________________
- In Soil: ________________________________________________________________
  Comment: __________________________________________________________________

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ____________________________________________________________
  Total energy applied to treatment zone: ___________ kWh ______________________ kWh/m³ __________________ kWh/yd³
  Other energy: ___________________________ kWh/m³ __________________ kWh/yd³
  Please note other energy: ____________________________________________________

Cost

Total Project Cost:

- Consultant Cost: ____________________________________________________________
- Thermal Vendor Cost: ______________________________________________________
- Energy Cost: ___________________________ m³ ___________________________ yd³
- Other Cost 1: ______________________________________________________________
- Other Cost 2: ______________________________________________________________
- Other Cost 3: ______________________________________________________________
  Please note other cost: __________ Other Cost 1: ____________________________
  __________ Other Cost 2: __________________________________________________
  __________ Other Cost 3: _________________________________________________
General Site Information

File Analyzed By: JT PD Date: 10/18/2006
Type of treatment: Conductive Steam ERH Other: 
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 
Treatment Status: Active Post 
Type of Test: Pilot Test Full Scale System 
Start of Test: Jul-04 End of Test: Nov-04 Duration: 
Type of Site: Non-DOD DoD 

Facility Name: Iowa Department of Transportation
Address: 
City, State, Zip Code: Sioux City, IA
OU# or Site #: 

Primary point of contact: Bill Heath
Organization: CES
Address: 419 Entiat St., Suite A
City, State, Zip Code: Kennewick, WA 99336
Phone #: 509-727-4276 email: bill@cesiweb.com

Other contacts or vendors who worked on site None
Point of contact: 
Type: Vendor, Consultant Vendor, Technical Applications Other 
Organization: 
Address: 
City, State, Zip Code: 
Phone #: email: 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data
Good temperature profile vs. time information Flux assessment
Groundwater elevations Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0395

**Impacted Zone:**
- Length (parallel to flow direction) (ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Post-treatment: __________
- Pre-treatment In: __________
- Upgradient: __________
- Downgradient: __________
- Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trihalomethane</td>
<td>Benzene</td>
<td>Crossgrd</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
</tr>
<tr>
<td>1,2-dichloromethane</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
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<td>1,1,1-trichloroethane</td>
<td>m,p-xylene</td>
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<tr>
<td>1,1,2-trichloroethane</td>
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<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Vinil Chloride</td>
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<td>None</td>
<td>None</td>
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</table>

**Comments:**

- __________
- __________
- __________

**Attachments:**

- __________
- __________
### Hydrogeologic Conceptual Model

#### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Geology:</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td></td>
<td>1. Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td></td>
<td>1. Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

---

#### Ground surface elevation based on wells in or adjacent to treatment zone:

- **ft amsl**
- **Unknown**

---

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
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</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Aquifer 3</td>
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<table>
<thead>
<tr>
<th>Depth to water:</th>
<th>low value (ft bgs):</th>
<th>high value (ft bgs):</th>
<th>Unknown:</th>
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</thead>
<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Flow direction</th>
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<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vertical hydraulic gradient (feet/foot):</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Transmissivity (ft²/day):</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

-----

**Comments:**

---

**Attachments:**

---
Thermal Treatment - Design

Facility ID#: 0395

Thermal treatment:  
- Conductive  
- Electrical Resistance  
- 3 phase  
- 6 phase  
- AC power  
- DC power  
- Steam  
- Steam + air  
- Steam + O2  
- Other (describe)

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded layers of lower permeability material  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test: Jul-04  
Duration: 

Hydraulic Control  
- Yes  
- No

Treatment Cell Design:  
Size of target zone (ft²): 3800  
Thickness of target zone (ft): 10  
Depth to top of target zone (ft bgs): 4  
Thickness of target zone below water table (ft): 2  
Number of energy delivery points: 19  
Number of extraction points: 12

Temperature Profile:  
Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C):  
Time to reach maximum representative temperature (days):  
Duration of treatment at representative temperature (days): 

Formation temperature immediately post-treatment: 
Formation temperature post-treatment monitoring event 1: 
Duration of post-treatment monitoring (days):

Mass of contaminant removed:  
- Via liquid pumping:  
- In vapor stream:  
Total: 3700 lb

Comments:  
19 ft spacing

Attachments: 

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater:

- In Soil:

Benzene = 4.38 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater:

- In Soil:

General comments on the thermal application:

Lessons Learned:

Energy

Total Energy Used: 588812 kWhr

Total energy applied to treatment zone: 515312 kWhr

Other energy: 73500 kWhr

Please note other energy: process equipment

Cost

Total Project Cost: 

- Consultant Cost:

- Thermal Vendor Cost:

- Energy Cost: m³ yd³

- Other Cost 1:

- Other Cost 2:

- Other Cost 3:

Please note other cost: Other Cost 1:

Other Cost 2:

Other Cost 3:
General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th>10/30/2006</th>
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<tbody>
<tr>
<td>Type of treatment:</td>
<td>____</td>
<td>Conductive</td>
<td>Steam</td>
<td>ERH</td>
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<tr>
<td>Type of Contaminant:</td>
<td>____</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>____</td>
<td>Active</td>
<td>____</td>
<td>Non-DOD</td>
</tr>
<tr>
<td>Type of Test:</td>
<td>____</td>
<td>Pilot Test</td>
<td>____</td>
<td>Full Scale System</td>
</tr>
<tr>
<td>Start of Test:</td>
<td>________________</td>
<td>End of Test:</td>
<td>________________</td>
<td>Duration:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Circuit Assembling Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td>Harwood Heights, IL</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Harwood Heights, IL</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td>________________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary point of contact:</th>
<th>Jeff Pope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>Clayton Goup</td>
</tr>
<tr>
<td>Address:</td>
<td>3140 Finley Rd</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Downers Grove, IL</td>
</tr>
<tr>
<td>Phone #:</td>
<td>630-795-3211</td>
</tr>
<tr>
<td>email:</td>
<td>j <a href="mailto:pope@claytongrp.com">pope@claytongrp.com</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other contacts or vendors who worked on site</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of point of contact:</td>
<td>Bill Heath</td>
</tr>
<tr>
<td>Type:</td>
<td>____ Vendor, Consultant</td>
</tr>
<tr>
<td>Organization:</td>
<td>CES</td>
</tr>
<tr>
<td>Address:</td>
<td>419 W. Entiat St</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Kennewick, WA 99336</td>
</tr>
<tr>
<td>Phone #:</td>
<td>509-727-4276</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:bill@cesiweb.com">bill@cesiweb.com</a></td>
</tr>
</tbody>
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**QA/QC**

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
<th>________________</th>
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<tbody>
<tr>
<td>____ Good pre- and post-treatment groundwater data</td>
<td>____ Good pre- and post-treatment soil data</td>
</tr>
<tr>
<td>____ Good temperature profile vs. time information</td>
<td>____ Flux assessment</td>
</tr>
<tr>
<td>____ Groundwater elevations</td>
<td>____ Geologic cross-section</td>
</tr>
<tr>
<td>____ Hydraulic Conductivity information</td>
<td>____</td>
</tr>
</tbody>
</table>

Facility ID#: 0400
## General Site Assessment Data

### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: In: __________
  - Post-treatment: In: __________

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: In: __________
  - Post-treatment: In: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
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<td>Naphthalene</td>
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<td>None</td>
<td>None</td>
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<tr>
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<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
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<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
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<tr>
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<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
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<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>None</td>
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<td>1,1,2-trichloroethane</td>
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<td></td>
<td>Vinyl Chloride</td>
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</tbody>
</table>

### Comments:

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

### Attachments:

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________
Hydrogeologic Conceptual Model

Geology:  

Vadose Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone:  
- ft amsl
- Unknown

Aquifer Characteristics:

Is more than 1 aquifer present?  
- No
- Yes (number):  
  - Aquifer 1
  - Aquifer 2
  - Aquifer 3
- Unknown (assume single aquifer)

Depth to water:  
- Low value (ft bgs):
- High value (ft bgs):
- Unknown:

Flow direction:

Horizontal hydraulic gradient (feet/foot):

Vertical hydraulic gradient (feet/foot):

K range (ft/day)  
- Measured using:  
  - Slug Test
  - Laboratory
  - Field data
- Low
- High

Transmissivity (ft2/day)  
- Measured using:  
  - Slug Test
  - Laboratory
  - Field data
- Low
- High

Comments:

Attachments:
### Thermal Treatment - Design

**Facility ID#: 0400**

Thermal treatment: [ ] Conductive [ ] Electrical Resistance  
[ ] 3 phase [ ] 6 phase [ ] AC power [ ] DC power  
[ ] Steam [ ] Steam + air [ ] Steam + O2  
[ ] Other (describe)  

**Type of Test:** [ ] Pilot test [ ] Full-scale System  

**Geology of Treatment Zone:**  
[ ] Relatively homogeneous and permeable unconsolidated sediments  
[ ] Relatively homogeneous and impermeable unconsolidated sediments  
[ ] Largely permeable sediments with inter-bedded lenses of lower permeability material  
[ ] Largely impermeable sediments with inter-bedded layers of higher permeability material  
[ ] Competent, but fractured bedrock (i.e. crystalline rock)  
[ ] Weathered bedrock, limestone, sandstone  

**Treatment Target Zone:**  
[ ] Saturated only  
[ ] Vadose only  
[ ] Both (Saturated and Vadose zones)  

**Start of Thermal Test:**  
Duration:  

**Hydraulic Control**  
[ ] Yes [ ] No  

**Treatment Cell Design:**  

**Size of target zone (ft²):**  
Thickness of target zone (ft):  
Depth to top of target zone (ft bgs):  
Thickness of target zone below water table (ft):  
Number of energy delivery points:  
Number of extraction points:  

**Temperature Profile:**  
Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C):  
Time to reach maximum representative temperature (days):  
Duration of treatment at representative temperature (days):  

**Formation temperature immediately post-treatment:**  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

**Mass of contaminant removed:**  
Via liquid pumping:  
In vapor stream:  
Total:  

**Comments:**  

**Attachments:**  

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

_____ In Groundwater: ________________________________

_____ In Soil: ________________________________

Was the Remediation Goal Achieved:

_____ In Groundwater: ________________________________

Comment: ____________________________________________________________________________________

_____ In Soil: ________________________________

Comment: ____________________________________________________________________________________

General comments on the thermal application:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

Lessons Learned

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

Energy

Total Energy Used: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

_____ Total energy applied to treatment zone: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

_____ Other energy: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

Please note other energy: _______________________________________________________________

Cost

Total Project Cost: ________________________________

_____ Consultant Cost: ________________________________

_____ Thermal Vendor Cost: ________________________________

_____ Energy Cost: ________________________________ m³ ___________ yd³

_____ Other Cost 1: ________________________________

_____ Other Cost 2: ________________________________

_____ Other Cost 3: ________________________________

Please note other cost: _____ Other Cost 1: ________________________________

_____ Other Cost 2: ________________________________

_____ Other Cost 3: ________________________________
<table>
<thead>
<tr>
<th>Type of treatment:</th>
<th>Conductive</th>
<th>Steam</th>
<th>ERH</th>
<th>Other:</th>
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</thead>
<tbody>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
<td>Wood Treating</td>
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<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
<td></td>
<td></td>
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<tr>
<td>Start of Test:</td>
<td>End of Test:</td>
<td>Duration:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
<td></td>
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</tr>
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</table>

**Facility Name:** Electronics Manufacturing Facility  
**Address:**  
**City, State, Zip Code:** Chicago, IL  
**OU# or Site #:**  

**Primary point of contact:** Bill Heath  
**Organization:** CES  
**Address:** 419 W Entiat St  
**City, State, Zip Code:** Kennewick, WA 99336  
**Phone #:** 509-727-4276  
**email:** bill@cesiweb.com

**QA/QC**

**Characteristics of Interest**

- Good pre- and post-treatment groundwater data  
- Good pre- and post-treatment soil data  
- Good temperature profile vs. time information  
- Flux assessment  
- Groundwater elevations  
- Geologic cross-section  
- Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation: Unknown
- Alternative method for determining size of impacted zone (See source zone definition attachments): Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: None
- Number of wells relative to treatment zone:
  - Pre-treatment:
    - In: _______
    - Upgradient: _______
    - Downgradient: _______
    - Crossgradient: _______
  - Post-treatment:
    - In: _______
    - Upgradient: _______
    - Downgradient: _______
    - Crossgradient: _______

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: _______
- Number of relevant soil borings with post-treatment data: _______
- Number inside treatment zone: _______
- Number outside treatment zone: _______

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
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<tr>
<td>Trichloroethene</td>
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<tr>
<td>Tetrachloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
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</tr>
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<td>None</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
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<td>None</td>
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<tr>
<td>1,1,2-trichloroethene</td>
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</tr>
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<tr>
<td>Benzene</td>
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<td>Naphthalene</td>
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<td>Jet Fuel</td>
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<td>Petroleum Hydrocarbons</td>
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<td>None</td>
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<td>None</td>
<td>None</td>
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<td>Other</td>
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<td>None</td>
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<td>None</td>
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</tbody>
</table>

**Comments:**

Impacted zone of 13000 yd³ (up to 38 ft bgs)

**Attachments:**

---
<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>✗ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>❌ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>❌ Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>❌ Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>✗ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>✗ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>✗ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>✗ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>❌ Largely permeable sediments with inter-beded lenses of lower permeability material</td>
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<td></td>
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<tr>
<td></td>
<td>✗ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl  __________ Unknown

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low (ft bgs):</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>high (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction: __________ __________ __________

Horizontal hydraulic gradient (feet/foot): __________ __________ __________ Unknown

Vertical hydraulic gradient (feet/foot): __________ __________ __________ Unknown

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
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<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmissivity (ft²/day):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured using:</td>
</tr>
<tr>
<td>low</td>
</tr>
<tr>
<td>high</td>
</tr>
</tbody>
</table>

Comments:
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
Attachments:____________________________________________________________________________________________
Thermal Treatment - Design

| Thermal treatment: | Conductive | Conductive  
|--------------------|------------|-----------
| Electrical Resistance | AC power | DC power |  
| 3 phase | 6 phase | 
| Steam | Steam + air | Steam + O2 |  
| Other (describe) | 

Type of Test: Pilot test  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test: 
Duration: 

Hydraulic Control: Yes  

Thermal Cell Design:  
- Size of target zone (ft²): 
- Thickness of target zone (ft): 
- Depth to top of target zone (ft bgs): 
- Thickness of target zone below water table (ft): 
- Number of energy delivery points: 
- Number of extraction points: 

Temperature Profile:  
- Initial formation temperature (deg C): 
- Maximum representative formation temperature (deg C): 
- Time to reach maximum representative temperature (days): 
- Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment: 
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
- Via liquid pumping:  
- In vapor stream:  
- Total: 

Attachments:  
- Treated - 12,500 yd³

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.


**Remediation Goal:**

- **In Groundwater:**
  - Comment:
- **In Soil:**
  - Comment:

Was the Remediation Goal Achieved:

- **In Groundwater**
  - Comment:
- **In Soil**
  - Comment:

General comments on the thermal application:

---

**75% PCE Reduction**

**Lessons Learned**

---

**Energy**

- Total Energy Used: ___ kWh, ___ kWh/m³, ___ kWh/yd³
  - Total energy applied to treatment zone: ___ kWh/m³, ___ kWh/yd³
  - Other energy: ___ kWh/m³, ___ kWh/yd³
  - Please note other energy: ____________________________________________________________________________________

**Cost**

- Total Project Cost: 120/yd³
  - Consultant Cost: __________________________
  - Thermal Vendor Cost: __________________________
  - Energy Cost: __________________________ m³, __________________________ yd³
  - Other Cost 1: 300,000
  - Other Cost 2: __________________________
  - Other Cost 3: __________________________

- Please note other cost: ____________________________________________________________________________________

- Other Cost 1: __________________________ capital cost
  - Other Cost 2: __________________________
  - Other Cost 3: __________________________
Facility Name: Operating Dry cleaner

Address: _____________________________________________________________________________

City, State, Zip Code: Chicago, IL suburb

OU# or Site #: ________________________________________________________________________

Primary point of contact: TRS website

Organization: _________________________________________________________________________

Address: _____________________________________________________________________________

City, State, Zip Code: __________________________________________________________________

Phone #: __________________________ email: ____________________________________________

Other contacts or vendors who worked on site: None

Point of contact: Jeff Pope

Type: Vendor, Consultant Vendor, Technical Applications Other

Organization: Clayton Group

Address: _____________________________________________________________________________

City, State, Zip Code: Chicago, IL

Phone #: 630-795-3211 email: ____________________________________________________________

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0412

#### Impacted Zone:
- Length (parallel to flow direction)(ft.):
- Width (ft.):
- Thickness (ft.):
- 
- Unknown

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data:
- Pre-treatment: None
- Post-treatment: None

- Number of wells relative to treatment zone:
  - Pre-treatment: In: _______ Upgradient: _______ Downgradient: _______ Crossgradient: _______
  - Post-treatment: In: _______ Upgradient: _______ Downgradient: _______ Crossgradient: _______

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data:
- Number inside treatment zone: _______
- Number outside treatment zone: _______

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Gasoline</td>
<td>Crossgradient</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>5,000 mg/kg</td>
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<td>1,1-dichloroethene</td>
<td>Napthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
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<td>Vinyl Chloride</td>
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</tbody>
</table>

#### Comments:

- ____________________________________________
- ____________________________________________
- ____________________________________________

#### Attachments:

- ____________________________________________
### Hydrogeologic Conceptual Model

#### Geology:

**Vadose Zone:**
- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [x] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

#### Ground surface elevation based on wells in or adjacent to treatment zone:
- [ ] ___ ft amsl
- [x] Unknown

#### Aquifer Characteristics:

- Is more than 1 aquifer present?
  - [x] Yes (number): _____________
  - [ ] No

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
  - low value (ft bgs): 70 |
  - high value (ft bgs): |
  - Unknown: |

- Flow direction

- Horizontal hydraulic gradient (feet/foot): [x]
- Vertical hydraulic gradient (feet/foot): [x]

- K range (ft/day)
  - Measured using: [ ] Slug Test [ ] Laboratory [ ] Field data
    - low: 2.83E-05
    - high:

- Transmissivity (ft²/day):
  - Measured using: [ ] Slug Test [ ] Laboratory [ ] Field data
    - low:
    - high:

#### Comments:

- [ ] ______________________________________________________________________
- [ ] ______________________________________________________________________
- [ ] ______________________________________________________________________
- [ ] ______________________________________________________________________

#### Attachments:

- [ ] ______________________________________________________________________
- [ ] ______________________________________________________________________
- [ ] ______________________________________________________________________
Thermal Treatment - Design

Thermal treatment: x Conductive
x Electrical Resistance

Type of Test: x Pilot test
x Full-scale System

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone
- Largely impermeable sediments with inter-bedded layers of higher permeability material

Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 11/18/2002

Duration of treatment at representative temperature (days): 120 d
Time to reach maximum representative temperature (days): Unknown
Maximum representative formation temperature (deg C): 80
Initial formation temperature (deg C): 10

Temperature Profile:

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<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
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</thead>
<tbody>
<tr>
<td></td>
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<tr>
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</table>

Mass of contaminant removed:

<table>
<thead>
<tr>
<th></th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>In vapor stream</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- **In Groundwater:**

- **In Soil:**
  
  All PCE samples to less than 520 mg/kg

Was the Remediation Goal Achieved:

- **In Groundwater**

  Comment:

- **In Soil**

  Comment:

  Yes, average PCE concentration = 62 mg/kg

General comments on the thermal application:

Lessons Learned

Energy

- Total Energy Used: _____________ ____________ ____________ ____________
  - Total energy applied to treatment zone: ____________ ____________ ____________ ____________
  - Other energy: ____________ ____________ ____________ ____________

Cost

- Total Project Cost: ____________
  - Consultant Cost: ____________
  - Thermal Vendor Cost: ____________
  - Energy Cost: ____________ ____________ ____________ ____________
  - Other Cost 1: ____________
  - Other Cost 2: ____________
  - Other Cost 3: ____________

  Please note other cost: ____________
  - Other Cost 1: ____________
  - Other Cost 2: ____________
  - Other Cost 3: ____________
Facility Name: Lockformer Site

Primary point of contact: Steve Faryan
Organization: EPA Region 5

Other contacts or vendors who worked on site: None

Point of contact: Stan Komperda
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: IL EPA

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
## General Site Assessment Data

### Impacted Zone:
- Length (parallel to flow direction)(ft.): [ ]
- Width (ft.): [ ]
- Thickness (ft.): [ ]

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: [ ]
- Pre-treatment: [ ]
- Post-treatment: [ ]

- Number of wells relative to treatment zone:
  - Pre-treatment: In: [ ] Uppgradient: [ ] Downgradient: [ ] Crossgradient: [ ]
  - Post-treatment: In: [ ] Uppgradient: [ ] Downgradient: [ ] Crossgradient: [ ]

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: [ ]
- Number of relevant soil borings with post-treatment data: [ ]

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
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<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
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<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
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<tr>
<td>Vinyl Chloride</td>
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<td>None</td>
<td>None</td>
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</tbody>
</table>

### Comments:

- [ ]
- [ ]
- [ ]

### Attachments:

- [ ]
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>(X) Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>(X) Relatively homogeneous and impermeable unconsolidated sediments</td>
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<tr>
<td></td>
<td>(X) Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
<td></td>
<td>(X) Largely impermeable sediments with inter-bedded layers of lower permeability material</td>
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<tr>
<td></td>
<td>(X) Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>(X) Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>(X) Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>(X) Relatively homogeneous and impermeable unconsolidated sediments</td>
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<tr>
<td></td>
<td>(X) Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<td></td>
<td>(X) Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<tr>
<td></td>
<td>(X) Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

#### Aquifer Characteristics:

- Is more than 1 aquifer present? _Yes_ (number): ____________ _Unknown (assume single aquifer)_

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
</tr>
</tbody>
</table>

- Flow direction ____________

- Horizontal hydraulic gradient (feet/foot): ____________ ____________ ____________ ____________ Unknown
- Vertical hydraulic gradient (feet/foot): ____________ ____________ ____________ ____________ Unknown

- K range (ft/day) Measured using: ____________ Slug Test ____________ Laboratory ____________ Field data
  - low: ____________ ____________ ____________ ____________ Unknown
  - high: ____________ ____________ ____________ ____________

- Transmissivity (ft²/day): Measured using: ____________ Slug Test ____________ Laboratory ____________ Field data
  - low: ____________ ____________ ____________ ____________ Unknown
  - high: ____________ ____________ ____________ ____________

#### Comments:

____________________________________________________________________________________________

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#### Attachments:

____________________________________________________________________________________________

____________________________________________________________________________________________

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____________________________________________________________________________________________
<table>
<thead>
<tr>
<th><strong>Thermal Treatment - Design</strong></th>
<th>Facility ID#: 0415</th>
</tr>
</thead>
<tbody>
<tr>
<td>x Thermal treatment: Conductive</td>
<td>x Electrical Resistance</td>
</tr>
<tr>
<td>x 3 phase</td>
<td>x 6 phase</td>
</tr>
<tr>
<td>x Steam</td>
<td></td>
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<tr>
<td>x Steam</td>
<td>x Steam + air</td>
</tr>
<tr>
<td>x Other (describe)</td>
<td></td>
</tr>
<tr>
<td>x Type of Test: Pilot test</td>
<td>x Full-scale System</td>
</tr>
<tr>
<td>x Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td>x Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td>x Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
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<tr>
<td>x Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
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<tr>
<td>x Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td>x Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td>x Treatment Target Zone: Saturated only</td>
<td>x Vadose only</td>
</tr>
<tr>
<td>x Start of Thermal Test: 6/25/2003</td>
<td>x Duration: 751</td>
</tr>
<tr>
<td>x Hydraulic Control</td>
<td>x Yes</td>
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<td>x Treatment Cell Design:</td>
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<tr>
<td>Size of target zone (ft2): 37750</td>
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<tr>
<td>Thickness of target zone (ft): 17</td>
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<tr>
<td>Depth to top of target zone (ft bgs): 1</td>
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<tr>
<td>Thickness of target zone below water table (ft): 0</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points: 244</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points: 244</td>
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</tr>
<tr>
<td>x Temperature Profile:</td>
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<tr>
<td>Initial formation temperature (deg C): 13</td>
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<tr>
<td>Maximum representative formation temperature (deg C): 95</td>
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<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td></td>
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<td>Duration of treatment at representative temperature (days):</td>
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<tr>
<td>Formation temperature immediately post-treatment:</td>
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<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
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<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
</tr>
<tr>
<td>x Mass of contaminant removed:</td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td></td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
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<tr>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>Attachments:</td>
<td></td>
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</tbody>
</table>

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:
- In Groundwater:
- In Soil:

Was the Remediation Goal Achieved:
- In Groundwater:
  - Comment:
- In Soil:
  - Comment:

General comments on the thermal application:
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

Total energy applied to treatment zone: 9015000 kWh

Other energy: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

Please note other energy: ______________________________________________________________________________________

Cost

Total Project Cost:
- Consultant Cost: ___________
- Thermal Vendor Cost: ___________
- Energy Cost: ___________ m³ ___________ yd³
- Other Cost 1: ___________
- Other Cost 2: ___________
- Other Cost 3: ___________

Please note other cost: ___________ Other Cost 1: ___________
Other Cost 2: ___________
Other Cost 3: ___________
General Site Information

File Analyzed By: JT  PD
Type of treatment:  Conductive  Steam  ERH  Other:
Type of Contaminant:  Chlorinated Solvents  Petroleum Hydrocarbons  Pesticides  Wood Treating  Other:
Treatment Status:  Active  Post
Type of Test:  Pilot Test  Full Scale System
Type of Site:  Non-DOD  DoD

Facility Name:  Former Electronics Manufacturing
Address:  
City, State, Zip Code:  Skokie, IL
OU# or Site #:  

Primary point of contact:  Bill Heath
Organization:  CES
Address:  419 Entiat Street, Suite A
City, State, Zip Code:  Kennewick, WA  99336
Phone #:  509-727-4276  email:  bill@ceisiweb.com

Other contacts or vendors who worked on site  None
Point of contact:
Type:  Vendor, Consultant  Vendor, Technical Applications  Other
Organization:  
Address:  
City, State, Zip Code:  
Phone #:  
email:  

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
General Site Assessment Data

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdtr</td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
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<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>cis,1,2-dichloroethene</td>
<td>Benene</td>
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<td>10 mg/L</td>
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<td>trans,1,2-dichloroethene</td>
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<td>Vinyl Chloride</td>
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</table>

Comments:

Attachments:
Geology:

Vadose Zone:

- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely permeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:

- Largely homogeneous and permeable unconsolidated sediments
- Largely homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: 

- Knickpoint elevation: 
- Slope of knickpoint: 
- Known
- Unknown (assume single aquifer)

Aquifer Characteristics:

Is more than 1 aquifer present?

- No
- Yes (number): 
- Unknown (assume single aquifer)

Depth to water:

- Low value (ft bgs): 
- High value (ft bgs): 
- Unknown:

Flow direction:

- Horizontal hydraulic gradient (feet/foot):
- Vertical hydraulic gradient (feet/foot):

- Measured using:
  - Slug Test
  - Laboratory
  - Field data
  - Unknown

K range (ft/day):

- Low: 0.028
- High: 0.28

Transmissivity (ft²/day):

- Low: 
- High:

- Measured using:
  - Slug Test
  - Laboratory
  - Field data
  - Unknown

Comments:

K = 10^-5 to 10^-4 cm/sec

Attachments:
## Thermal Treatment - Design

- **Thermal treatment:**
  - [x] Conductive
  - [x] Electrical Resistance
  - [x] 3 phase
  - [x] 6 phase
  - [x] AC power
  - [x] DC power
  - Steam
  - Steam + air
  - Steam + O2
  - [x] Other (describe)

- **Type of Test:**
  - [x] Pilot test
  - [x] Full-scale System

- **Geology of Treatment Zone:**
  - [x] Relatively homogeneous and permeable unconsolidated sediments
  - [x] Largely permeable sediments with inter-bedded layers of lower permeability material
  - [x] Relatively homogeneous and impermeable unconsolidated sediments
  - [x] Largely permeable sediments with inter-bedded lenses of higher permeability material
  - [x] Competent, but fractured bedrock (i.e. crystalline rock)
  - [x] Weathered bedrock, limestone, sandstone

- **Treatment Target Zone:**
  - [x] Saturated only
  - [x] Vadose only
  - [x] Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - Duration: 170 days

- **Hydraulic Control:**
  - [x] Yes
  - [x] No

- **Treatment Cell Design:**
  - Size of target zone (ft²): 23,000
  - Thickness of target zone (ft): 10
  - Depth to top of target zone (ft bgs): 5
  - Thickness of target zone below water table (ft): 17
  - Number of energy delivery points: 197
  - Number of extraction points: 37

- **Temperature Profile:**
  - Initial formation temperature (deg C): 10
  - Maximum representative formation temperature (deg C): 100
  - Time to reach maximum representative temperature (days): 60
  - Duration of treatment at representative temperature (days): 70

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>70</td>
</tr>
</tbody>
</table>

- **Mass of contaminant removed:**
  - Via liquid pumping: __________ lb __________ kg __________ kg
  - In vapor stream: __________ lb __________ kg __________ kg
  - Total: __________ lb __________ kg __________ kg

- **Notes:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

Total Project Cost: $32/yd3

Energy

Total Energy Used: 1,775,000 kWhr

Cost

Total Project Cost: $148,000

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Was the Remediation Goal Achieved:

In Groundwater:

In Soil:

General comments on the thermal application:

Lessons Learned:

Comment:

Comment:

Comment:

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General Site Information

File Analyzed By: JT PD

Type of treatment: Conductive Steam ERH Other: 

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 

Treatment Status: Active Post 

Type of Test: Pilot Test Full Scale System 

Start of Test: 12/1/1998 End of Test: 4/30/1999 Duration: 

Type of Site: Non-DOD DoD 

Facility Name: Former Electronics Manufacturing

City, State, Zip Code: Skokie, IL

OU# or Site #: 

Primary point of contact: Bill Heath

Organization: CES

Address: 419 Entiat Street, Suite A

City, State, Zip Code: Kennewick, WA 99336

Phone #: 509-727-4276 email: bill@cesiweb.com

Other contacts or vendors who worked on site None

Point of contact: 

Type: Vendor, Consultant Vendor, Technical Applications Other 

Organization: 

Address: 

City, State, Zip Code: 

Phone #: 

email: 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data

Good temperature profile vs. time information Flux assessment

Groundwater elevations Geologic cross-section

Hydraulic Conductivity information
**General Site Assessment Data**

**Facility ID:** 0420

### Impacted Zone:
- Length (parallel to flow direction(ft.)): _______
- Width (ft.): _______
- Thickness (ft.): _______

**Impacted zone as defined by documentation**

**Alternative method for determining size of impacted zone (See source zone definition attachments)**

**Map attachment**

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: ______

**Pre-treatment:** ______  **Post-treatment:** ______

**Number of wells relative to treatment zone:**

- Pre-treatment In: ______  Upgradient: ______  Downgradient: ______  Crossgradient: ______
- Post-treatment In: ______  Upgradient: ______  Downgradient: ______  Crossgradient: ______

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: ______

**Number of relevant soil borings with post-treatment data:**

**Number inside treatment zone:** ______  **Number outside treatment zone:** ______

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: ______

**Number of relevant soil borings with post-treatment data:**

**Number inside treatment zone:** ______  **Number outside treatment zone:** ______

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Chemicals of Concern</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
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<td>None</td>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>1,1-Dichloroethene</td>
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<td></td>
<td>1,2-Dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-Dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>1,1,1-Trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-Trichloroethene</td>
<td>m,p-xylene</td>
<td></td>
<td>1,1,2-Trichloroethene</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,2-Trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<td></td>
<td>None</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- ______
- ______
- ______

### Attachments:

- ______
- ______
- ______
Hydrogeologic Conceptual Model

Geology:

Zone
Unconsolidated Sediments

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: _____ ft amsl

Yes (number): ___________

Unknown (assume single aquifer):

Aquifer Characteristics:

Is more than 1 aquifer present? No Yes (number): __________

Depth to water:
- low value (ft bgs): __________
- high value (ft bgs): __________
- Unknown: __________

Flow direction: __________

Horizontal hydraulic gradient (feet/foot): __________

Vertical hydraulic gradient (feet/foot): __________

K range (ft/day):

Measured using: Slug Test Laboratory Field data

low: __________
high: __________

K = 10^-5 to 10^-4 cm/sec

Transmissivity (ft2/day):

Measured using: Slug Test Laboratory Field data

low: __________
high: __________

Unknown

Comments:

Attachments:
### Thermal Treatment - Design

| Facility ID#: 0420 |

<table>
<thead>
<tr>
<th><strong>Thermal treatment:</strong></th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Test:</strong></td>
<td>Pilot test</td>
<td>Full-scale System</td>
</tr>
<tr>
<td><strong>Geology of Treatment Zone:</strong></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td><strong>Treatment Target Zone:</strong></td>
<td>Saturated only</td>
<td>Vadose only</td>
</tr>
<tr>
<td><strong>Start of Thermal Test:</strong></td>
<td>12/1/1998</td>
<td>Duration: 18 weeks</td>
</tr>
<tr>
<td><strong>Hydraulic Control:</strong></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Treatment Cell Design:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Size of target zone (ft²):</strong></td>
<td>Unknown</td>
<td>( _ x _ ft)</td>
</tr>
<tr>
<td><strong>Thickness of target zone (ft):</strong></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td><strong>Depth to top of target zone (ft bgs):</strong></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td><strong>Thickness of target zone below water table (ft):</strong></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td><strong>Number of energy delivery points:</strong></td>
<td>185</td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Number of extraction points:</strong></td>
<td>37</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

| **Temperature Profile:** | | |
| **Initial formation temperature (deg C):** | 10 | Unknown |
| **Maximum representative formation temperature (deg C):** | 100 | Unknown |
| **Time to reach maximum representative temperature (days):** | 60 | Unknown |
| **Duration of treatment at representative temperature (days):** | 70 | Unknown |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Mass of contaminant removed: | | |
| Via liquid pumping: | Unknown | |
| In vapor stream: | Unknown | |
| Total: | Unknown | |

| Comments: | |
| Attachments: | |
Performance
Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:

___ In Soil

Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy
Total Energy Used: _______ kWhr _______ kWhr/m³ _______ kWhr/yd³

___ Total energy applied to treatment zone: _______ kWhr _______ kWhr/m³ _______ kWhr/yd³

___ Other energy: _______ kWhr _______ kWhr/m³ _______ kWhr/yd³

Please note other energy: ___________________________________________________________

Cost
Total Project Cost: $32/cubic yard

___ Consultant Cost: ________________________________

___ Thermal Vendor Cost: ________________________________

___ Energy Cost: ________________________________ m³ ___ yd³

___ Other Cost 1: ________________________________

___ Other Cost 2: ________________________________

___ Other Cost 3: ________________________________

Please note other cost: ___ Other Cost 1: ________________________________

___ Other Cost 2: ________________________________

___ Other Cost 3: ________________________________
### General Site Information

<table>
<thead>
<tr>
<th>Filed Analyzed By:</th>
<th>JT PD</th>
<th>Date:</th>
<th>Facility ID#:</th>
<th>0423</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive, Steam, ERH, Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides, Wood Treating, Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active, Post</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test, Full Scale System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD, DoD</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Facility Name:
- **Naval Station Great Lakes**
- **Decauter Ave**
- **Great Lakes, IL 60088**
- **OU# or Site #: Site 22**

### Primary point of contact:
- **Bob Davis**
- **Tetra Tech**
- **661 Andersen Dr., Foster Plaza 7**
- **Pittsburgh, PA 15220**
- **Phone #: 412-921-7251**
- **email: robert.davis@tnus.com**

### Other contacts or vendors who worked on site:
- **None**

### Point of contact:
- **David Fleming**
- **Vendor, Consultant**
- **Vendor, Technical Applications**
- **Other**
- **TRS**
- **7421-A Warren Ave SE**
- **Snoqualmie, WA 98065**
- **Phone #: 425-396-4266**
- **email: dfleming@thermalrs.com**

### QA/QC

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Good pre- and post-treatment groundwater data</td>
<td>X</td>
</tr>
<tr>
<td>Good pre- and post-treatment soil data</td>
<td></td>
</tr>
<tr>
<td>Good temperature profile vs. time information</td>
<td>X</td>
</tr>
<tr>
<td>Flux assessment</td>
<td></td>
</tr>
<tr>
<td>Groundwater elevations</td>
<td>X</td>
</tr>
<tr>
<td>Geologic cross-section</td>
<td></td>
</tr>
<tr>
<td>Hydraulic Conductivity information</td>
<td></td>
</tr>
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</table>
### General Site Assessment Data

**Facility ID:** 0423

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 to 20</td>
</tr>
</tbody>
</table>

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

<table>
<thead>
<tr>
<th>Monitor Wells:</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

- Number of wells relative to treatment zone:
  - Pre-treatment: In: 6, Uppgradient: 3, Downgradient: 2, Crossgradient: 2
  - Post-treatment: In: 4, Uppgradient: 3, Downgradient: 2, Crossgradient: 2

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>Number inside treatment zone:</th>
<th>Number outside treatment zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

- Number of relevant soil borings with post-treatment data: 7

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>BTEX</td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td>None None</td>
<td>None None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Naphthalene</td>
<td></td>
<td>None None</td>
<td>None None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethane</td>
<td>Benzene</td>
<td></td>
<td>None None</td>
<td>None None</td>
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<tr>
<td></td>
<td>trans-1,2-dichloroethane</td>
<td>Toluene</td>
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<td>None None</td>
<td>None None</td>
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<tr>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>None None</td>
<td>None None</td>
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<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td>None None</td>
<td>None None</td>
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<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>p-xylene</td>
<td></td>
<td>None None</td>
<td>None None</td>
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<td></td>
<td>1,1,2-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None None</td>
<td>None None</td>
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<tr>
<td></td>
<td>1,2,2-trichloroethane</td>
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<td></td>
<td>None None</td>
<td>None None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None None</td>
<td>None None</td>
</tr>
</tbody>
</table>

#### Comments:

- Additional comments on site assessment data

#### Attachments:

- Additional documentation and reports related to site assessment
## Hydrogeologic Conceptual Model

**Geology:**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

**Ground surface elevation based on wells in or adjacent to treatment zone:** 600 ft amsl

**Aquifer Characteristics:**

- Is more than 1 aquifer present? Yes (number): ____________ Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs):</th>
<th>Unknown</th>
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<tbody>
<tr>
<td>Aquifer 1</td>
<td>low: 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high: 10</td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>low:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high:</td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td>low:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high:</td>
<td></td>
</tr>
</tbody>
</table>

- Flow direction: southerly

- Horizontal hydraulic gradient (feet/foot): 0.1
- Vertical hydraulic gradient (feet/foot): ____________ Unknown

- K range (ft/day)
  - Measured using: Slug Test
  - low: 0.2
  - high: ____________ Unknown

- Transmissivity (ft²/day):
  - Measured using: Slug Test
  - low: ____________ Unknown
  - high: ____________ Unknown

**Comments:**

Attachments:
### Thermal Treatment - Design

**Thermal treatment:**
- Conductive
- Electrical Resistance
- **Steam**
- **Steam + O2**
- **Steam + air**
- **AC power**
- **DC power**

**Type of Test:**
- Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- Duration: 134 days

**Hydraulic Control:**
- Yes
- No

**Treatment Cell Design:**
- Size of target zone (ft²): 2400
- Thickness of target zone (ft): 16.58
- Depth to top of target zone (ft bgs): 0.5
- Thickness of target zone below water table (ft): 12
- Number of energy delivery points: 16
- Number of extraction points: 16

**Temperature Profile:**
- Initial formation temperature (deg C): 15
- Maximum representative formation temperature (deg C): 100
- Time to reach maximum representative temperature (days): 30
- Duration of treatment at representative temperature (days): 104

**Date** | **Temperature (deg C)**
--- | ---
100 | Unknown
N/A | N/A

**Mass of contaminant removed:**
- Via liquid pumping: Unknown lb kg
- In vapor stream: Unknown lb kg
- Total: Unknown lb kg

**Volume treated:** 1400 yd³

**Attachments:**

---

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
**Remediation Goal:**
- **In Groundwater:**  
- **In Soil:** PCE <20 mg/kg or 98.6% reduction

**Was the Remediation Goal Achieved:**
- **In Groundwater**
  - Comment:  
- **In Soil**
  - Comment: PCE <4 mg/kg, 99% reduction

**General comments on the thermal application:**

**Lessons Learned**
- Clay soils (low permeability soils) - should consider additional vapor recovery wells

**Energy**

**Total Energy Used:**
- x kWhr  
- kWhr/m³  
- kWhr/yd³

- **Total energy applied to treatment zone:** 632,866 kWhr/m³ kWhr/yd³

**Other energy:**

**Cost**

**Total Project Cost:**
- x Consultant Cost: 360,000
- x Thermal Vendor Cost: 446,000

**Energy Cost:**
- Other Cost 1:  
- Other Cost 2:  
- Other Cost 3:  

**Other cost:**

**Please note other energy:**

**Other Cost 1:**

**Other Cost 2:**

**Other Cost 3:**

---

**Please note other energy:**

---

---
General Site Information

File Analyzed By: JT PD Date: 10/16/2006

Type of treatment: ___ Conductive ___ Steam x ERH ___ Other: __________

Type of Contaminant: x Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides
___ Wood Treating ___ Other: __________

Treatment Status: ___ Active x Post

Type of Test: ___ Pilot Test x Full Scale System

Start of Test: 9/22/2004 End of Test: 11/1/2004 Duration: 56 d

Type of Site: x Non-DOD ___ DoD

Facility Name: Confidential IL

City, State, Zip Code: Olney, IL

Primary point of contact: Waye Sheu

Organization: Malcolm Pirnie

City, State, Zip Code: Chicago, IL

Phone #: 847-517-8114 ext 103 email: wsheu@pirnie.com

Other contacts or vendors who worked on site ___ None

Point of contact: __________

Type: x Vendor, Consultant ___ Vendor, Technical Applications ___ Other __________

Organization: TRS

City, State, Zip Code: __________ email: __________

Phone #: __________

QA/QC

Characteristics of Interest

___ Good pre- and post-treatment groundwater data ___ Good pre- and post-treatment soil data

___ Good temperature profile vs. time information ___ Flux assessment

___ Groundwater elevations ___ Geologic cross-section

___ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:**

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Impacted zone as defined by documentation**

**Alternative method for determining size of impacted zone (See source zone definition attachments)**

**Map attachment**

<table>
<thead>
<tr>
<th>Monitor Wells:</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Number of wells relative to treatment zone:**

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>In:</th>
<th>Upgradient:</th>
<th>Downgradient:</th>
<th>Crossgradient:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Post-treatment</th>
<th>In:</th>
<th>Upgradient:</th>
<th>Downgradient:</th>
<th>Crossgradient:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Soil Borings:**

**Number of relevant soil borings with pre-treatment data:**

**Number of relevant soil borings with post-treatment data:**

**Number inside treatment zone:**

**Number outside treatment zone:**

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>ChlorinatedSolvents</th>
<th>PetroleumHydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>5.000 mg/kg</td>
<td>None</td>
<td>0.01 mg/kg</td>
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</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
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<td>None</td>
<td>None</td>
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<td>Ethylbenzene</td>
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</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

**Area 1**

### Attachments:

---

---
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
  - Pre-treatment: __________
  - Post-treatment: __________
  - Number of wells relative to treatment zone:
    - Pre-treatment: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________
    - Post-treatment: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>Groundwater</td>
<td>None</td>
<td>10,000 mg/kg</td>
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<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>Groundwater</td>
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<td>None</td>
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<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>Groundwater</td>
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<td>None</td>
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<tr>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>Groundwater</td>
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<tr>
<td></td>
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<td>Ethylbenzene</td>
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<tr>
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<td>m/p-xylene</td>
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<tr>
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<td>None</td>
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<td>1,1,2-trichloroethene</td>
<td>cis-1,2-dichloroethene</td>
<td>Groundwater</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>Benzene</td>
<td>Groundwater</td>
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<td>None</td>
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<td></td>
<td></td>
<td></td>
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<td>None</td>
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</tbody>
</table>

**Comments:**

**Attachments:**

---

Area 2
Hydrogeologic Conceptual Model

Geology:

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: ______________ ft amsl  x Unknown

Aquifer Characteristics:

Is more than 1 aquifer present?  No  Yes (number): _____________  x Unknown (assume single aquifer)

Aquifer 1  Aquifer 2  Aquifer 3

Depth to water:
- low value (ft bgs): _____________  _____________  _____________  
- high value (ft bgs): _____________  _____________  _____________  
- Unknown: _____________  _____________  _____________

Flow direction

- _____________  _____________  _____________

Horizontal hydraulic gradient (feet/foot): _____________  _____________  _____________  x Unknown

Vertical hydraulic gradient (feet/foot): _____________  _____________  _____________  x Unknown

K range (ft/day)

Measured using:  Slug Test  Laboratory  Field data
- low _____________  _____________  _____________  x Unknown
- high _____________  _____________  _____________

Transmissivity (ft²/day):

Measured using:  Slug Test  Laboratory  Field data
- low _____________  _____________  _____________  x Unknown
- high _____________  _____________  _____________

Comments:

- Very tight soils

Attachments:

- 10 foot spacing
**Thermal Treatment - Design**

**Facility ID:** 0425

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
<th>3 phase</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
<th>Steam</th>
<th>Steam + air</th>
<th>Steam + O2</th>
<th>Other (describe)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
<th>Relatively homogeneous and permeable unconsolidated sediments</th>
<th>Relatively homogeneous and impermeable unconsolidated sediments</th>
<th>Largely permeable sediments with inter-bedded lenses of lower permeability material</th>
<th>Largely impermeable sediments with inter-bedded layers of higher permeability material</th>
<th>Competent, but fractured bedrock (i.e. crystalline rock)</th>
<th>Weathered bedrock, limestone, sandstone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>9/22/2004</th>
<th>Duration: 56 day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Hydraulic Control:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</table>

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>400</th>
<th>Unknown</th>
<th>(20 x 20 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>8</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>2</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>0</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>4</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>1</td>
<td>Unknown</td>
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</table>

**Temperature Profile:**

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th>20</th>
<th>Unknown</th>
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</thead>
<tbody>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>100</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>28</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>28</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Formation temperature immediately post-treatment:**

**Formation temperature post-treatment monitoring event 1:**

**Duration of post-treatment monitoring (days):**

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th>Unknown</th>
<th>Unknown</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>690 lb</td>
<td>3 kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Comments:**

10 ft spacings

**Attachments:**

Contaminant removal is from both treatment zones

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment - Design

Thermal treatment: x Conductive  

Type of Test: x Pilot test  

Geology of Treatment Zone: x Relatively homogeneous and permeable unconsolidated sediments  

Treatment Target Zone: x Saturated only  

Start of Thermal Test: 9/22/2004  

Hydraulic Control: x Yes  

Treatment Cell Design:
- Size of target zone (ft²): 600  
- Thickness of target zone (ft): 15  
- Depth to top of target zone (ft bgs): 20  
- Thickness of target zone below water table (ft): 15  
- Number of energy delivery points: 8  
- Number of extraction points: 8  

Temperature Profile:
- Initial formation temperature (deg C): 90  
- Maximum representative formation temperature (deg C): 95  
- Time to reach maximum representative temperature (days): 48  
- Duration of treatment at representative temperature (days): 8  

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:
- Via liquid pumping: ___ lb ___ kg ___ Unknown  
- In vapor stream: ___ lb ___ kg ___ Unknown  
- Total: ___ lb ___ kg ___ Unknown  

Comments: The two electrodes from the area between zones 1 and 2 are included in this sheet because they extend down to 35 ft 10 ft spacings  

Contaminant removal is from both treatment zones  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
**Remediation Goal:**

<table>
<thead>
<tr>
<th>Performance</th>
<th>Energy</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In Groundwater:</strong></td>
<td>kWhr/m³</td>
<td><strong>kWhr/yd³</strong></td>
</tr>
<tr>
<td><strong>In Soil:</strong></td>
<td>kWhr/m³</td>
<td><strong>kWhr/yd³</strong></td>
</tr>
</tbody>
</table>

**IL EPA Csat = 4440.76 mg/kg and a site specific goal of 75.18 mg/kg**

**Was the Remediation Goal Achieved:**

<table>
<thead>
<tr>
<th>In Groundwater</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yes</strong></td>
<td></td>
</tr>
</tbody>
</table>

**General comments on the thermal application:**

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

**Lessons Learned**

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

**Energy**

<table>
<thead>
<tr>
<th>Total Energy Used:</th>
<th>kWhr</th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>x</strong></td>
<td>kWhr</td>
<td>kWhr/m³</td>
<td>kWhr/yd³</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Total energy applied to treatment zone:</strong></th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Other energy:</strong></th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Please note other energy:</th>
</tr>
</thead>
</table>

**Cost**

<table>
<thead>
<tr>
<th>Total Project Cost:</th>
<th>Consultant Cost:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>x</strong></td>
<td>Consultant Cost:</td>
</tr>
</tbody>
</table>

| __Thermal Vendor Cost:__ | __Energy Cost:__ | __Other Cost 1:__ |
|___________________________|___________________|____________________|
| 232000 | | |

<table>
<thead>
<tr>
<th><strong>Other Cost 2:</strong></th>
<th><strong>Other Cost 3:</strong></th>
</tr>
</thead>
</table>
### General Site Information

- **File Analyzed By:** JT PD
- **Date:** 4/18/2005
- **Type of treatment:** Conductive, Steam, ERH, Other:
- **Type of Contaminant:** Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides, Wood Treating, Other: methylene chloride
- **Treatment Status:** Active, Post
- **Type of Test:** Pilot Test, Full Scale System
- **Start of Test:** 12/8/1999
- **End of Test:** 11/10/2000
- **Duration:** 329 days
- **Type of Site:** Non-DOD, DoD
- **Facility Name:** Avery Dennison Mfg. Facility
- **Address:** 2340 Ernie Krueger Circle
- **City, State, Zip Code:** Waukegan, IL
- **Facility ID#:** 0440
- **OU# or Site #:**

### Facility Contacts or Vendors

- **Primary point of contact:** Jennifer Seul
  - **Organization:** IL EPA
  - **Address:**
  - **City, State, Zip Code:**
  - **Phone #:** 217-785-9399
  - **email:**

- **Other contacts or vendors who worked on site:** None
  - **Point of contact:**
    - **Type:** Vendor, Consultant, Vendor, Technical Applications, Other
    - **Organization:**
    - **Address:**
    - **City, State, Zip Code:**
    - **Phone #:**
    - **email:**

### QA/QC

- **Characteristics of Interest**
  - **Good pre- and post-treatment groundwater data**
  - **Good pre- and post-treatment soil data**
  - **Good temperature profile vs. time information**
  - **Flux assessment**
  - **Groundwater elevations**
  - **Geologic cross-section**
  - **Hydraulic Conductivity information**
### General Site Assessment Data

| Impacted Zone: | Length (parallel to flow direction)(ft.): | | Width (ft.): | Thickness (ft.): | Unknown |
|----------------|------------------------------------------|--------------------------|-----------------|---------------------|
| Monitor Wells: | Number of relevant monitoring wells with groundwater data: | Pre-treatment: | Post-treatment: | None |
| Soil Borings: | Number of relevant soil borings with pre-treatment data: | Number of relevant soil borings with post-treatment data: | Number inside treatment zone: | Number outside treatment zone: | 16,000 yd³ |

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trihalomethanes</td>
<td>BTEX</td>
<td>Vinyl Chloride</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrahydroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>t,1-dichloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
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<td>None</td>
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<td>1,1-dichloroethene</td>
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<td>Methylene chloride</td>
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<td>Others</td>
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<td>None</td>
<td>None</td>
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</table>

**Comments:**

Impact area of 16,000 yd³

**Attachments:**
### Hydrogeologic Conceptual Model

#### Geology: Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>• Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>• Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>• Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>• Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>• Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>• Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>• Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>• Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>• Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>• Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>• Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>• Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone: 727 ft amsl

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>X</th>
<th>Yes (number): at least 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>6 (perched)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>25 (average)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Flow direction: NW

#### Horizontal hydraulic gradient (feet/foot): 0.00328

#### Vertical hydraulic gradient (feet/foot): X Unknown

#### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>X Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td>X Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

- Additional information or notes about the hydrogeologic conceptual model.

#### Attachments:

- Relevant documents or supporting materials related to the hydrogeologic study.
Thermal Treatment:  

- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
- Steam
  - Steam
  - Steam + air
  - Steam + O2

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 12/8/1999
- Duration: 329 days

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:  

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>24500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>95</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>30</td>
</tr>
</tbody>
</table>

Temperature Profile:  

| Initial formation temperature (deg C): | 13 |
| Maximum representative formation temperature (deg C): | west 90 / east 80 |
| Time to reach maximum representative temperature (days): | 288 |
| Duration of treatment at representative temperature (days): | 41 |

| Formation temperature immediately post-treatment: | Unknown |
| Formation temperature post-treatment monitoring event 1: | Unknown |
| Duration of post-treatment monitoring (days): | Unknown |

Mass of contaminant removed:  

| Via liquid pumping: | Unknown |
| In vapor stream: | Unknown |
| Total: | Unknown |

Comments:  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Facility ID#: 0440

Remediation Goal:

In Groundwater:

In Soil:

Methylene chloride: unsaturated 24 mg/kg
saturated 2,000 mg/kg

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

yes, but note that none of the saturated soils were over 2,000 mg/kg in pre-treatment samples

General comments on the thermal application:

Had to extend the time from 25 weeks to 47 weeks because of differences in soil heating versus modelled heating

Lessons Learned

Energy

Total Energy Used: _______ kWh _______ kWh/m³ _______ kWh/yd³

Total energy applied to treatment zone: _______ kWh/m³ _______ kWh/yd³

Other energy: _______ kWh/m³ _______ kWh/yd³

Please note other energy:

Cost

Total Project Cost:

Consultant Cost: _______ 

Thermal Vendor Cost: _______ 

Energy Cost: _______ m³ _______ yd³

Other Cost 1: _______ 

Other Cost 2: _______ 

Other Cost 3: _______ 

Please note other cost: _______ 

Other Cost 1: _______ 

Other Cost 2: _______ 

Other Cost 3: _______ 

Other Cost 4: _______ 

Other Cost 5: _______
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By: JT PD</th>
<th>Date: 10/18/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive Steam ERH Other:</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active Post</td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test Full Scale System</td>
</tr>
<tr>
<td>Start of Test: 7/9/2005</td>
<td>End of Test: 20-Dec</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD DoD</td>
</tr>
</tbody>
</table>

### Facility Name

Former Steel Manufacturing Facility

City, State, Zip Code: Fort Wayne, IN

OU# or Site #: ____________

### Primary contact

Jon Hacker

Organization: Ft. Wayne Steel Corp

Address: ____________

City, State, Zip Code: ____________

Phone #: 260-434-2850 email: jhacker@valbruna.us

### Other contacts or vendors who worked on site

Jeff Pope

Vendor, Consultant Vendor, Technical Applications Other

Clayton Group

Address: 3140 Finley Rd

City, State, Zip Code: Downers Grove, IL 60515

Phone #: 630-795-3211 email: pope@claytongrp.com

### QA/QC

- __ Good pre- and post-treatment groundwater data
- __ Good pre- and post-treatment soil data
- __ Good temperature profile vs. time information
- __ Flux assessment
- __ Groundwater elevations
- __ Geologic cross-section
- __ Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): ____________
- Width (ft): ____________
- Thickness (ft): ____________
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: ____________
- Pre-treatment: ____________
- Post-treatment: ____________
- None
- Number of wells relative to treatment zone:
  - Pre-treatment In: ______ Upgradient: ______ Downgradient: ______ Crossgradient: ______
  - Post-treatment In: ______ Upgradient: ______ Downgradient: ______ Crossgradient: ______

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: ____________
- Number inside treatment zone: ______
- Number outside treatment zone: ______
- Number of relevant soil borings with post-treatment data: ______

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross</td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrahydrothene</td>
<td>Jet Fuel</td>
<td></td>
<td>100 mg/L 5,000 mg/kg 50 mg/L 100 mg/kg</td>
<td>None None None None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphtalene</td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
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<td>None None None None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
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<td>None None None None</td>
</tr>
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<td>Ethylbenzene</td>
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</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m+p-xylene</td>
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<td>None None None None</td>
</tr>
<tr>
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<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>None</td>
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<td>None None None None</td>
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</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
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<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td></td>
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<td></td>
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<td>None</td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
</tbody>
</table>

### Comments:

Estimated 60,000 lbs of TCE in the soil.

### Attachments:

- [Map attachment](#)
- [Source zone definition attachments](#)
### Geology:

**Zone**
- **Vadose Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Largely permeable sediments with inter-beded lenses of lower permeability material
- **Saturated Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Largely permeable sediments with inter-beded lenses of lower permeability material

**Aquifer Characteristics:**
- Is more than 1 aquifer present? Yes (number): 1
- Depth to water:
  - Low value (ft bgs): 10
  - High value (ft bgs): 12
- Flow direction
- Horizontal hydraulic gradient (ft/foot):
- Vertical hydraulic gradient (ft/foot):
- K range (ft/day): low, high
- Transmissivity (ft²/day):
  - Measured using: Slug Test, Laboratory, Field data
  - Measured using: Slug Test, Laboratory, Field data

### Ground Surface Elevation:
- Based on wells in or adjacent to treatment zone: 10 ft amsl

### Aquifer 1
- Unknown (assume single aquifer)

### Attachments:
- Comments:

### Hydrogeologic Conceptual Model
- Facility ID#: 0445

---

#### Vadose Zone:
- Weathered bedrock, limestone, sandstone

#### Saturated Zone:
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

---

#### Weathered bedrock, limestone, sandstone

---

#### Relatively homogeneous and permeable unconsolidated sediments

---

#### Largely permeable sediments with inter-beded lenses of lower permeability material

---

#### Largely impermeable sediments with inter-beded layers of higher permeability material

---

#### Competent, but fractured bedrock (i.e. crystalline rock)

---

#### Weathered bedrock, limestone, sandstone

---

#### Relatively homogeneous and impermeable unconsolidated sediments

---

#### Largely permeable sediments with inter-beded lenses of lower permeability material

---

#### Largely impermeable sediments with inter-beded layers of higher permeability material

---

#### Competent, but fractured bedrock (i.e. crystalline rock)

---

#### Weathered bedrock, limestone, sandstone

---
Thermal Treatment - Design

Thermal treatment:  Δ Conductive

Electrical Resistance:

- 3 phase
- 6 phase
- AC power
- DC power

Steam:

- Steam
- Steam + air
- Steam + O2

Other (describe):

Type of Test:

- Pilot test
- Full-scale System

Geology of Treatment Zone:

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 7/9/2005

Duration: 164 d

Hydraulic Control:

- Yes
- No

Treatment Cell Design:

Size of target zone (ft²):

- 12289
- Unknown

Thickness of target zone (ft):

- 14 to 26
- Unknown

Depth to top of target zone (ft bgs):

- 8
- Unknown

Thickness of target zone below water table (ft):

- 12 to 24
- Unknown

Number of energy delivery points:

- 41
- Unknown

Number of extraction points:

- 30
- Unknown

Temperature Profile:

Initial formation temperature (deg C):

- 13
- Unknown

Maximum representative formation temperature (deg C):

- 90
- Unknown

Time to reach maximum representative temperature (days):

- 80
- Unknown

Duration of treatment at representative temperature (days):


Formation temperature immediately post-treatment:


Formation temperature post-treatment monitoring event 1:


Duration of post-treatment monitoring (days):


Mass of contaminant removed:

Via liquid pumping:


In vapor stream:


Total:

- 24348
- Unknown

Area A - 7718 ft² at 8 to 28 ft

Area B - 2872 ft² at 8 to 22 ft

Area C - 1699 ft² at 8 to 34 ft

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
**General comments on the thermal application:**

**Lessons Learned**

**Energy**

<table>
<thead>
<tr>
<th>Total Energy Used: 1663351 kWhr</th>
<th>kWh</th>
<th>kWh/m³</th>
<th>kWh/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy applied to treatment zone:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other energy:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please note other energy:

**Cost**

<table>
<thead>
<tr>
<th>Total Project Cost:</th>
<th>Consultant Cost:</th>
<th>Thermal Vendor Cost: 435302</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Cost:</td>
<td>m³</td>
<td>yd³</td>
</tr>
<tr>
<td>Other Cost 1:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Cost 2:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Cost 3:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please note other cost:

| Other Cost 1: | Other Cost 2: | Other Cost 3: |
General Site Information

File Analyzed By: JT PD Date: 9/13/2006
Type of treatment: x Conductive ___ Steam ___ ERH ___ Other: ____________
Type of Contaminant: x Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides
___ Wood Treating ___ Other: ____________
Treatment Status: ___ Active x Post
Type of Test: ___ Pilot Test x Full Scale System
Start of Test: Jul-97 End of Test: Dec-97 Duration: 60 d
Type of Site: x Non-DOD ___ DoD

Facility Name: Former Premix/EMS Facility
Address: 400 S. Bridge St.
City, State, Zip Code: Portland, IN
OU# or Site #: __________________________________________

Primary point of contact: Ralph S. Baker, Ph.D.
Organization: TerraTherm, Inc.
Address: 10 Stevens Road
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: rbaker@terratherm.com

Other contacts or vendors who worked on site: ___ None
Point of contact: George L. Stegemeier, Ph.D.
Type: Vendor, Consultant Vendor, Technical Applications x Other Shell tech. contact
Organization: GLS Engineering, Inc.
Address: 5819 Queensloch Dr.
City, State, Zip Code: Houston, TX 77096
Phone #: 713-245-7785 email: gstegemeier@shell.com

QA/QC

Characteristics of Interest
___ Good pre- and post-treatment groundwater data x Good pre- and post-treatment soil data
x Good temperature profile vs. time information ___ Flux assessment
___ Groundwater elevations x Geologic cross-section
x Hydraulic Conductivity information
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): 150
- Width (ft.): 50
- Thickness (ft.): 750
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

Monitor Wells:
- Number of relevant monitoring wells with groundwater data: 
  - Pre-treatment: 
  - Post-treatment: 

Soil Borings:
- Number of relevant soil borings with pre-treatment data: 
  - Number of relevant soil borings with post-treatment data: 
    - Number inside treatment zone: 
    - Number outside treatment zone: 

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgrad</td>
<td>None</td>
<td>100 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>1,000 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>Benene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
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<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
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<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
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<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Larger treatment area

Attachments:
## General Site Assessment Data

### Impacted Zone:
- Length (parallel to flow direction)(ft.): unknown
- Width (ft.): unknown
- Thickness (ft.): unknown

*Map attachment*

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: none
- Pre-treatment: __________
- Post-treatment: __________

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>Upgradient</th>
<th>Downgradient</th>
<th>Crossgradient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Post-treatment</th>
<th>Upgradient</th>
<th>Downgradient</th>
<th>Crossgradient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: unknown
- Number of relevant soil borings with post-treatment data: unknown
- Number inside treatment zone: unknown
- Number outside treatment zone: unknown

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>0.5 mg/kg</td>
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<td>cis,1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
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<td>1,1-dichloroethane</td>
<td>Toluene</td>
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<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Crossdr</td>
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<td>None</td>
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<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>Crossdr</td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Smaller treatment area**

### Attachments:

---
Hydrogeologic Conceptual Model

Geology:  

Vadose Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Saturated Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone:  

Ft amsl  

X Unknown

Is more than 1 aquifer present?  
- No  
- Yes (number): ________  
- Unknown (assume single aquifer)

Depth to water:  
- Low value (ft bgs): 22  
- High value (ft bgs): 25  
- Unknown:

Flow direction

Horizontal hydraulic gradient (feet/foot):  

Unknown

Vertical hydraulic gradient (feet/foot):  

Unknown

K range (ft/day)  

Measured using:  
- Slug Test  
- Laboratory  
- Field data

Low:  
- 1.42 (10^-5)  
- Unknown  

High:  
- 7.09 (10^-5)  

Transmissivity (ft²/day):  

Measured using:  
- Slug Test  
- Laboratory  
- Field data

Low:  
- Unknown

High:  
- Unknown

Comments:

k = 0.005 to 0.025 millidarcy

Attachments:  

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment: Conductive

Electrical Resistance

Steam

Type of Test: Pilot test

Full-scale System

Geology of Treatment Zone:

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded lenses of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: Jul-97

Duration: 63 d

Hydraulic Control: Yes

Treatment Cell Design:

Size of target zone (ft2): 7500

unknown

(150 x 50 ft)

Thickness of target zone (ft): 18

unknown

Depth to top of target zone (ft bgs): 0

unknown

Thickness of target zone below water table (ft): 0

unknown

Number of energy delivery points: 130

unknown

Number of extraction points: 130

unknown

Temperature Profile:

Initial formation temperature (deg C): unknown

Maximum representative formation temperature (deg C): >260

unknown

Time to reach maximum representative temperature (days): 63

unknown

Duration of treatment at representative temperature (days): unknown

unknown

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1: Jun-98

<37

Duration of post-treatment monitoring (days):

unknown

unknown

Mass of contaminant removed:

Via liquid pumping: unknown

lb

kg

unknown

In vapor stream: unknown

lb

kg

unknown

Total: unknown

lb

kg

unknown

Comments:

Well spacing of 7.5 ft (triangular).

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>x</th>
<th>Thermal treatment:</th>
<th>x</th>
<th>Conductive</th>
<th>smaller Treatment area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Steam</td>
<td>Steam + air</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other (describe)</td>
<td></td>
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<table>
<thead>
<tr>
<th>x</th>
<th>Type of Test:</th>
<th>x</th>
<th>Pilot test</th>
<th>Full-scale System</th>
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</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Geology of Treatment Zone:</th>
<th>x</th>
<th>Relatively homogeneous and permeable unconsolidated sediments</th>
<th>Relatively homogeneous and impermeable unconsolidated sediments</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>x</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<tr>
<td></td>
<td></td>
<td>x</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Treatment Target Zone:</th>
<th>x</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Start of Thermal Test:</th>
<th>x</th>
<th>Duration: 60 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td></td>
<td>60</td>
<td>d</td>
</tr>
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<table>
<thead>
<tr>
<th>x</th>
<th>Hydraulic Control:</th>
<th>x</th>
<th>Yes</th>
<th>No</th>
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<table>
<thead>
<tr>
<th>x</th>
<th>Treatment Cell Design:</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Size of target zone (ft2):</th>
<th>600</th>
<th>Unknown</th>
<th>(30 x 20 ft)</th>
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<tr>
<td>Thickness of target zone (ft):</td>
<td>12</td>
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<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>0</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>0</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>18</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>18</td>
<td>Unknown</td>
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</table>

**Temperature Profile:**

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<tr>
<th>Initial formation temperature (deg C):</th>
<th>x</th>
<th>Unknown</th>
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<tbody>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>&gt;100</td>
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<tr>
<td>Time to reach maximum representative temperature (days):</td>
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<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>x</td>
<td>Unknown</td>
</tr>
<tr>
<td>Date</td>
<td>Temperature (deg C)</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td></td>
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**Formation temperature immediately post-treatment:**

<table>
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<th>Formaion temperature immediately post-treatment:</th>
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**Formation temperature post-treatment monitoring event 1:**

<table>
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<tr>
<th>Formation temperature post-treatment monitoring event 1:</th>
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</thead>
<tbody>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Mass of contaminant removed:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th>lb</th>
<th>kg</th>
<th>x</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td>lb</td>
<td>kg</td>
<td>x</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>lb</td>
<td>kg</td>
<td>x</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Comments:**

```
___________________________________________________________________________
```

**Attachments:**

```
___________________________________________________________________________
```

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Remediation Goal:

- **In Groundwater:**

- **In Soil:**

  - PCE - 8 mg/kg; TCE - 25 mg/kg; 1,1-DCE - 0.080 mg/kg

#### Was the Remediation Goal Achieved:

- **In Groundwater**

  - Comment:

- **In Soil**

  - Comment:

  - Yes all reached in larger treatment area

#### General comments on the thermal application:

- 

- 

- 

- 

- 

- 

#### Lessons Learned

- 

- 

- 

- 

- 

- 

#### Energy

- **Total Energy Used:**

  - kWh

  - kWh/m³

  - kWh/yd³

  - Total energy applied to treatment zone:

  - kWh/m³

  - kWh/yd³

  - Other energy:

  - kWh/m³

  - kWh/yd³

  - Please note other energy:

#### Cost

- **Total Project Cost:**

  - Consultant Cost:

  - Thermal Vendor Cost:

  - Energy Cost:

  - Other Cost 1:

  - Other Cost 2:

  - Other Cost 3:

  - Please note other cost:

  - Other Cost 1:

  - Other Cost 2:

  - Other Cost 3:
General Site Information

File Analyzed By: JT x PD x x Date: 10/18/2006
Type of treatment: x Conductive x Steam x ERH x Other: ___________
Type of Contaminant: x Chlorinated Solvents x Petroleum Hydrocarbons x Pesticides
__ Wood Treating __ Other: ___________
Treatment Status: x Active x Post
Type of Test: x Pilot Test __ Full Scale System
Start of Test: 2/14/2003 End of Test: 9/6/2003 Duration: 175 d
Type of Site: x Non-DOD __ DoD

x Facility Name: DOE Paducah Gaseous Diffusion Plant
Address: ___________________________________________________________________
City, State, Zip Code: Paducah, KY (McCracken County)
OU# or Site #: ___________________________________________________________________

x Primary point of contact: Bryan Clayton
Organization: Bechtel-Jacobs
Address: ___________________________________________________________________
City, State, Zip Code: ___________________________________________________________________
Phone #: 270-441-5412 email: btc@bechteljacobs.org

x Other contacts or vendors who worked on site __________ None
Point of contact: David Williams & David Dollins
Type: __ Vendor, Consultant x Vendor, Technical Applications __ Other __ EPA / DOE
Organization: EPA __________ / DOE
Address: ___________________________________________________________________
City, State, Zip Code: ___________________________________________________________________
Phone #: 4045628554 / 2704416819 email: ___________________________________________________________________

QA/QC

x Characteristics of Interest
__ Good pre- and post-treatment groundwater data __ Good pre- and post-treatment soil data
__ Good temperature profile vs. time information __ Flux assessment
__ Groundwater elevations __ Geologic cross-section
__ Hydraulic Conductivity information
### General Site Assessment Data

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________
  - Width (ft): __________
  - Thickness (ft): __________
  - Depth: __________

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: __________
    - Pre-treatment: __________
    - Post-treatment: __________
  - Number of wells relative to treatment zone:
    - Pre-treatment: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________
  - Post-treatment: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: __________
  - Number of relevant soil borings with post-treatment data: __________
  - Number inside treatment zone: __________
  - Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>0.000 mg/L</td>
<td>100 mg/kg</td>
<td></td>
<td>5.0 mg/L</td>
<td>1.0 mg/kg</td>
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<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
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<td>trans-1,2-dichloroethene</td>
<td>None</td>
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<tr>
<td>1,1-dichloroethene</td>
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</tr>
<tr>
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<tr>
<td>1,1,1-trichloroethane</td>
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<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Estimated 209,000 gallons of TCE was released

Attachments:
## Hydrogeologic Conceptual Model

### Geology:

- **Vadose Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Saturated Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

### Ground surface elevation based on wells in or adjacent to treatment zone:

- **370 ft amsl**
- **Unknown**

### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - No
  - **X** Yes (number): _____________

- **Depth to water:**
  - **Aquifer 1**
    - Low value (ft bgs): 16
    - High value (ft bgs): 26
    - Unknown:
  - **Aquifer 2**
    - Low value (ft bgs): 36
    - High value (ft bgs): 46
    - Unknown:
  - **Aquifer 3**
    - Low value (ft bgs): 56
    - High value (ft bgs): 66
    - Unknown:

- **Flow direction:**
  - **N**

- **Horizontal hydraulic gradient (feet/foot):**
  - **X** Unknown

- **Vertical hydraulic gradient (feet/foot):**
  - **X** Unknown

### K range (ft/day)

- Measured using: ____ Slug Test  ____ Laboratory  ____ Field data
  - **Aquifer 1**
    - Low: 100
    - High: 1000
  - **Aquifer 2**
    - Low: 100
    - High: 1000
  - **Aquifer 3**
    - Low: 100
    - High: 1000

### Transmissivity (ft²/day)

- Measured using: ____ Slug Test  ____ Laboratory  ____ Field data
  - **Aquifer 1**
    - Low: 100
    - High: 1000
  - **Aquifer 2**
    - Low: 100
    - High: 1000
  - **Aquifer 3**
    - Low: 100
    - High: 1000

### Comments:

- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________

### Attachments:

- __________________________________________________________________________
- __________________________________________________________________________
Thermal Treatment - Design

Facility ID#: 0470

Thermal treatment:  
- Conductive
- Electrical Resistance

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 2/14/2003
- Duration: 175 d

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

- Size of target zone (ft^2): 6825
- Thickness of target zone (ft): 95
- Depth to top of target zone (ft bgs): 2
- Thickness of target zone below water table (ft): 67
- Number of energy delivery points: 6
- Number of extraction points: 6

Temperature Profile:

- Initial formation temperature (deg C): 20
- Maximum representative formation temperature (deg C): 70
- Time to reach maximum representative temperature (days): 112
- Duration of treatment at representative temperature (days): 63

Date | Temperature (deg C)
-----------------|-------------------
9/5/2003 | 91
10/29/2003 | 58

Mass of contaminant removed:

- Via liquid pumping: ____________ lb  ____________ kg  Unknown
- In vapor stream: ____________ lb  ____________ kg  Unknown
- Total: ____________ lb  ____________ kg  Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Objective: To demonstrate implementability of this technology in UCRS saturated and unsaturated soil and in RGA groundwater

Lessons Learned

Electrodes can fail to heat at discrete depths if the steel shot displaces the electric insulating (bentonite) materials making the electrode act as 1 continuous electrode which in turn may not have feed enough power to the bottom of the electrode to heat up the formation.

Energy

Total Energy Used: 2283850 kWhr

x Total energy applied to treatment zone: __________ kWhr/m³ __________ kWhr/yd³

x Other energy: __________ kWhr/m³ __________ kWhr/yd³

Please note other energy: ______________________________

Cost

Total Project Cost: 6300000

x Consultant Cost: ______________________________

x Thermal Vendor Cost: ______________________________

x Energy Cost: ______________________________ m³ __________ yd³

x Other Cost 1: ______________________________

x Other Cost 2: ______________________________

x Other Cost 3: ______________________________

Please note other cost: __________ Other Cost 1: ______________________________

__________________________________________________________

In Soil

UCRS (0-50') to reduce TCE in soil by 75%

RGA (~50-90') groundwater to less than 1% TCE solubility (11000ppb)

Was the Remediation Goal Achieved:

x In Groundwater

Comment: Yes a 99.1% reduction

x In Soil

Comment: Yes a 98% reduction

General comments on the thermal application:

In Soil

UCRS (0-50') to reduce TCE in soil by 75%

In Groundwater

RGA (~50-90') groundwater to less than 1% TCE solubility (11000ppb)
QA/QC

_____ Characteristics of Interest
_____ Good pre- and post-treatment groundwater data
_____ Good pre- and post-treatment soil data
_____ Good temperature profile vs. time information
_____ Flux assessment
_____ Groundwater elevations
_____ Geologic cross-section
_____ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:**

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
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<tr>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<td>Trichloroethene</td>
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<td>1,1-dichloroethene</td>
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<td>Vinyl Chloride</td>
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</tbody>
</table>

**Comments:**

---

**Attachments:**
<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction: __________

Horizontal hydraulic gradient (feet/foot): __________
Vertical hydraulic gradient (feet/foot): __________

K range (ft/day): Measured using: Slug Test Laboratory Field data
low: __________ __________ __________ __________
high: __________ __________ __________ __________

Transmissivity (ft²/day): Measured using: Slug Test Laboratory Field data
low: __________ __________ __________ __________
high: __________ __________ __________ __________

---

Comments: ________________________________________

Attachments: ______________________________________
<table>
<thead>
<tr>
<th>Facility ID#: 0495</th>
</tr>
</thead>
</table>

**Thermal Treatment - Design**

**Thermal treatment:**  
- Conductive  
- Electrical Resistance  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  
- Steam  
  - Steam  
  - Steam + air  
  - Steam + O2

**Type of Test:**  
- Pilot test  
- Full-scale System

**Type of Test:**  
- RFH

**Geology of Treatment Zone:**  
- Relatively homogeneous and permeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Weathered bedrock, limestone, sandstone

**Other (describe):**

**Treatment Target Zone:**  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**  
- Duration: ______________

**Hydraulic Control:**  
- Yes  
- No

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>__________</th>
<th>__________</th>
<th>Unknown</th>
<th>( __ x __ ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>__________</td>
<td>__________</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>__________</td>
<td>__________</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>__________</td>
<td>__________</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>__________</td>
<td>__________</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>__________</td>
<td>__________</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

**Temperature Profile:**

| Initial formation temperature (deg C): | __________ | __________ | Unknown |
| Maximum representative formation temperature (deg C): | __________ | __________ | Unknown |
| Time to reach maximum representative temperature (days): | __________ | __________ | Unknown |
| Duration of treatment at representative temperature (days): | __________ | __________ | Unknown |

**Formation temperature immediately post-treatment:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Formation temperature post-treatment monitoring event 1:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Duration of post-treatment monitoring (days):**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<tr>
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<td></td>
</tr>
</tbody>
</table>

**Mass of contaminant removed:**

| Via liquid pumping: | __________ | __________ | Unknown |
| In vapor stream: | __________ | __________ | Unknown |
| Total: | __________ | __________ | Unknown |

**Comments:**

| __________________________________________________________________________ |
|____________________________________________________________________________|
|____________________________________________________________________________|
|____________________________________________________________________________|
|____________________________________________________________________________|

**Attachments:**

| __________________________________________________________________________ |
|____________________________________________________________________________|
|____________________________________________________________________________|
|____________________________________________________________________________|
|____________________________________________________________________________|

*Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.*
Cost and Performance

Remediation Goal:

In Groundwater: 

In Soil: 

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

Lessons Learned:

Energy

Total Energy Used:

Total energy applied to treatment zone: 

Other energy: 

Please note other energy:

Cost

Total Project Cost:

Consultant Cost: 

Thermal Vendor Cost: 

Energy Cost: 

Other Cost 1: 

Other Cost 2: 

Other Cost 3: 

Please note other cost:

Other Cost 1: 

Other Cost 2: 

Other Cost 3:
General Site Information

File Analyzed By: JT PD ERH Date: 7/26/2006

Type of treatment: Conductive Steam ERH Other: ____________

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides

Wood Treating Other: ____________

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System

Start of Test: 7/31/2003 End of Test: 9/22/2003 Duration: 53 days

Type of Site: Non-DOD DoD

Facility Name: Naval Weapons Industrial Reserve Plant

Address: __________________________________________________________

City, State, Zip Code: Bedford, MA

OU# or Site #: Site 3

Primary point of contact: Maritza Montegross

Organization: Navy NAVFAC Mid-Atlantic

Address: 9742 Maryland Ave.

City, State, Zip Code: Norfok, VA  23511

Phone #: 757-444-5872 email: maritza.montegross@navy.mil

Other contacts or vendors who worked on site: None

Point of contact: Joe Francis

Type: Vendor, Consultant Vendor, Technical Applications Other

Organization: TetraTech

Address: 133 Federal St., 6th Floor

City, State, Zip Code: Boston, MA  02110

Phone #: 617-457-8409 email: joseph.francis@tteci.com

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data

Good temperature profile vs. time information

Groundwater elevations

Hydraulic Conductivity information

Good pre- and post-treatment soil data

Flux assessment

Geologic cross-section
### General Site Assessment Data

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): ______________
  - Width (ft.): ______________
  - Thickness (ft.): ______________
  - Impacted zone as defined by documentation:
  - Alternative method for determining size of impacted zone (See source zone definition attachments):
  - Map attachment:

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data:
    - Pre-treatment: 17
    - Post-treatment: 17
  - Number of wells relative to treatment zone:
    - In: ______________
    - Upgradient: ______________
    - Downgradient: ______________
    - Crossgradient: ______________

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data:
    - ______________
  - Number outside treatment zone:
    - ______________

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>10 mg/L</td>
<td>1 mg/kg</td>
<td>1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>1 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>1 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>0.01 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>1 mg/L</td>
<td>0.01 mg/kg</td>
<td>0.01 mg/L</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,2-dichloroethane</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-DCE (total)</td>
<td>1 mg/L</td>
<td>0.5 mg/kg</td>
<td>0.5 mg/L</td>
<td>None</td>
<td>None</td>
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</table>

#### Comments:

- Pg 29 - Pilot report (appendix A) for pre data and pg 34 for post data
- Appendix D in Appendix A - Soils data

- Attachments:
Geology:

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: ______________ ft amsl  x Unknown

Aquifer Characteristics:
- Is more than 1 aquifer present? No Yes (number): _____________  x Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
<tr>
<td>Depth to water:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>low (ft bgs):</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high (ft bgs):</td>
<td>30</td>
<td></td>
<td></td>
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<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Flow direction: WSW

Horizontal hydraulic gradient (feet/foot): ______________  x Unknown
Vertical hydraulic gradient (feet/foot): ______________  x Unknown

K range (ft/day) Measured using: Slug Test Laboratory Field data
- low | 0.099 | | |
- high | | | |

Transmissivity (ft²/day): Measured using: Slug Test Laboratory Field data
- low | | | |
- high | | | |

Field data:  x Unknown

Comments:

K = 3.5e-5 cm/s

No GW elevation data yet

Attachments: 
Thermal Treatment - Design

Thermal treatment:  x  Conductive  x  Electrical Resistance  

Steam  3 phase  x  6 phase  AC power  DC power  

Steam  Steam + air  Steam + O2  

Type of Test:  x  Pilot test  Full-scale System  

Geology of Treatment Zone:  x  Relatively homogeneous and permeable unconsolidated sediments  

Relatively homogeneous and impermeable unconsolidated sediments  

Largely permeable sediments with inter-bedded lenses of lower permeability material  

Largely impermeable sediments with inter-bedded layers of higher permeability material  

Competent, but fractured bedrock (i.e. crystalline rock)  

Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  x  Saturated only  Vadose only  Both (Saturated and Vadose zones)  

Start of Thermal Test:  7/31/2006  Duration:  53 days  

Hydraulic Control  x  Yes  No  

Treatment Cell Design:

Size of target zone (ft²):  7200  Unknown  ( 40 x 80 ft)  

Thickness of target zone (ft):  15  Unknown  

Depth to top of target zone (ft bgs):  20  Unknown  

Thickness of target zone below water table (ft):  15  Unknown  

Number of energy delivery points:  24  Unknown  

Number of extraction points:  24  Unknown  

Temperature Profile:

Initial formation temperature (deg C):  13  Unknown  

Maximum representative formation temperature (deg C):  95  Unknown  

Time to reach maximum representative temperature (days):  38  Unknown  

Duration of treatment at representative temperature (days):  15  Unknown  

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:

Via liquid pumping:  89.9  lb  kg  Unknown  

In vapor stream:  Unknown  

Total:  89.9  lb  kg  Unknown  

Comments:  14 ft electrode spacing  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- X In Groundwater: 1. determine the potential effectiveness, implementability, and cost of using ERH to treat entire source area; 2. 95% reduction in VOCs in pilot test area; 3. develop cost info
- ___ In Soil: __________________________________________________________________________

Was the Remediation Goal Achieved:

- X In Groundwater
  
  Comment: No, cis-1,2-DCE went way up
- ___ In Soil __________________________________________________________________________
  
  Comment: __________________________________________________________________________

General comments on the thermal application:

GW table dropped in treatment zone and contaminated GW might have flowed into treated area 85% of total energy of 726391 kWhr

Lessons Learned

Know lithology well when designing an application

Energy

- X Total energy applied to treatment zone: __________ kWhr/m³ __________ kWhr/yd³
- X Other energy: __________ kWhr/m³ __________ kWhr/yd³
  
  Please note other energy: __________________________________________________________________

Cost

- X Total Project Cost: __________________________________________________________________
  
  Consultant Cost: __________________________________________________________________
  
  Thermal Vendor Cost: __________________________________________________________________
  
  Energy Cost: __________ m³ __________ yd³
  
  Other Cost 1: __________________________________________________________________
  
  Other Cost 2: __________________________________________________________________
  
  Other Cost 3: __________________________________________________________________
  
  Please note other cost: __________ Other Cost 1: __________________________________________________________________
  
  __________ Other Cost 2: __________________________________________________________________
  
  __________ Other Cost 3: __________________________________________________________________
General Site Information

File Analyzed By: JT  PD  
Type of treatment:  Conductive  Steam  ERH  Other:  
Type of Contaminant:  Chlorinated Solvents  Petroleum Hydrocarbons  Pesticides  Wood Treating  Other:  
Treatment Status:  Active  Post  
Type of Test:  Pilot Test  Full Scale System  
Start of Test:  7/31/2003  End of Test:  9/22/2003  Duration:  53 days  
Type of Site:  Non-DOD  DoD  

Facility Name:  Naval Weapons Industrial Reserve Plant
Address:  
City, State, Zip Code:  Bedford, MA
OU# or Site #:  Site 4

Primary point of contact:  Maritza Montegross
Organization:  Navy NAVFAC Mid-Atlantic
Address:  9742 Maryland Ave.
City, State, Zip Code:  Norfolk, VA  23511
Phone #:  757-444-5872  email: maritza.montegross@navy.mil

Other contacts or vendors who worked on site  None
Point of contact:  Joe Francis
Type:  Vendor, Consultant  Vendor, Technical Applications  Other  
Organization:  TetraTech
Address:  133 federal St., 6th Floor
City, State, Zip Code:  Boston, MA  02110
Phone #:  617-457-8409  email: joseph.francis@tteci.com

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good temperature profile vs. time information
Groundwater elevations
Hydraulic Conductivity information
Impacted Zone:

- Length (parallel to flow direction)(ft.): 
- Width (ft.): 
- Thickness (ft.): 

Unknown

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

Monitor Wells:

- Number of relevant monitoring wells with groundwater data: 
- Pre-treatment: 
- Post-treatment: 

Number of wells relative to treatment zone:

- Pre-treatment: In: 
- Upgradient: 
- Downgradient: 
- Crossgradient: 

- Post-treatment: In: 
- Upgradient: 
- Downgradient: 
- Crossgradient: 

Soil Borings:

- Number of relevant soil borings with pre-treatment data: 
- Number of relevant soil borings with post-treatment data: 
- Number inside treatment zone: 
- Number outside treatment zone: 

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Bencene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Toluene</td>
<td>0.5 mg/L</td>
<td>None</td>
<td>0.005 mg/L</td>
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<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Ethylbenezene</td>
<td>1 mg/L</td>
<td>10 mg/kg</td>
<td>0.5 mg/L</td>
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<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>m/p-xylene</td>
<td>5 mg/L</td>
<td>100 mg/kg</td>
<td>0.5 mg/L</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>o-xylene</td>
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<td>50 mg/kg</td>
<td>0.1 mg/L</td>
</tr>
<tr>
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<td>1,1,1-trichloroethane</td>
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<td>1 mg/L</td>
<td>10 mg/kg</td>
<td>0.1 mg/L</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
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<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
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<td></td>
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<td>None</td>
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<td>None</td>
</tr>
</tbody>
</table>

Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)

Comments:

Post-treatment GW data - pg. 32 and pre-treatment GW - pg. 19

Soil samples only have pre data and benzene was ND in all soil samples based on the detection limit

Source zone was 50ft by 20ft by 18.5ft (9.5 to 28)

Attachments:
### Hydrogeologic Conceptual Model

**Facility ID #: 0501**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>• Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>• Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>• Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>• Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- **Geology:**

- **Zone:**
  - Vadose Zone:
  - Saturated Zone:

- **Ground surface elevation based on wells in or adjacent to treatment zone:**
  - ft amsl: ____________  **Unknown**

- **Aquifer Characteristics:**

  - Is more than 1 aquifer present? **No**
  - **Yes (number):** ____________  **Unknown (assume single aquifer)**

  - **Aquifer 1**
    - Depth to water:
      - low value (ft bgs): 10.5
      - high value (ft bgs): 20.5
      - Unknown: ____________

  - **Aquifer 2**
    - Depth to water:
      - low value (ft bgs):
      - high value (ft bgs):
      - Unknown: ____________

  - **Aquifer 3**
    - Depth to water:
      - low value (ft bgs):
      - high value (ft bgs):
      - Unknown: ____________

- **Flow direction:**
  - NNW

- **Horizontal hydraulic gradient (feet/foot):**
  - ____________

- **Vertical hydraulic gradient (feet/foot):**
  - ____________  **Unknown**

- **K range (ft/day):**
  - Measured using: ____________
  - **Slug Test**
  - **Laboratory**
  - **Field data**
  - **Unknown**

  - Low: 0.0032
  - High: 0.0992

- **Transmissivity (ft²/day):**
  - Measured using: ____________
  - **Slug Test**
  - **Laboratory**
  - **Field data**
  - **Unknown**

  - Low: ____________
  - High: ____________

- **Comments:**

  - K = 3.5e-5 cm/s to 11.2e-7 cm/s  **No GW elevation data yet**

- **Attachments:**

  - ____________

  - ____________

  - ____________

  - ____________
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#:</th>
<th>0501</th>
</tr>
</thead>
</table>

- **Thermal treatment:**
  - Conduction
  - Electrical Resistance

- **Type of Test:**
  - Pilot test

- **Geology of Treatment Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Treatment Target Zone:**
  - Saturated only
  - Vadose only
  - Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - 7/31/2006
  - Duration: 53 days

- **Hydraulic Control:**
  - Yes
  - No

- **Treatment Cell Design:**
  - Size of target zone (ft²): 1000
  - Thickness of target zone (ft): 18.5
  - Depth to top of target zone (ft bgs): 9.5
  - Thickness of target zone below water table (ft): 11
  - Number of energy delivery points: 8
  - Number of extraction points: 8

- **Temperature Profile:**
  - Initial formation temperature (deg C): 14
  - Maximum representative formation temperature (deg C): 93
  - Time to reach maximum representative temperature (days): 50
  - Duration of treatment at representative temperature (days): 3

- **Mass of contaminant removed:**
  - Via liquid pumping: Unknown
  - In vapor stream: 69.5
  - Total: 69.5

- **Attachments:**
  - 6 months of post-treatment sampling
    - 19,425 ft³ or 719 yd³

- **Notes:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: Achieve site cleanup objective of 50 ppb benzene in GW

- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment: Yes, in treatment zone

- In Soil
  - Comment:

General comments on the thermal application:

23% of total 726,391 kWhr

Lessons Learned

Energy

Total Energy Used: 167070 kWhr kWhr/m³ kWhr/m³ kWhr/yd³

- Total energy applied to treatment zone: kWhr/m³ kWhr/m³ kWhr/yd³
- Other energy: kWhr/m³ kWhr/m³ kWhr/yd³

- Please note other energy:

Cost

Total Project Cost:

- Consultant Cost:
- Thermal Vendor Cost:
- Energy Cost: m³ yd³
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:

- Please note other cost:

- Other Cost 1:
- Other Cost 2:
- Other Cost 3:
General Site Information

File Analyzed By: JT PD ERH Other: Date: 10/26/2006
Type of treatment: Conductive Steam ERH Other: _____________
Type of contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Wood Treating Other: PCBs
Treatment Status: Active Post _____________
Type of Test: Pilot Test Full Scale System
Start of Test: 14-Jun-01 End of Test: _____________ Duration: _____________
Type of Site: Non-DOD DoD

Facility Name: Metal Recycling Facility (H. Cohen)
Address: _____________
City, State, Zip Code: Boston, MA
OU# or Site #: _____________

Primary point of contact: Brian Coty
Organization: Shaw
Address: 88C Elm Street
City, State, Zip Code: Hopkinton, MA 01748-1656
Phone #: 508-435-9561 email: brian.coty@shawgrp.com

Other contacts or vendors who worked on site: None
Point of contact: Jay Dablow
Type: Vendor, Consultant Vendor, Technical Applications Other: _____________
Organization: ERM (formerly Shaw)
Address: 3 Hutton Centre, Suite 600
City, State, Zip Code: Santa Ana, CA 92707
Phone #: 714-430-1476 email: jay.dablow@erm.com

QA/QC

Characteristics of Interest
Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information Flux assessment
Groundwater elevations Geologic cross-section
Hydraulic Conductivity information
Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Tetrahydrofuran</td>
<td></td>
<td></td>
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<td>none</td>
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<tr>
<td>1,1-dichloroethene</td>
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<td></td>
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<td>none</td>
<td>none</td>
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<tr>
<td>1,2-dichloroethene</td>
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<td>none</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
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<td></td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

Notes:
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Monitor Wells: Number of relevant monitoring wells with groundwater data:
- Soil Borings: Number of relevant soil borings with pre-treatment data:
- Soil Borings: Number of relevant soil borings with post-treatment data:
- Number inside treatment zone: Number outside treatment zone:

General Site Assessment Data

Facility ID: 0505

Impacted Zone: Length (parallel to flow direction)(ft.): 125 Width (ft.): 150 Thickness (ft.): 1

Unknown

Comments:

Attachments:
<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: _________ ft amsl _________ Unknown

Is more than 1 aquifer present? | No | Yes (number): | Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td>low value (ft bgs):</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
<td></td>
</tr>
</tbody>
</table>

Flow direction | ________ | ________ | ________ |

Horizontal hydraulic gradient (feet/foot): | ________ | ________ | ________ | ________ Unknown |

Vertical hydraulic gradient (feet/foot): | ________ | ________ | ________ | ________ Unknown |

K range (ft/day) | Measured using: | Slug Test | Laboratory | Field data | Unknown |
| low | 0.011 | | | | |
| high | 0.36 | | | | |

Transmissivity (ft2/day): | Measured using: | Slug Test | Laboratory | Field data | Unknown |
| low | | | | | |
| high | | | | | |

Comments:                                                                 |

Attachments:                                                              |

Facility ID#: 0505
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power

Steam:  
- Steam
- Steam + air
- Steam + O2

Other (describe):  

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- Jun-01

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft²):  
- Unknown

Thickness of target zone (ft):  
- Unknown

Depth to top of target zone (ft bgs):  
- Unknown

Thickness of target zone below water table (ft):  
- Unknown

Number of energy delivery points:  
- 16

Number of extraction points:  
- 6

Temperature Profile:

Initial formation temperature (deg C):  
- 10

Maximum representative formation temperature (deg C):  
- 60

Time to reach maximum representative temperature (days):  
- Unknown

Duration of treatment at representative temperature (days):  
- Unknown

Formation temperature immediately post-treatment:  
- Unknown

Formation temperature post-treatment monitoring event 1:  
- Unknown

Duration of post-treatment monitoring (days):  
- Unknown

Mass of contaminant removed:

Via liquid pumping:  
- Unknown

In vapor stream:  
- Unknown

Total:  
- Unknown

Notes:  
- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

___ In Groundwater: ________________________________

___ In Soil: ________________________________

Was the Remediation Goal Achieved:

___ In Groundwater: ________________________________

   Comment: ____________________________________________

___ In Soil: ________________________________

   Comment: ____________________________________________

General comments on the thermal application:

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

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Lessons Learned

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

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_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

Energy

Total Energy Used: ________________________________ kWhr kWhr/m³ kWhr/yd³

   ___ Total energy applied to treatment zone: ________________________________ kWhr/m³ kWhr/yd³

   ___ Other energy: ________________________________ kWhr/m³ kWhr/yd³

   Please note other energy: ____________________________________________________________

Cost

Total Project Cost:

___ Consultant Cost: ________________________________

___ Thermal Vendor Cost: ________________________________

___ Energy Cost: ________________________________ m³ yd³

___ Other Cost 1: ________________________________

___ Other Cost 2: ________________________________

___ Other Cost 3: ________________________________

   Please note other cost: __ Other Cost 1: ________________________________

   __ Other Cost 2: ________________________________

   __ Other Cost 3: ________________________________
General Site Information

Facility Name: Manufacturing Facility - Plastics
Address: 2 Technology Park Drive
City, State, Zip Code: Westford, MA, 01886
Phone #: 978-589-3000
email: __________________________________________________

Primary point of contact:
Organization: ENSR
Address: 2 Technology Park Drive
City, State, Zip Code: Westford, MA, 01886
Phone #: 978-589-3000
email: __________________________________________________

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:**

**General Site Assessment Data**

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________
  - Width (ft.): __________
  - Thickness (ft.): __________
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: __________
  - Pre-treatment: __________
  - Post-treatment: __________
  - Number of wells relative to treatment zone:
    - Pre-treatment: In: __________ Upgradient: __________ Downgradient: __________ Crossgradient: __________
    - Post-treatment: In: __________ Upgradient: __________ Downgradient: __________ Crossgradient: __________

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: __________
  - Number of relevant soil borings with post-treatment data: __________
  - Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Benzene</td>
<td>Cross</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Jet Fuel</td>
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<td>1,2-dichloroethane</td>
<td>Naphthalene</td>
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<tr>
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<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>Toluene</td>
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<td>None</td>
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<td>Ethylbenzene</td>
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</tr>
</tbody>
</table>

### Comments:

- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________

### Attachments:

- ____________________________________________________________________________
- ____________________________________________________________________________
### Hydrogeologic Conceptual Model

#### Geology:

**Vadose Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

#### Ground surface elevation based on wells in or adjacent to treatment zone:
- **ft amsl:**
- **Unknown:**

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - **No**
  - **Yes (number):**
  - **Unknown (assume single aquifer):**

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low value (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High value (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction:**

- **Horizontal hydraulic gradient (feet/foot):**
- **Vertical hydraulic gradient (feet/foot):**

- **K range (ft/day):**
  - **Measured using:**
    - Slug Test
    - Laboratory
    - Field data
  - **K range:**
    - Low
    - High

- **Transmissivity (ft²/day):**
  - **Measured using:**
    - Slug Test
    - Laboratory
    - Field data
  - **Transmissivity:**
    - Low
    - High

#### Comments:

[Blank space for comments]

#### Attachments:

[Blank space for attachments]

---

**Facility ID#:** 0510
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
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<tr>
<th>Supplies:</th>
<th>3 phase</th>
<th>6 phase</th>
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<th>DC power</th>
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<tbody>
<tr>
<td>SI Level:</td>
<td>Steam</td>
<td>Steam + air</td>
<td>Steam + O2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI Level:</td>
<td>Steam</td>
<td>Steam + air</td>
<td>Steam + O2</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
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</thead>
<tbody>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Weathered bedrock, limestone, sandstone
- Relatively homogeneous and impermeable unconsolidated sediments
- Competent, but fractured bedrock (i.e. crystalline rock)

Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: Mar-00
Duration: 15 months
Hydraulic Control: Yes No

Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>25</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
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<td>Number of energy delivery points:</td>
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</tr>
<tr>
<td>Number of extraction points:</td>
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</tbody>
</table>

Temperature Profile:

| Initial formation temperature (deg C): | unknown |
| Maximum representative formation temperature (deg C): | unknown |
| Time to reach maximum representative temperature (days): | unknown |
| Duration of treatment at representative temperature (days): | unknown |

Formation temperature immediately post-treatment:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature post-treatment monitoring event 1:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Duration of post-treatment monitoring (days):

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

22,500 yd³ treated in two areas of 1600 yd² and 1100 yd²

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater:

Comment:

In Soil:

Comment:

General comments on the thermal application:


Lessons Learned


Energy

Total Energy Used: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

Total energy applied to treatment zone: ___________ kWh/m³ ___________ kWh/yd³

Other energy: ___________ kWh/m³ ___________ kWh/yd³

Please note other energy: ____________________________

Cost

Total Project Cost: ___________ $46/yd³

Consultant Cost: ___________

Thermal Vendor Cost: ___________

Energy Cost: ___________ m³ ___________ yd³

Other Cost 1: ___________ 850000

Other Cost 2: ___________ 180000/yr

Other Cost 3: ___________________________

Please note other cost: ___________

Other Cost 1: ___________________________ Capital cost

Other Cost 2: ___________________________ O&M

Other Cost 3: ___________________________
### General Site Information

- **File Analyzed By:** JT, PD, ERH  
  **Date:** 9/13/2006
- **Type of treatment:** Conductive
- **Type of Contaminant:** Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides, Wood Treating, coal tar, PCP, Br(a)P
- **Treatment Status:** Active, Post
- **Type of Test:** Pilot Test
- **Start of Test:** 4-Mar
- **End of Test:** 5-Mar
- **Duration:** 260
- **Type of Site:** Non-DOD, DoD

- **Facility Name:** Former Manufactured gas plant
- **Address:**
  - **City, State, Zip Code:** North Adams, MA
  - **OU# or Site #:**

- **Primary point of contact:** Ralph Baker
- **Organization:** TerraTherm
- **Address:** 356 Broad Street
- **City, State, Zip Code:** Fitchburg, MA
- **Phone #:** 978-343-0300  
  **email:** rbaker@terratherm.com

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good temperature profile vs. time information
  - Groundwater elevations
  - Hydraulic Conductivity information
  - Good pre- and post-treatment soil data
  - Flux assessment
  - Geologic cross-section
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __
- Width (ft.): __
- Thickness (ft): __
  - Unknown

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: ___
- Pre-treatment: ___
- Post-treatment: ___

  - None

- Number of wells relative to treatment zone:
  - Pre-treatment: In: ___
  - Upgradient: ___
  - Downgradient: ___
  - Crossgradient: ___
  - Post-treatment: In: ___
  - Upgradient: ___
  - Downgradient: ___
  - Crossgradient: ___

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: ___
- Number of relevant soil borings with post-treatment data: ___
- Number inside treatment zone: ___ pre, ___ post
- Number outside treatment zone: ___

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical: Groundwater (mg/L)</th>
<th>Average Post-treatment Concentration per Chemical: Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
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<td>None</td>
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<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

* C11 - C22 aromatics

unadjusted

Numbers are based on the depths of 6 to 14 feet, see the attached sheet for concentrations per chemical average for 14 to 18 feet

**Attachments:**

...
Hydrogeologic Conceptual Model

Geology:

Vadose Zone:
- x Relatively homogeneous and permeable unconsolidated sediments
- x Relatively homogeneous and impermeable unconsolidated sediments
- n Largely permeable sediments with inter-beded lenses of lower permeability material
- n Largely impermeable sediments with inter-beded layers of higher permeability material
- n Competent, but fractured bedrock (i.e. crystalline rock)
- n Weathered bedrock, limestone, sandstone

Saturated Zone:
- x Relatively homogeneous and permeable unconsolidated sediments
- x Relatively homogeneous and impermeable unconsolidated sediments
- n Largely permeable sediments with inter-beded lenses of lower permeability material
- n Largely impermeable sediments with inter-beded layers of higher permeability material
- n Competent, but fractured bedrock (i.e. crystalline rock)
- n Weathered bedrock, limestone, sandstone

Unknown:
- n high value (ft bgs): _____________
- n low value (ft bgs): _____________

Ground surface elevation based on wells in or adjacent to treatment zone: _____________ ft amsl

Aquifer Characteristics:

Is more than 1 aquifer present?  x No  Yes (number): _____________  x Unknown (assume single aquifer)

Aquifer 1  Aquifer 2  Aquifer 3
Depth to water:
- low value (ft bgs): _____________
- high value (ft bgs): _____________
- Unknown: _____________

Flow direction: _____________

x Horizontal hydraulic gradient (feet/foot): _____________

x Vertical hydraulic gradient (feet/foot): _____________

x K range (ft/day):
- Measured using: x Slug Test  Laboratory  Field data
- low: _____________
- high: _____________

Transmissivity (ft²/day):
- Measured using: x Slug Test  Laboratory  Field data
- low: _____________
- high: _____________

x Field data

Geology is all fill:
- Local aquifer outside of the gas holder is DTW = 33 ft

Comments:

Attachments:
Thermal Treatment - Design

Thermal treatment: [Conductive] [Electrical Resistance]
- [3 phase] [6 phase] [AC power] [DC power]
- [Steam] [Steam + air] [Steam + O2]
- [Other (describe)]

Type of Test: [Pilot test] [Full-scale System]

Geology of Treatment Zone: [Relatively homogeneous and permeable unconsolidated sediments]
- [Largely permeable sediments with inter-bedded lenses of lower permeability material]
- [Largely permeable sediments with inter-bedded layers of higher permeability material]
- [Competent, but fractured bedrock (i.e. crystalline rock)]
- [Other (describe)]

Treatment Target Zone: [Saturated only] [Vadose only] [Both (Saturated and Vadose zones)]

Start of Thermal Test: [4-Mar] Duration: [370 days]

Hydraulic Control: [Yes] [No]

Treatment Cell Design:
- Size of target zone (ft²): [3020]
- Thickness of target zone (ft): [12]
- Depth to top of target zone (ft bgs): [4]
- Thickness of target zone below water table (ft): [4]
- Number of energy delivery points: [12]
- Number of extraction points: [8]

Temperature Profile:
- Initial formation temperature (deg C): [16]
- Maximum representative formation temperature (deg C): [325]
- Time to reach maximum representative temperature (days): [291]
- Duration of treatment at representative temperature (days): [79]

<table>
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<th>Date</th>
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</tr>
</thead>
<tbody>
<tr>
<td>3/17/2005</td>
<td>271</td>
</tr>
<tr>
<td>6/3/2005</td>
<td>123</td>
</tr>
<tr>
<td>8</td>
<td>Unknown</td>
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<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Mass of contaminant removed:
- Via liquid pumping: [16,700 gal of coal tar]
- In vapor stream: [166,000 as naphthalene]

Total: [lb] [kg] [Unknown]

Comments:
25 wells spaced on ~12 ft centers. Operated in 3 stages: 1) dewatering, 2) thermally-enhanced free-product recovery with gentle heating, and 3) ISTD to achieve target interwell temperatures of 617F (325C).

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
In Groundwater: (1) eliminate DNAPL, (2) reduce VOCs and SVOCs, VPH, EPH to below UCLs via ISTD; (3) reduce VOCs, SVOCs, VPH, EPH to below S-3 GW - 1 standards.

In Soil: Benzo(a)pyrene (B(a)P) - 4 mg/kg; Benzene - 10 mg/kg; TPH* - 200 mg/Kg (* C11-C22 aromatics, unadjusted)

Was the Remediation Goal Achieved:

- **In Groundwater**
  - Comment:

- **In Soil**
  - Comment: was met from 6-14 feet, but not from 14-18' except for benzen which was met.

General comments on the thermal application:

Lessons Learned

### Energy

<table>
<thead>
<tr>
<th>Total Energy Used:</th>
<th>kWh</th>
<th>kWh/m³</th>
<th>kWh/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td>701,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total energy applied to treatment zone: __________ kWh/m³ __________ kWh/yd³

Other energy: __________ kWh/m³ __________ kWh/yd³

Please note other energy: __________

### Cost

Total Project Cost:

- **Consultant Cost:** __________
- **Thermal Vendor Cost:** 850,000
- **Energy Cost:** 55,000 m³ yd³

Other Cost 1: __________
Other Cost 2: __________
Other Cost 3: __________

Please note other cost: -237/ton

Other Cost 1: __________
Other Cost 2: __________
Other Cost 3: __________
### General Site Information

- **File Analyzed By:** JT PD
- **Date:** 8/20/2007
- **Type of treatment:**
  - X Conductive
  - ____ Steam
  - ____ ERH
  - ____ Other:
- **Type of Contaminant:**
  - X Chlorinated Solvents
  - X Petroleum Hydrocarbons
  - ____ Pesticides
  - ____ Wood Treating
  - Other:
- **Treatment Status:**
  - Active
  - ____ Post
- **Type of Test:**
  - ____ Pilot Test
  - X Full Scale System
- **Start of Test:** 8/15/2006
- **End of Test:** 3/16/2007
- **Duration:** 214 Days
- **Type of Site:**
  - X Non-DOD
  - ____ DoD
- **Facility Name:** South Eastern MA
- **Address:**
- **City, State, Zip Code:** South Eastern MA
- **OU# or Site #:**
- **Primary point of contact:** Ralph Baker
  - **Organization:** TerraTherm
  - **Address:** 10 Stevens Road
  - **City, State, Zip Code:** Fitchburg, MA 01420
  - **Phone #:** 978-343-0300
  - **email:** rbaker@terratherm.com
- **Other contacts or vendors who worked on site:** None
  - **Type:** Vendor, Consultant
  - **Vendor, Technical Applications:**
  - **Other:**
  - **Organization:**
  - **Address:**
  - **City, State, Zip Code:**
  - **Phone #:**
  - **email:**

### QA/QC

- **Characteristics of Interest**
  - ____ Good pre- and post-treatment groundwater data
  - ____ Good pre- and post-treatment soil data
  - ____ Good temperature profile vs. time information
  - ____ Flux assessment
  - ____ Groundwater elevations
  - ____ Geologic cross-section
  - ____ Hydraulic Conductivity information
### Impacted Zone:
- Length (parallel to flow direction)(ft.): ---
- Width (ft.): ---
- Thickness (ft.): ---
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment: ---
  - Post-treatment: ---
- Number of wells relative to treatment zone:
  - Pre-treatment: ---
  - Upgradient: ---
  - Downgradient: ---
  - Crossgradient: ---
- Post-treatment:
  - In: ---
  - Upgradient: ---
  - Downgradient: ---
  - Crossgradient: ---

### Soil Borings:
- Number of relevant soil borings with pre-treatment data:
  - Number inside treatment zone: ---
  - Number outside treatment zone: ---

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td><strong>Groundwater (mg/L)</strong></td>
<td><strong>Soil (mg/kg)</strong></td>
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### Comments:

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### Attachments:

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## Hydrogeologic Conceptual Model

### Geology:

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<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<tr>
<td></td>
<td>X Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
<td></td>
<td>X Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>X Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>X Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
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<td></td>
<td>X Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone: 200 ft amsl Unknown

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>X Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Flow direction

- North

### Horizontal hydraulic gradient (feet/foot):

- Measured using: X Slug Test
- Low: 0.01
- High: Unknown

### Vertical hydraulic gradient (feet/foot):

- Measured using: Field data
- Low: 0.01
- High: Unknown

### K range (ft/day)

- Measured using: Slug Test
- Low: 28
- High: Unknown

### Transmissivity (ft²/day):

- Measured using: Field data
- Low: 0.01
- High: Unknown

**Notes:**

- 0-14 ft bgs consisted of fill material and layers of tar (napthalene, toluene, TCB, DCB and MCB)
- 14-21 ft bgs consisted of native sands

### Comments:

- [Additional comments here]

### Attachments:

- [Additional attachments here]
### Thermal Treatment - Design

**Facility ID#: 0517**

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>In Situ Thermal Desorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Resistance</td>
<td>3 phase 6 phase AC power DC power</td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td>Steam + air</td>
<td>Steam + O2</td>
</tr>
<tr>
<td>Other (describe)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Type of Test:**

- [x] Pilot test
- [ ] Full-scale System

**Geology of Treatment Zone:**

- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:** 8/15/2007

**Duration:** 214 Days

**Hydraulic Control:**

- [x] Yes
- [ ] No

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>10,175</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>21</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>0</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>5 to 7</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>24</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>Vapor Extraction</td>
</tr>
</tbody>
</table>

**Temperature Profile:**

| Initial formation temperature (deg C): | 15 |
| Maximum representative formation temperature (deg C): | 150 (vadose), 100 (saturated) |
| Time to reach maximum representative temperature (days): | 200 Days |
| Duration of treatment at representative temperature (days): | Unknown |

**Formation temperature immediately post-treatment:**

**Formation temperature post-treatment monitoring event 1:**

**Duration of post-treatment monitoring (days):**

---

**Notes:**

- Water screens were used for vapor extraction.

**Mass removed by the hydraulic containment/NAPL recovery system unknown at this time.**

**Comments:**

**Attachments:**

*Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.*
Cost and Performance

Facility ID#: 0517

Remediation Goal:

- In Groundwater: 
- In Soil: 

Was the Remediation Goal Achieved:

- In Groundwater: 
- In Soil: saturated zone. No evidence of vertical mobilization of tar/NAPL based on visual inspection of soil cores through treated tar zones and post treatment soil concentration data.

General comments on the thermal application:

Lessons Learned:

Energy

Total Energy Used: 1,900,000 kWh

- Total energy applied to treatment zone: 
- Other energy: Please note other energy: 

Cost

Total Project Cost:

- Consultant Cost: 
- Thermal Vendor Cost: 1,370,000 
- Energy Cost: 266,000 m³ yd³
- Other Cost 1: 
- Other Cost 2: 
- Other Cost 3: Please note other cost: 

Other Cost 1: 
Other Cost 2: 
Other Cost 3: 

### General Site Information

| X | File Analyzed By: | JT  | PD  | Date: | 11/9/2006 |
| X | Facility Name: | Silresim Superfund Site |  |
| X | Address: |  |
| X | City, State, Zip Code: | Lowell, MA |
| X | OU# or Site #: |  |

| X | Primary point of contact: | Jim DiLorenzo |  |
| X | Organization: | EPA |  |
| X | Address: |  |
| X | City, State, Zip Code: | Lowell, MA |
| X | Phone #: | 617-918-1247 |
| X | email: | dilorenzo.jim@epa.gov |

|  | Other contacts or vendors who worked on site | None |  |
|  | Point of contact: |  |
|  | Type: | Vendor, Consultant |
|  | Organization: |  |
|  | Address: |  |
|  | City, State, Zip Code: |  |
|  | Phone #: |  |
|  | email: |  |

### QA/QC

|  | Characteristics of Interest |  |
|  | Good pre- and post-treatment groundwater data |  |
|  | Good pre- and post-treatment soil data |  |
|  | Good temperature profile vs. time information |  |
|  | Flux assessment |  |
|  | Groundwater elevations |  |
|  | Geologic cross-section |  |
|  | Hydraulic Conductivity information |  |
### Impact Zone
- **Length (parallel to flow direction)**: 725 ft
- **Width**: 225 ft
- **Thickness (ft)**: 6 ft

- **Impacted zone as defined by documentation**
- **Alternative method for determining size of impacted zone** (See source zone definition attachments)
- **Map attachment**

### Monitor Wells
- **Number of relevant monitoring wells with groundwater data**
  - **Pre-treatment**: 1
  - **Post-treatment**: 2

- **Number of wells relative to treatment zone**
  - **Pre-treatment**: In: 1, Upgradient: 1, Downgradient: 1, Crossgradient: 
  - **Post-treatment**: In: 2, Upgradient: 1, Downgradient: 1, Crossgradient: 

### Soil Borings
- **Number of relevant soil borings with pre-treatment data**: 10
- **Number of relevant soil borings with post-treatment data**: 2
- **Number inside treatment zone**: 1
- **Number outside treatment zone**: 5

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Other</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>500 mg/L</td>
<td>500 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>10 mg/L</td>
<td>100 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>5 mg/L</td>
<td>100 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>n-p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>1,1,1-trichloroethene</td>
<td>1 mg/L</td>
</tr>
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<td></td>
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<td></td>
<td>10 mg/L</td>
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<td></td>
<td>X</td>
<td></td>
<td></td>
<td>5 mg/L</td>
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<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>5 mg/L</td>
<td>10 mg/kg</td>
</tr>
<tr>
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<td>100 mg/L</td>
<td>None</td>
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<td>10 mg/L</td>
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<td>50 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

**Attachments:**
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Aquifer Characteristics:

- Is more than 1 aquifer present? **X**
  - Yes (number): 3

- Depth to water:
  - Low value (ft bgs): **X**
  - High value (ft bgs): **X**

- Flow direction: **X**
  - Northwest

- Horizontal hydraulic gradient (feet/foot):
  - Aquifer 1: 0.017
  - Aquifer 2: 0.009 - 0.021
  - Aquifer 3: unknown

- Vertical hydraulic gradient (feet/foot):
  - Aquifer 1: 0.079 - 0.183
  - Aquifer 2: 0.009 - 0.021
  - Aquifer 3: unknown

#### K range (ft/day)

- **X**
  - Measured using: Slug Test, Laboratory, Field data

- Low: 0.31, 0.42
- High: unknown

#### Transmissivity (ft²/day)

- Measured using: Slug Test, Laboratory, Field data

- Low: unknown
- High: unknown

---

### Comments:

---

### Attachments:

---
Thermal Treatment - Design

Thermal treatment:  
X  Conductive

Electrical Resistance  
X  3 phase

Steam  
Steam + air

Type of Test:  
X  Pilot test

Geology of Treatment Zone:  
X  Relatively homogeneous and permeable unconsolidated sediments

Treatment Target Zone:  
X  Both (Saturated and Vadose zones)

Start of Thermal Test:  
10/11/2002

Hydraulic Control  
X  Yes

Size of target zone (ft²):  
850

Thickent of target zone (ft):  
40

Depth to top of target zone (ft bgs):  
2.5

Thickness of target zone below water table (ft):  
15

Number of extraction points:  
12

Number of energy delivery points:  
4

Temperature Profile:  
Initial formation temperature (deg C):  
10

Maximum representative formation temperature (deg C):  
105

Time to reach maximum representative temperature (days):  
73

Duration of treatment at representative temperature (days):  
17

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
Via liquid pumping:  

In vapor stream:  

Total:  
1500

Comments:  

Attached:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater:
- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater:
  - Comment:
- In Soil:
  - Comment:

General comments on the thermal application:

Objective: Prove efficacy of ERH at site by reducing soil and groundwater contaminant concentrations.

Lessons Learned:

Tubing in 70 wells melted, so need to use a non-coated teflon tubing with a thick wall.

Energy

Total Energy Used: 286,200 kWhr, __kWhr/m^3, __kWhr/yd^3

- Total energy applied to treatment zone: __kWhr/m^3, __kWhr/yd^3
- Other energy: __kWhr/m^3, __kWhr/yd^3
  - Please note other energy: __kWhr/m^3, __kWhr/yd^3

Cost

Total Project Cost: 1,600,000

- Consultant Cost: ____________
- Thermal Vendor Cost: 400,000
- Energy Cost: 30,000 __m^3, __yd^3
- Other Cost 1: 180,000
- Other Cost 2: 140,000
- Other Cost 3: 800,000

Please note other cost:

- Other Cost 1: drilling, site prep and restoration and pre- and post- sampling
- Other Cost 2: lab (80,000) and GAC (60,000)
- Other Cost 3: everything else
General Site Information

File Analyzed By: JT PD

Type of treatment:  
- Conductive
- Steam  
- ERH

Type of Contaminant:  
- Chlorinated Solvents
- Petroleum Hydrocarbons
- Pesticides
- Wood Treating

Treatment Status:  
- Active
- Post

Type of Test:  
- Pilot Test
- Full Scale System

Start of Test:  
End of Test:  
Duration: 

Type of Site:  
- Non-DOD
- DoD

Facility Name: Naval Station Annapolis

City, State, Zip Code: Annapolis, MD

OU# or Site #: 

Primary point of contact: Steven Kawachak

Organization: Shaw

City, State, Zip Code: 

Phone #: 609-588-6349  
email: sgkawachak@shawgrp.com

Other contacts or vendors who worked on site:  
- None

Type:  
- Vendor, Consultant
- Vendor, Technical Applications
- Other

Organization: 

Address: 

City, State, Zip Code: 

Phone #:  
email: 

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of wells relative to treatment zone:
  - Pre-treatment In: __________
  - Uppgradient: __________
  - Downgradient: __________
  - Crossgradient: __________
  - Post-treatment In: __________
  - Uppgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossuy</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
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<td>None</td>
</tr>
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<tr>
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<td></td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

Estimated 60,000 lbs of TCE in the soil.

**Attachments:**

---

(Additional data and attachments may be included, but not explicitly provided in the image.)
Hydrogeologic Conceptual Model

Geology:

Zone Unconsolidated Sediments
Vadose Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: 
- ft amsl
- Unknown

Aquifer Characteristics:

- Is more than 1 aquifer present? No, Yes (number): 
  - Unknown (assume single aquifer)

Depth to water:
  - Low value (ft bgs): 60
  - High value (ft bgs): 
  - Unknown:

Flow direction: 

Horizontal hydraulic gradient (feet/foot): 
- Unknown

Vertical hydraulic gradient (feet/foot): 
- Unknown

K range (ft/day): 
- Measured using: Slug Test, Laboratory, Field data
  - Low: 
  - High: 
  - Unknown: 

Transmissivity (ft²/day): 
- Measured using: Slug Test, Laboratory, Field data
  - Low: 
  - High: 
  - Unknown: 

Comments: 

Attachments:
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  
  - Steam  
  - Steam + air  
  - Steam + O2  
  - Other (describe)  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
Duration:  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  
Size of target zone (ft²):  
Thickness of target zone (ft):  
Depth to top of target zone (ft bgs):  
Thickness of target zone below water table (ft):  
Number of extraction points:  
Number of energy delivery points:  

Temperature Profile:  
Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C):  
Time to reach maximum representative temperature (days):  
Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
Via liquid pumping:  
In vapor stream:  
Total:  

Comments:  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater: ____________________________________________________________
- In Soil: _________________________________________________________________

Was the Remediation Goal Achieved:

- In Groundwater: __________________________________________________________
  Comment: _______________________________________________________________
- In Soil: _________________________________________________________________
  Comment: _______________________________________________________________

General comments on the thermal application:

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
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Lessons Learned

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
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____________________________________________________________________________

Total energy applied to treatment zone:

- Total energy applied to treatment zone: _______ kWhr/m³ _______ kWhr/yd³
- Other energy: _______ kWhr/m³ _______ kWhr/yd³

Please note other energy: ____________________________________________________

Energy Cost:

- Consultant Cost: __________________________________________________________
- Thermal Vendor Cost: _____________________________________________________
- Energy Cost: _______ m³ _______ yd³
- Other Cost 1: _____________________________________________________________
- Other Cost 2: _____________________________________________________________
- Other Cost 3: _____________________________________________________________

Please note other cost: _______ Other Cost 1: _________________________________
__________________________ Other Cost 2: _________________________________
__________________________ Other Cost 3: _________________________________

Other Cost:

- Total Project Cost: _________________________________________________________
- Energy Cost: _____________________________________________________________
- Other Cost 1: _____________________________________________________________
- Other Cost 2: _____________________________________________________________
- Other Cost 3: _____________________________________________________________

Please note other cost: _______ Other Cost 1: _________________________________
__________________________ Other Cost 2: _________________________________
__________________________ Other Cost 3: _________________________________

Cost and Performance Facility ID#: 0528

Lessons Learned

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

90% reduction in soil of 9.7 mg/kg
Facility ID#: 0530

Type of treatment:  x  Conductive  
      
Type of Contaminant:  x  Chlorinated Solvents  
      
Treatment Status:  x  Active  
      
Type of Test:  x  Pilot Test  
      
Start of Test:  9/1/2002  
      
Type of Site:  x  DoD  
      
Facility Name:  Loring Air Force Base  

Primary point of contact:  Eva Davis  

Other contacts or vendors who worked on site:  None  

Point of contact:  Naji Akladiss  

Other Characteristics of Interest  

Good pre- and post-treatment groundwater data  
Good pre- and post-treatment soil data  
Good temperature profile vs. time information  
Flux assessment  
Groundwater elevations  
Geologic cross-section  
Hydraulic Conductivity information
General Site Assessment Data

Facility ID: 0530

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
</tr>
</thead>
</table>

| Alternative method for determining size of impacted zone (See source zone definition attachments) | Map attachment |

Motion Wells: Number of relevant monitoring wells with groundwater data:

<table>
<thead>
<tr>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Number of wells relative to treatment zone:

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>Upgradient</th>
<th>Downgradient</th>
<th>Crossgradient</th>
</tr>
</thead>
<tbody>
<tr>
<td>In: 14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Soil Borings: Number of relevant soil borings with pre-treatment data:

<table>
<thead>
<tr>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Number of relevant soil borings with post-treatment data:

<table>
<thead>
<tr>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Number inside treatment zone: 17

Number outside treatment zone: 8

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross tie</td>
<td></td>
<td>0.005 mg/L</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>1 mg/L</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Tolune</td>
<td></td>
<td></td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>0.005 mg/L</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>α-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>0.005 mg/L</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td>Tolune</td>
<td></td>
<td></td>
<td>None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>carbon tetrachloride</td>
<td></td>
<td></td>
<td></td>
<td>0.001 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>xylenel</td>
<td></td>
<td></td>
<td></td>
<td>0.005 mg/L</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>chlorobenzene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>tricloroethene</td>
<td></td>
<td></td>
<td></td>
<td>0.005 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>methylene chloride</td>
<td></td>
<td></td>
<td></td>
<td>0.001 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Attachments:
## Hydrogeologic Conceptual Model

### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): ___________ **x**
  - Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Depth to water (ft bgs):</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Low value</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High value</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Low value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction**
  - SW

- **Horizontal hydraulic gradient (feet/foot):** 0.03
  - Aquifer 1
  - Aquifer 2
  - Aquifer 3
  - Unknown

- **Vertical hydraulic gradient (feet/foot):**
  - Aquifer 1
  - Aquifer 2
  - Aquifer 3
  - Unknown

- **K range (ft/day):**
  - Measured using: Slug Test, Laboratory, Field data
  - Low
  - High
  - Unknown

- **Transmissivity (ft²/day):**
  - Measured using: Slug Test, Laboratory, Field data
  - Low
  - High
  - Unknown

### Ground surface elevation based on wells in or adjacent to treatment zone:

- 740 ft amsl
- Unknown

### Comments:

________________________________________________________________________

________________________________________________________________________

Attachments:

________________________________________________________________________

________________________________________________________________________
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
- 3 phase
- 6 phase
- AC power
- DC power

Steam:  
- Steam
- Steam + air
- Steam + O2

Other (describe)

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 9/1/2002
- Duration: 83 d

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

- Size of target zone (ft²): 7500
- Thickness of target zone (ft): 100
- Depth to top of target zone (ft bgs): 0
- Thickness of target zone below water table (ft): 70 to 80
- Number of energy delivery points: 2
- Number of extraction points: 7

Temperature Profile:

- Initial formation temperature (deg C): 7
- Maximum representative formation temperature (deg C): 25
- Time to reach maximum representative temperature (days): 83
- Duration of treatment at representative temperature (days): 1

Mass of contaminant removed:

- Via liquid pumping: 7.3 lb
- In vapor stream: 4.03 lb
- Total: 7.36 lb

Date | Temperature (deg C)
--- | ---

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Performance

**Remediation Goal:**

<table>
<thead>
<tr>
<th>In Groundwater</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In Soil</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Was the Remediation Goal Achieved:**

<table>
<thead>
<tr>
<th>In Groundwater</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In Soil</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**General comments on the thermal application:**

Objective - Improving the understanding of mechanisms controlling DNAPL and dissolved phase contaminant behavior in fractured bedrock, evaluating how a remediation technology could be successfully implemented and controlled in fractured bedrock, reduce the mass of contaminants in the subsurface to reduce overall remediation timeframe, and evaluating characterization needs for fractured bedrock systems.

Demobilization costs are not included in the cost below.

### Lessons Learned

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

### Energy

<table>
<thead>
<tr>
<th>Total Energy Used: 445.03 kWhr</th>
<th>kWhr</th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy applied to treatment zone: 357.25 kWhr</td>
<td>kWhr</td>
<td>kWhr/m³</td>
<td>kWhr/yd³</td>
</tr>
<tr>
<td>Other energy: 87.78 kWhr</td>
<td>kWhr</td>
<td>kWhr/m³</td>
<td>kWhr/yd³</td>
</tr>
<tr>
<td>Please note other energy:</td>
<td>kWhr</td>
<td>kWhr/m³</td>
<td>kWhr/yd³</td>
</tr>
</tbody>
</table>

### Cost

<table>
<thead>
<tr>
<th>Total Project Cost: 1918850</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultant Cost:</td>
</tr>
<tr>
<td>Thermal Vendor Cost:</td>
</tr>
<tr>
<td>Energy Cost:</td>
</tr>
<tr>
<td>Other Cost 1:</td>
</tr>
<tr>
<td>Other Cost 2:</td>
</tr>
<tr>
<td>Other Cost 3:</td>
</tr>
<tr>
<td>Please note other cost:</td>
</tr>
</tbody>
</table>

**Characterization**

<table>
<thead>
<tr>
<th>Characterization</th>
</tr>
</thead>
<tbody>
<tr>
<td>post-sampling, reporting, and miscellaneous</td>
</tr>
</tbody>
</table>
General Site Information

File Analyzed By: JT x PD _____ Date: 10/30/2006
Type of treatment: _____ Conductive _____ Steam _____ ERH x Other: Hot air
Type of Contaminant: _____ Chlorinated Solvents _____ Petroleum Hydrocarbons _____ Pesticides
_____ Wood Treating _____ Other: ________________________________
Treatment Status: _____ Active x Post
Type of Test: _____ Pilot Test x Full Scale System
Start of Test: 1/16/1996 End of Test: Mar-98 Duration: 2 years
Type of Site: x Non-DOD _____ DoD

Facility Name: Union Chemical Company Superfund Site
Address: ____________________________________________
City, State, Zip Code: South Hope, ME
OU# or Site #: ________________________________________

Primary point of contact: Terrence Connelly
Organization: EPA
Address: 1 Congress Street, Suite 110
City, State, Zip Code: __________________________________
Phone #: 617-918-1373 email: connelly.terry@epa.gov

Other contacts or vendors who worked on site None
Point of contact: ______________________________________
Type: _____ Vendor, Consultant _____ Vendor, Technical Applications _____ Other _________
Organization: ________________________________________
Address: ____________________________________________
City, State, Zip Code: __________________________________
Phone #: ____________________________________________ email: ____________________________

QA/QC

Characteristics of Interest
_____ Good pre- and post-treatment groundwater data
_____ Good temperature profile vs. time information
_____ Groundwater elevations
_____ Good pre- and post-treatment soil data
_____ Flux assessment
_____ Geologic cross-section
_____ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:**

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________  
  - Width (ft.): __________  
  - Thickness (ft.): __________  
  - Unknown  
  - Impacted zone as defined by documentation  
  - Alternative method for determining size of impacted zone (See source zone definition attachments)  
  - Map attachment

**Monitor Wells:**

- Number of relevant monitoring wells with groundwater data: __________  
  - Pre-treatment: __________  
  - Post-treatment: __________  
  - Number of wells relative to treatment zone:
    - Pre-treatment: In: __________  
      - Upgradient: __________  
      - Downgradient: __________  
      - Crossgradient: __________  
    - Post-treatment: In: __________  
      - Upgradient: __________  
      - Downgradient: __________  
      - Crossgradient: __________  

**Soil Borings:**

- Number of relevant soil borings with pre-treatment data: __________  
- Number of relevant soil borings with post-treatment data: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
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<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________

**Attachments:**

- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
Hydrogeologic Conceptual Model

Unconsolidated Sediments

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: ______ ft amsl ______ Unknown

Aquifer Characteristics:

Is more than 1 aquifer present?  No ______ Yes (number): ________ ______ Unknown (assume single aquifer)

Depth to water:
- low value (ft bgs): ________ ________ ________ ________
- high value (ft bgs): ________ ________ ________ ________
- Unknown: ________ ________ ________ ________

Flow direction: ________ ________ ________ ________

Horizontal hydraulic gradient (feet/foot): ________ ________ ________ ________ ________ Unknown

Vertical hydraulic gradient (feet/foot): ________ ________ ________ ________ ________ Unknown

K range (ft/day) Measured using: Slug Test Laboratory Field data
- low: ________ ________ ________ ________ Unknown
- high: ________ ________ ________ ________

Transmissivity (ft2/day): Measured using: Slug Test Laboratory Field data
- low: ________ ________ ________ ________ Unknown
- high: ________ ________ ________ ________

Comments: ______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________

Attachments: ______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  16-Jan-96
Duration:  2 years

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft2):  Unknown ( ___ x ___ ft)
Thickness of target zone (ft):  Unknown
Depth to top of target zone (ft bgs):  Unknown
Thickness of target zone below water table (ft):  Unknown
Number of energy delivery points:  91
Number of extraction points:  30

Temperature Profile:

Initial formation temperature (deg C):  Unknown
Maximum representative formation temperature (deg C):  Unknown
Time to reach maximum representative temperature (days):  Unknown
Duration of treatment at representative temperature (days):  Unknown

Formation temperature immediately post-treatment:
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping:  lb  kg  Unknown
In vapor stream:  lb  kg  Unknown
Total:  lb  kg  Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:


Lessons Learned


Energy

Total Energy Used: 

Total energy applied to treatment zone:

Other energy:

Please note other energy:

Cost

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
General Site Information

X File Analyzed By: JT X PD ______ Date: 9/18/2006
Type of treatment: ______ Conductive X Steam ______ ERH ______ Other: ______
Type of Contaminant: ______ Chlorinated Solvents ______ Petroleum Hydrocarbons ______ Pesticides
X Wood Treating ______ Other: ______
Treatment Status: ______ Active X Post
Type of Test: ______ Pilot Test X Full Scale System
Start of Test: 1995 End of Test: 2001 Duration: 59 months
Type of Site: X Non-DOD ______ DoD

X Facility Name: Bell Lumber and Pole Company
Address: ________________________________
City, State, Zip Code: New Brighton, MY
OU# or Site #: ________________________________

X Primary point of contact: Lyle Johnson
Organization: Western Research Institute
Address: 365 N. 9th St.
City, State, Zip Code: Laramie, WY 82072
Phone #: 307-721-2281 email: bylei@uwyo.edu

X Other contacts or vendors who worked on site: None
Point of contact: ________________________________
Type: ______ Vendor, Consultant ______ Vendor, Technical Applications ______ Other ______
Organization: ________________________________
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: ________________________________ email: ________________________________

QA/QC

X Characteristics of Interest
____ Good pre- and post-treatment groundwater data ______ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information ______ Flux assessment
____ Groundwater elevations ______ Geologic cross-section
____ Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation: __________
- Alternative method for determining size of impacted zone (See source zone definition attachments): __________
- Map attachment: __________

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>x Benzene</td>
<td>x Crossdr</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>x Jet Fuel</td>
<td>x PCE</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethylene</td>
<td>x Naphthalene</td>
<td>x Fuel Oil</td>
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<td>None</td>
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<tr>
<td></td>
<td>trans-1,2-dichloroethylene</td>
<td>x Toluene</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>x x</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>x x</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>x x</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2,2-trichloroethane</td>
<td>x x</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>x x</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>x x</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>x x</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>x x</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2,2-trichloroethane</td>
<td>x x</td>
<td>x x</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

2 acres impacted

**Attachments:**

---

0535

**Facility ID:** 6255
## Hydrogeologic Conceptual Model

### Facility ID:

0535

### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td>1️⃣ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>2️⃣ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>3️⃣ Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>4️⃣ Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>5️⃣ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>6️⃣ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated</td>
<td>1️⃣ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>2️⃣ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>3️⃣ Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>4️⃣ Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>5️⃣ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>6️⃣ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number)</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Flow direction

SW

### Horizontal hydraulic gradient (feet/foot):

0.004

### Vertical hydraulic gradient (feet/foot):

Unknown

### K range (ft/day)

<table>
<thead>
<tr>
<th></th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>3.1(10^-3) cm/s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>9.5(10^-3) cm/s</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Transmissivity (ft²/day):

<table>
<thead>
<tr>
<th></th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone:

Unknown

### Radial velocity

Radial velocity is 0.1

to 0.6 ft/dy

### Confining layer

K=1(10^7) cm/s

### Attachments:

[Blank Line]

[Blank Line]
Thermal Treatment - Design

Thermal treatment:  
____ Conductive  
____ Electrical Resistance

Type of Test:  
____ Pilot test  
____ Full-scale System

Hydraulic Control

Geology of Treatment Zone:
____ Relatively homogeneous and permeable unconsolidated sediments
____ Relatively homogeneous and impermeable unconsolidated sediments
____ Largely permeable sediments with inter-bedded layers of lower permeability material
____ Largely impermeable sediments with inter-bedded layers of higher permeability material
____ Competent, but fractured bedrock (i.e. crystalline rock)
____ Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
____ Saturated only  
____ Vadose only  
____ Both (Saturated and Vadose zones)

Start of Thermal Test:  
1995  
Duration: 59 months

Treatment Cell Design:

Size of target zone (ft2):  
26336  
____ Unknown

Thickness of target zone (ft):  
____ Unknown

Depth to top of target zone (ft bgs):  
____ Unknown

Thickness of target zone below water table (ft):  
____ Unknown

Number of energy delivery points:  
6  
____ Unknown

Number of extraction points:  
1  
____ Unknown

Temperature Profile:

Initial formation temperature (deg C):  
____ Unknown

Maximum representative formation temperature (deg C):  
54  
____ Unknown

Time to reach maximum representative temperature (days):  
450  
____ Unknown

Duration of treatment at representative temperature (days):  
____ Unknown

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping:  
____ lb  
____ kg  
____ Unknown

In vapor stream:  
____ lb  
____ kg  
____ Unknown

Total:  
500,000  
____ lb  
____ kg  
____ Unknown

Date  
Temperature (deg C)

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater:

In Soil:

Comment:

General comments on the thermal application:

Project did not achieve design flow rates or temperature. Organic production exceeded expectations. Only treated upper 1/3 of the impacted zone.

Lessons Learned:

Energy:

Total Energy Used: ____________________ kWhr/m3 kWhr/yd3 kWhr/yd

Total energy applied to treatment zone: ____________________ kWhr/m3 kWhr/yd3 kWhr/yd

Other energy: ____________________ kWhr/m3 kWhr/yd3 kWhr/yd

Please note other energy:

Cost:

Total Project Cost: 1858400

Consultant Cost: ____________________

Thermal Vendor Cost: ____________________

Energy Cost: ____________________ m3 yd

Other Cost 1: ____________________

Other Cost 2: ____________________

Other Cost 3: ____________________

Please note other cost: ____________________
General Site Information

File Analyzed By: JT PD Date: 10/26/2006
Type of treatment: Conductive Steam ERH Other: RFH
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Wood Treating Other: ___________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 2/18/1998 End of Test: 8/21/1998 Duration: 185 days
Type of Site: Non-DOD DoD

Facility Name: Mobil Oil
Address: ________________________________
City, State, Zip Code: MN
OU# or Site #: ________________________________

Primary point of contact: Ray Kasevich
Organization: KSN Energies
Address: 291 Main St., 3rd Floor, PO Box 612
City, State, Zip Code: Great Barrington, MA 01230
Phone #: 413-528-4651 email: rkasevich@ksenergies.com

Other contacts or vendors who worked on site None
Point of contact: ________________________________
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: ________________________________
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: ________________________________ email: ________________________________

QA/QC

Characteristics of Interest
Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data
Good temperature profile vs. time information Flux assessment
Groundwater elevations Geologic cross-section
Hydraulic Conductivity information

QA/QC
### General Site Assessment Data

**Facility ID:** __________

**Thickness (ft):** __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
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</tr>
<tr>
<td>Tetrachloroethylene</td>
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</tr>
<tr>
<td>Trichloroethene</td>
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<td>None</td>
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</tr>
<tr>
<td>Tetrachloroethene</td>
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<tr>
<td>1,1-dichloroethene</td>
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<td>None</td>
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</tr>
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<td>1,1,2-trichloroethane</td>
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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
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<td>None</td>
</tr>
</tbody>
</table>

**Average Pre-treatment Concentration per Chemical:**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 mg/L</td>
<td>100 mg/kg</td>
<td>100 mg/L</td>
<td>50 mg/kg</td>
<td></td>
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**Average Post-treatment Concentration per Chemical:**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

**Number inside treatment zone:** __________

**Number outside treatment zone:** __________

**Soil Borings:**

- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________

**Monitor Wells:**

- Number of relevant monitoring wells with groundwater data: __________

**Comments:**

________________________________________________________________________

________________________________________________________________________

Attachments:

________________________________________________________________________

________________________________________________________________________
Hydrogeologic Conceptual Model

Facility ID#: 0540

Geology:

Zone | Unconsolidated Sediments
--- | ---
Vadose Zone: | 
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone: | 
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl

Aquifer Characteristics:

Is more than 1 aquifer present? | No | Yes (number): ____________ | Unknown (assume single aquifer)

| Aquifer 1 | Aquifer 2 | Aquifer 3 |
--- | --- | ---
Depth to water: | | |
- low value (ft bgs): | 10 | |
- high value (ft bgs): | | |
- Unknown: | | |

Flow direction: |

Horizontal hydraulic gradient (feet/foot): |

Vertical hydraulic gradient (feet/foot): |

K range (ft/day) | Measured using: | Slug Test | Laboratory | Field data |
--- | --- | --- | --- | --- |
- low: | 53.9 | | | |
- high: | | | | |

Transmissivity (ft²/day): | Measured using: | Slug Test | Laboratory | Field data |
--- | --- | --- | --- | --- |
- low: | | | | |
- high: | | | | |

K = 0.019 cm/sec

Attachments:

Comments:

K = 0.019 cm/sec
### Thermal Treatment - Design

**Thermal treatment:**
- Conductive
- Electrical Resistance
- Steam
- Steam + air
- Steam + O2

**Type of Test:**
- Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- 2/18/1998
- Duration: 185 d

**Hydraulic Control:**
- Yes
- No

**Treatment Cell Design:**
- Size of target zone (ft²):
- Thickness of target zone (ft):
- Depth to top of target zone (ft bgs):
- Thickness of target zone below water table (ft):
- Number of energy delivery points:
- Number of extraction points:

**Temperature Profile:**
- Initial formation temperature (deg C):
- Maximum representative formation temperature (deg C):
- Time to reach maximum representative temperature (days):
- Duration of treatment at representative temperature (days):

**Formation temperature immediately post-treatment:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
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</thead>
</table>

**Formation temperature post-treatment monitoring event 1:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
</table>

**Mass of contaminant removed:**
- Via liquid pumping:
- In vapor stream:
- Total:

<table>
<thead>
<tr>
<th>Mass</th>
<th>lb</th>
<th>kg</th>
</tr>
</thead>
</table>

**Comments:**

300 yd³ - treated (or 116 yd³ per RF well x 3 wells = ~348 yd³ treated)

**Attachments:**

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater: ____________________________
- In Soil: 1) reduce residual soil concentrations to remove on-going GW source 2) decrease remediation time frame

Was the Remediation Goal Achieved:

- In Groundwater: ____________________________
  Comment: ____________________________
- In Soil: ____________________________
  Comment: ____________________________

General comments on the thermal application:

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Lessons Learned

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Energy

Total Energy Used: ____________________________  kWhr  kWhr/m³  kWhr/yd³

  Total energy applied to treatment zone: ____________________________  kWhr/m³  kWhr/yd³

  Other energy: ____________________________  kWhr/m³  kWhr/yd³

  Please note other energy: ____________________________

Cost

Total Project Cost: ____________________________

  Consultant Cost: ____________________________
  Thermal Vendor Cost: ____________________________
  Energy Cost: ____________________________  m³  yd³
  Other Cost 1: ____________________________
  Other Cost 2: ____________________________
  Other Cost 3: ____________________________

  Please note other cost: ____________________________

  Other Cost 1: ____________________________
  Other Cost 2: ____________________________
  Other Cost 3: ____________________________
General Site Information

File Analyzed By: JT PD ERH Date: 10/30/2006

Type of treatment: Conductive Steam ERH Other: Petroleum Hydrocarbons

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System

Start of Test: End of Test: Duration:

Type of Site: Non-DOD DoD

Facility Name: Ashland Refinery

Address:

City, State, Zip Code: St. Paul, MN

OU# or Site #:

Primary point of contact: Ray Kasevich

Organization: KSN Energies

Address: 291 Main St., 3rd Floor, PO Box 612

City, State, Zip Code: Great Barrington, MA 01230

Phone #: 413-528-4651 email: rkasevich@ksnenergies.com

Other contacts or vendors who worked on site

Point of contact: Daniel Berg

Type: Vendor, Consultant Vendor, Technical Applications Other

Organization: MN Pollution Control Agency

Address:

City, State, Zip Code:

Phone #: 651-296-0550 email: daniel.berg#pca.state.mn.us

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

<table>
<thead>
<tr>
<th>Impact Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
</tr>
</thead>
</table>

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

<table>
<thead>
<tr>
<th>Monitor Wells:</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- None

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>Number of relevant soil borings with post-treatment data:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- None

<table>
<thead>
<tr>
<th>Types of Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chlorinated Solvents</strong></td>
</tr>
<tr>
<td>Trichloroethylene</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
</tr>
<tr>
<td>cis-1,2-dichloroethylene</td>
</tr>
<tr>
<td>trans-1,2-dichloroethylene</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
</tr>
<tr>
<td>1,2,2-trichloroethane</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
</tr>
<tr>
<td>Chlorinated Solvents</td>
</tr>
<tr>
<td>Trichloroethylene</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
</tr>
<tr>
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<tr>
<td>1,2-dichloroethane</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
</tr>
<tr>
<td>1,2,2-trichloroethane</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
</tr>
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### Comments:

- None

### Attachments:

- None
<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl  __________ Unknown

Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): __________</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td>low value (ft bgs): __________</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs): __________</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td></td>
<td>Unknown: __________</td>
<td>__________</td>
<td>__________</td>
</tr>
</tbody>
</table>

Flow direction

Horizontal hydraulic gradient (feet/foot): __________ __________ __________ __________ Unknown

Vertical hydraulic gradient (feet/foot): __________ __________ __________ __________ Unknown

K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using: Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>high</td>
<td>__________</td>
<td>__________</td>
</tr>
</tbody>
</table>

Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Measured using: Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>high</td>
<td>__________</td>
<td>__________</td>
</tr>
</tbody>
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Comments:

Attachments:
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Type of Test</td>
<td>Pilot test</td>
</tr>
<tr>
<td>Full-scale System</td>
<td></td>
</tr>
<tr>
<td>Geology of Treatment Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Treatment Target Zone</td>
<td>Saturated only</td>
</tr>
<tr>
<td></td>
<td>Vadose only</td>
</tr>
<tr>
<td></td>
<td>Both (Saturated and Vadose zones)</td>
</tr>
<tr>
<td>Start of Thermal Test</td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td></td>
</tr>
<tr>
<td>Hydraulic Control</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Size of target zone (ft&lt;sup&gt;2&lt;/sup&gt;)</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone (ft)</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs)</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft)</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points</td>
<td></td>
</tr>
<tr>
<td>Temperature Profile</td>
<td></td>
</tr>
<tr>
<td>Initial formation temperature (deg C)</td>
<td></td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C)</td>
<td></td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td></td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td></td>
</tr>
<tr>
<td>Formation temperature immediately post-treatment</td>
<td></td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
<td></td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
</tr>
<tr>
<td>Mass of contaminant removed</td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping</td>
<td></td>
</tr>
<tr>
<td>In vapor stream</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Temperature (deg C)</td>
<td></td>
</tr>
<tr>
<td>Mass Flux Measurements</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: 
  - Comment: 

- In Soil: 
  - Comment: 

Was the Remediation Goal Achieved:

- In Groundwater: 
  - Comment: 

- In Soil: 
  - Comment: 

General comments on the thermal application:


Lessons Learned:


____ Energy

- Total Energy Used: 
  - Total energy applied to treatment zone: 
  - Other energy: 
    - Please note other energy: 

____ Cost

- Total Project Cost: 
  - Consultant Cost: 
  - Thermal Vendor Cost: 
  - Energy Cost: 
    - m$^3$  yd$^3$
  - Other Cost 1: 
  - Other Cost 2: 
  - Other Cost 3: 
    - Please note other cost: 
      - Other Cost 1: 
      - Other Cost 2: 
      - Other Cost 3: 

### General Site Information

- **File Analyzed By:** JT PD
- **Date:** 10/30/2006
- **Type of Treatment:** Conductive Steam ERH RFH
- **Type of Contaminant:** Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:
- **Treatment Status:** Active Post
- **Type of Test:** Pilot Test Full Scale System
- **Start of Test:** 3/1/1996 End of Test: 3/31/1996 Duration: 30 days
- **Type of Site:** Non-DOD DoD

### Facility Name:

- **Confidential Gasoline Service Station**
- **Address:**
- **City, State, Zip Code:** St. Paul, MN
- **OU# or Site #:**

### Primary point of contact:

- **Ray Kasevich**
- **Organization:** KAI Technologies
- **Address:**
- **City, State, Zip Code:**
- **Phone #:**
- **email:**

### Other contacts or vendors who worked on site:

- **None**

### Point of contact:

- **Type:** Vendor, Consultant Vendor, Technical Applications Other
- **Organization:**
- **Address:**
- **City, State, Zip Code:**
- **Phone #:**
- **email:**

### QA/QC

### Characteristics of Interest:

- **Good pre- and post-treatment groundwater data**
- **Good pre- and post-treatment soil data**
- **Good temperature profile vs. time information**
- **Flux assessment**
- **Groundwater elevations**
- **Geologic cross-section**
- **Hydraulic Conductivity information**
**General Site Assessment Data**

**Facility ID:** 0050

<table>
<thead>
<tr>
<th>Impacted Zone</th>
<th>Length (parallel to flow direction)(ft.)</th>
<th>Width (ft.)</th>
<th>Thickness (ft.)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacted zone as defined by documentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative method for determining size of impacted zone (See source zone definition attachments)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Map attachment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitor Wells</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

| Number of wells relative to treatment zone: |
| Pre-treatment In: | Upgradient: | Downgradient: | Crossgradient: |
| Post-treatment In: | Upgradient: | Downgradient: | Crossgradient: |

<table>
<thead>
<tr>
<th>Soil Borings</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

| Number of relevant soil borings with post-treatment data: |
| None |

<table>
<thead>
<tr>
<th>Number inside treatment zone:</th>
<th>Number outside treatment zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross gradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>None</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

______________________________________________________________________________________________

______________________________________________________________________________________________

______________________________________________________________________________________________

### Attachments:

______________________________________________________________________________________________
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td><strong>Relatively homogeneous and permeable unconsolidated sediments</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Relatively homogeneous and impermeable unconsolidated sediments</strong></td>
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<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td><strong>Relatively homogeneous and permeable unconsolidated sediments</strong></td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
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<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone:  

<table>
<thead>
<tr>
<th>Elev (ft amsl)</th>
<th>Unknown</th>
</tr>
</thead>
</table>

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

#### Flow direction

<table>
<thead>
<tr>
<th>Flow direction</th>
<th></th>
</tr>
</thead>
</table>

#### Horizontal hydraulic gradient (feet/foot):  

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
</table>

| Vertical hydraulic gradient (feet/foot):  

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
</table>

#### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

- [Comment]
- [Comment]
- [Comment]

#### Attachments:

- [Attachment]
- [Attachment]
- [Attachment]
Thermal Treatment - Design

Thermal treatment:  
- __Conductive__
- __Electrical Resistance__
- ___ 3 phase ___ 6 phase ___ AC power ___ DC power

Steam:  
- ___ Steam ___ Steam + air ___ Steam + O2

Other (describe)  
- ___ RFH___

Type of Test:  
- __Pilot test___ Full-scale System

Geology of Treatment Zone:  
- ___ Relatively homogeneous and permeable unconsolidated sediments___
- ___ Relatively homogeneous and impermeable unconsolidated sediments___
- ___ Largely permeable sediments with inter-bedded lenses of lower permeability material___
- ___ Largely impermeable sediments with inter-bedded layers of higher permeability material___
- ___ Competent, but fractured bedrock (i.e. crystalline rock)___
- ___ Weathered bedrock, limestone, sandstone___

Treatment Target Zone:  
- ___ Saturated only___ Vadose only ___ Both (Saturated and Vadose zones)

Start of Thermal Test:  
- __Date___ Time to reach maximum representative temperature (days): ___

Hydraulic Control:  
- ___ Yes ___ No

Size of target zone (ft2): ___ Unknown ___ (____ x ____ ft)

Thickness of target zone (ft): ___ Unknown ___

Depth to top of target zone (ft bgs): ___ Unknown ___

Thickness of target zone below water table (ft): ___ Unknown ___

Number of energy delivery points: ___ Unknown ___

Number of extraction points: ___ Unknown ___

Temperature Profile:

Initial formation temperature (deg C): ___ Unknown ___

Maximum representative formation temperature (deg C): ___ Unknown ___

Time to reach maximum representative temperature (days): ___ Unknown ___

Duration of treatment at representative temperature (days): ___ Unknown ___

Formation temperature immediately post-treatment: ___

Date  
Temperature (deg C)  

Formation temperature post-treatment monitoring event 1: ___

Duration of post-treatment monitoring (days): ___

Mass of contaminant removed:

- Via liquid pumping: ___ lb ___ kg ___ Unknown
- In vapor stream: ___ lb ___ kg ___ Unknown
- Total: ___ lb ___ kg ___ Unknown

Comments:

Attachments:

37 yd3 treated

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
___ Performance
Remediation Goal:

___ In Groundwater

___ In Soil

Was the Remediation Goal Achieved:

___ In Groundwater

___ In Soil

General comments on the thermal application:

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

Lessons Learned

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

___ Energy
Total Energy Used: ___________________________________________ kWhr kWhr/m³ kWhr/yd³

___ Total energy applied to treatment zone: ______________________ kWhr/m³ kWhr/yd³

___ Other energy: ____________________________________________ kWhr/m³ kWhr/yd³

___ Please note other energy: __________________________________________________________

___ Cost
Total Project Cost:

___ Consultant Cost: _____________________________________________

___ Thermal Vendor Cost: _________________________________________

___ Energy Cost: _____________________________________________ m³ yd³

___ Other Cost 1: _____________________________________________

___ Other Cost 2: _____________________________________________

___ Other Cost 3: _____________________________________________

___ Please note other cost: ___ Other Cost 1: ______________________

___ Other Cost 2: ______________________

___ Other Cost 3: ______________________

Comment:

In Soil:

In Groundwater:

General comments on the thermal application:

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

In Groundwater:

In Soil:

General comments on the thermal application:

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

In Groundwater:

In Soil:

General comments on the thermal application:

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
General Site Information

File Analyzed By: JT PD  Date: 9/13/2006

Type of treatment: x Conductive  Steam  ERH  Other:  

Type of Contaminant:  Chlorinated Solvents  Petroleum Hydrocarbons  Pesticides  Wood Treating  Other: PCBs

Treatment Status:  Active  Post  

Type of Test:  x Pilot Test  Full Scale System  

Start of Test:  Apr-97  End of Test: Jul-97  Duration: varied

Type of Site:  x Non-DOD  DoD

Facility Name: Missouri Electric Works
Address: Missouri State Route 61
City, State, Zip Code: Cape Girardeau, MO
OU# or Site #: CERCLIS ID Number: MOD980965982

Primary point of contact: Paulettia France-Isetts, RPM
Organization: US EPA Region 7
Address: 726 Minnesota Ave.
City, State, Zip Code: Kansas City, KS 66101
Phone #: 913-551-7701 email: france-isett.paulettia@epa.gov

Other contacts or vendors who worked on site: None
Point of contact: Ralph Baker
Type: Vendor, Consultant  Vendor, Technical Applications  Other  
Organization: TerraTherm
Address: 10 Stevens Rd.
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: rbaker@terratherm.com

QA/QC

Characteristics of Interest

x  Good pre- and post-treatment groundwater data  x  Good pre- and post-treatment soil data

x  Good temperature profile vs. time information  

x  Flux assessment

x  Groundwater elevations  

x  Geologic cross-section

x  Hydraulic Conductivity information
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation: __________
- Alternative method for determining size of impacted zone (See source zone definition attachments): __________
- Map attachment: __________

Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: In: __________ Upgradient: __________ Downgradient: __________ Crossgradient: __________
  - Post-treatment: In: __________ Upgradient: __________ Downgradient: __________ Crossgradient: __________

Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>Hexane</td>
<td>Crosscut</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>Arclor 1260 @6&quot;</td>
<td>None</td>
<td>1,000 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td>Arclor 1260 @12&quot;</td>
<td>None</td>
<td>1 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethylene</td>
<td>Benene</td>
<td>Arclor 1260 @18&quot;</td>
<td>None</td>
<td>1 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethylene</td>
<td>Toluene</td>
<td>Arclor 1260 @24&quot;</td>
<td>None</td>
<td>1 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>Arclor 1260 @18&quot;</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethane</td>
<td>m+p-xylene</td>
<td>Arclor 1260 @36&quot;</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethane</td>
<td>o-xylene</td>
<td>Arclor 1260 @30&quot;</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Arclor 1260 @24&quot;</td>
<td>Arclor 1260 @24&quot;</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Arclor 1260 @24&quot;</td>
<td>Arclor 1260 @24&quot;</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Concentration averages at different depths for thermal blanket 1 demo

Attachments:

- Comments: None
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft): __________
- Thickness (ft): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>Crossgradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>Jet Fuel</td>
<td>None</td>
<td>100 mg/kg</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>None</td>
<td>None</td>
<td>Benzene</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>Acetol 1260 @12ºC</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>Benzene</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>None</td>
<td>None</td>
<td>Toluene</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>None</td>
<td>None</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2,4-Trichloroethane</td>
<td>None</td>
<td>None</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>None</td>
<td>None</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Acetol 1260 @6ºC</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Acetol 1260 @18ºC</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Acetol 1260 @24ºC</td>
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<tr>
<td>1,1,2,2-Tetrachloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2,2-Trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Concentration averages at different depths for thermal blanket 2 demo**

**Attachments:**

---

**Comments:**

---

Facility ID: 0560
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): ______________
- Width (ft.): ______________
- Thickness (ft.): ______________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment: ______________
  - Post-treatment: ______________

<table>
<thead>
<tr>
<th>Wells relative to treatment zone:</th>
<th>In</th>
<th>Upgradient</th>
<th>Downgradient</th>
<th>Crossgradient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-treatment</td>
<td>______________</td>
<td>______________</td>
<td>______________</td>
<td>______________</td>
</tr>
<tr>
<td>Post-treatment</td>
<td>______________</td>
<td>______________</td>
<td>______________</td>
<td>______________</td>
</tr>
</tbody>
</table>

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: ______________ (11 samples)
- Number of relevant soil borings with post-treatment data: ______________ (14 samples)
- Number inside treatment zone: ______________
- Number outside treatment zone: ______________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

**Concentration averages at different depths for thermal wells demo at multiple depths**

Attachments:
### Hydrogeologic Conceptual Model

**Facility ID #:** 0560

#### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Geology

- **Ground surface elevation based on wells in or adjacent to treatment zone:** 404 ft amsl
- **Unknown:**

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): 1
  - Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs):</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### K range (ft/day)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Measured using:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slug Test</td>
<td>Laboratory</td>
</tr>
<tr>
<td>low</td>
<td>3 x 10E-3 md</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>50 md</td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0560</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Thermal blanket 1</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Electrical Resistance</th>
<th>3 phase</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>Steam + air</td>
<td>Steam + O2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
<th>Relatively homogeneous and permeable unconsolidated sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>x Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td>x Largely permeable sediments with inter-bedded layers of lower permeability material</td>
<td></td>
</tr>
<tr>
<td>x Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td>x Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td>x Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>x Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>3/13/1997</th>
<th>Duration:</th>
<th>32 days</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Hydraulic Control:</th>
<th>x Yes</th>
<th>No</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Treatment Cell Design:</th>
<th>Size of target zone (ft²):</th>
<th>100</th>
<th>Unknown</th>
<th>(8 x 20 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>2</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>0</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>0</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>1</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>2</td>
<td>Unknown</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
<th>Initial formation temperature (deg C):</th>
<th>23.8</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>315</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>30</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>1</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Formation temperature immediately post-treatment:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
<td></td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
<th>Via liquid pumping:</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

Comments: 

Attachments: 

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Thermal blankets 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

**Electrical Resistance**

- 3 phase
- 6 phase
- AC power
- DC power
- Steam
- Steam + air
- Steam + O2
- Other (describe)

**Type of Test:**

- x Pilot test
- Full-scale System

**Geology of Treatment Zone:**

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**

- x Saturated only
- x Vadose only
- x Both (Saturated and Vadose zones)

**Start of Thermal Test:**

- 7/9/1997
- Duration: 22 days

**Hydraulic Control:**

- x Yes
- No

**Treatment Cell Design:**

- Size of target zone (ft2): 110
- Thickness of target zone (ft): 2
- Depth to top of target zone (ft bgs): 0
- Thickness of target zone below water table (ft): 0
- Number of energy delivery points: 2
- Number of extraction points: 2

**Temperature Profile:**

- Initial formation temperature (deg C): 29.4
- Maximum representative formation temperature (deg C): 315
- Time to reach maximum representative temperature (days): 22
- Duration of treatment at representative temperature (days): 1

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Formation temperature immediately post-treatment:
- Formation temperature post-treatment monitoring event 1:
- Duration of post-treatment monitoring (days):

**Mass of contaminant removed:**

- Via liquid pumping: lb, kg
- In vapor stream: lb, kg
- Total: lb, kg

**Comments:**

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Thermal Treatment - Design

**Thermal treatment:**
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
- Steam
  - Steam
  - Steam + air
  - Steam + O2
- Other (describe)

**Type of Test:**
- Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:** 4/21/1997
**Duration:** 42 days

**Hydraulic Control:**
- Yes
- No

### Treatment Cell Design:

**Size of target zone (ft2):** 144
**Thickness of target zone (ft):** 12
**Depth to top of target zone (ft bgs):** 0
**Thickness of target zone below water table (ft):** 0
**Number of energy delivery points:** 12
**Number of extraction points:** 6

**Temperature Profile:**
- Initial formation temperature (deg C): 79
- Maximum representative formation temperature (deg C): 325
- Time to reach maximum representative temperature (days): 45
- Duration of treatment at representative temperature (days): 6

**Formation temperature immediately post-treatment:**
**Formation temperature post-treatment monitoring event 1:**
**Duration of post-treatment monitoring (days):**

**Mass of contaminant removed:**
- Via liquid pumping: 40 lb, x kg
- In vapor stream: 4 (10^-10) lb, x kg
- Total: 40 lb, x kg

### Notes:
- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.

---

**Mass in thermal well application only**
**Thermal wells on a 5ft center spacing**
Cost and Performance

Remediation Goal:
- In Groundwater: ____________________________
- In Soil: __________________________________

Was the Remediation Goal Achieved:
- In Groundwater: ____________________________
  Comment: ________________________________

- In Soil: ____________________________
  Comment: ________________________________

Yes

Lessons Learned:

Goals of all 3 demos: 1. Clean soils within arrays to achieve <2ppm total PCBs, 2. Show stack discharges could meet compliance stds with the state and federal for PCBs and polychlorinated dibenzodioxins/dibenzofurans (PCDDs/PCDFs), and 3. obtain a system destruction and removal efficiency (DRE) for PCBs greater than 99.9999%

General comments on the thermal application:

Energy
Total Energy Used: ____________________________________ kWhr kWhr/m³ kWhr/yd³
- Total energy applied to treatment zone: _____________________ kWhr/m³ kWhr/yd³
- Other energy: _____________________ kWhr/m³ kWhr/yd³
  Please note other energy: ____________________________________

Cost
Total Project Cost: ________________________________
- Consultant Cost: ________________________________
- Thermal Vendor Cost: ________________________________
- Energy Cost: ________________________________ m³ yd³
- Other Cost 1: ________________________________
- Other Cost 2: ________________________________
- Other Cost 3: ________________________________
  Please note other cost: ____________ Other Cost 1: ____________________
  ____________ Other Cost 2: ____________________
  ____________ Other Cost 3: ____________________
### General Site Information

- **File Analyzed By:** JT PD
- **Type of treatment:** Conductive Steam ERH Other:
- **Type of Contaminant:** Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:
- **Treatment Status:** Active Post
- **Type of Test:** Pilot Test Full Scale System
- **Start of Test:**
- **End of Test:**
- **Duration:** 120 d
- **Type of Site:** Non-DOD DoD
- **Facility Name:** Confidential St. Louis, MO
- **Address:**
- **City, State, Zip Code:** St. Louis, MO
- **OU# or Site #:**
- **Primary point of contact:** David Sarr
- **Organization:**
- **City, State, Zip Code:**
- **Phone #:** 703-709-6500 email: david.sarr@wspgroup.com
- **Other contacts or vendors who worked on site:** None
- **Point of contact:** Dacre Bush
- **Type:** Vendor, Consultant Vendor, Technical Applications Other
- **Organization:** McMillian-McGee
- **Address:**
- **City, State, Zip Code:**
- **Phone #:** 805-295-9071 email: dacre.bush@mcmillian-mcgee.com

### QA/QC

- **Characteristics of Interest:**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:**

**Thicknes (ft):**

**Width (ft):**

**Thickness (ft):**

**Types of Contaminants**

**Impacted Zone:**

- **Length (parallel to flow direction)(ft.):**
- **Width (ft):**
- **Thickness (ft):**

- **Map attachment**

**Impacted zone as defined by documentation**

- **Alternative method for determining size of impacted zone (See source zone definition attachments)**

**Monitor Wells:**

- **Number of relevant monitoring wells with groundwater data:**
- **Number of relevant monitoring wells with pre-treatment data:**
- **Number of relevant monitoring wells with post-treatment data:**

**Number of wells relative to treatment zone:**

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>Upgradient</th>
<th>Downgradient</th>
<th>Crossgradient</th>
</tr>
</thead>
<tbody>
<tr>
<td>In:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Soil Borings:**

- **Number of relevant soil borings with pre-treatment data:**
- **Number of relevant soil borings with post-treatment data:**

**Number inside treatment zone:**

**Number outside treatment zone:**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Benzene</td>
<td>Crosslier</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Jet Fuel</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>Benzene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethylene</td>
<td></td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethylene</td>
<td></td>
<td>m,p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-trichloroethylene</td>
<td>n-xylene</td>
<td>naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethylene</td>
<td></td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethylene</td>
<td></td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- 
- 
- 

**Attachments:**

- 
- 
- 

### Geology:

**Vadose Zone:**
- [x] Relatively homogeneous and permeable unconsolidated sediments
- [x] Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- [x] Relatively homogeneous and permeable unconsolidated sediments
- [x] Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

---

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depth to water:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flow direction:**

**Horizontal hydraulic gradient (feet/foot):**

**Vertical hydraulic gradient (feet/foot):**

**K range (ft/day):**

**Transmissivity (ft²/day):**

---

### Comments:

---

### Attachments:

---
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#</th>
<th>0542</th>
</tr>
</thead>
</table>

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power

Steam:  
- Steam
  - Steam + air
  - Steam + O2

Type of Test:  
- Pilot test
  - Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
  - Largely homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
  - Vadose only
  - Both (Saturated and Vadose zones)

Start of Thermal Test:  
- Duration: 120 d

Hydraulic Control:  
- Yes
  - No

Treatment Cell Design:
- Size of target zone (ft²):
  - Unknown ( ___ x ___ ft)
- Thickness of target zone (ft):
  - Unknown
- Depth to top of target zone (ft bgs):
  - Unknown
- Thickness of target zone below water table (ft):
  - Unknown
- Number of energy delivery points:
  - Unknown
- Number of extraction points:
  - Unknown

Temperature Profile:
- Initial formation temperature (deg C):
  - Unknown
- Maximum representative formation temperature (deg C):
  - 95
  - Unknown
- Time to reach maximum representative temperature (days):
  - Unknown
- Duration of treatment at representative temperature (days):
  - Unknown

Formation temperature immediately post-treatment:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature post-treatment monitoring event 1:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Duration of post-treatment monitoring (days):

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mass of contaminant removed:
- Via liquid pumping:
  - lb
  - kg
  - Unknown
- In vapor stream:
  - lb
  - kg
  - Unknown
- Total:
  - 69000 lb
  - kg
  - Unknown

Comments:

24 ft spacing

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:

___ In Soil

Comment:

General comments on the thermal application:

Goal: 99% reduction

Lessons Learned

__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________

Energy

Total Energy Used: 203.58 kWh

___ kWh/m³

___ kWh/yd³

___ Total energy applied to treatment zone:

___ Other energy:

___ Please note other energy:

Cost

Total Project Cost:

___ Consultant Cost:

___ Thermal Vendor Cost:

___ Energy Cost:

___ Other Cost 1:

___ Other Cost 2:

___ Other Cost 3:

___ Please note other cost:

___ Other Cost 1:

___ Other Cost 2:

___ Other Cost 3:
Facility Name: Operating Industrial Manufacturing Facility, Confidential Location, Missouri

Primary point of contact: Larry Williams
Organization: SECOR
Address: 400 Bruns Lane
City, State, Zip Code: Springfield, IL 62702
Phone #: 217-698-7247 ext 25 email: lwilliams@SECOR.com

Other contacts or vendors who worked on site: None

Type of Contaminant:
- Chlorinated Solvents
- Petroleum Hydrocarbons
- Pesticides
- Wood Treating
- Other:

Treatment Status:
- Active
- Post

Type of Test:
- Pilot Test
- Full Scale System

Start of Test: 6/24/2005 End of Test: 10/18/2005 Duration: 117 d

Type of Site:
- Non-DOD
- DoD

Characteristics of Interest
- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

#### Impacted Zone:
- Length (parallel to flow direction)(ft.): ___
- Width (ft.): ___
- Thickness (ft.): ___
- Impacted zone as defined by documentation: Unknown
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: ___
- Pre-treatment: ___
- Post-treatment: ___

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: ___
- Number of relevant soil borings with post-treatment data: ___
- Number inside treatment zone: ___
- Number outside treatment zone: ___

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossdr</td>
<td>10 mg/L</td>
<td>0.01 mg/L</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichlorotrifluoroethane</td>
<td>Ethylbenzene</td>
<td></td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:
- None

#### Attachments:
- None
### Hydrogeologic Conceptual Model

**Facility ID#:** 0564

#### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Vadose Zone</th>
<th>Saturated Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Geology:

- Weathered bedrock, limestone, sandstone
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of higher permeability material
- Largely impermeable sediments with inter-bedded lenses of lower permeability material
- Relatively homogeneous and impermeable unconsolidated sediments
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

#### Ground surface elevation based on wells in or adjacent to treatment zone:

- **Unknown** ft amsl

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - No
  - Yes (number):
  - **Unknown** (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Flow direction

#### Horizontal hydraulic gradient (feet/foot):

- **Unknown**

#### Vertical hydraulic gradient (feet/foot):

- **Unknown**

#### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td><strong>Unknown</strong></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft2/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td><strong>Unknown</strong></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

The geology is a residual clay with variable limestone and chert floaters.

#### Attachments:

- [Attachment 1](#)
- [Attachment 2](#)
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0564</th>
</tr>
</thead>
</table>

**Thermal treatment:**
- ☒ Conductive
- ☒ Electrical Resistance
- ☒ 3 phase
- ☒ 6 phase
- ☒ AC power
- ☒ DC power
- ☒ Steam
- ☒ Steam + air
- ☒ Steam + O2
- ☒ Other (describe)

**Type of Test:**
- ☒ Pilot test
- ☒ Full-scale System

**Geology of Treatment Zone:**
- ☒ Relatively homogeneous and permeable unconsolidated sediments
- ☒ Relatively homogeneous and impermeable unconsolidated sediments
- ☒ Largely permeable sediments with inter-bedded lenses of lower permeability material
- ☒ Largely impermeable sediments with inter-bedded layers of higher permeability material
- ☒ Competent, but fractured bedrock (i.e. crystalline rock)
- ☒ Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- ☒ Saturated only
- ☒ Vadose only
- ☒ Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- ☒ 6/24/2006
- ☒ Duration: 117 d

**Hydraulic Control:**
- Yes
- No

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>700</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>18</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>4</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>20</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>18</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>31</td>
</tr>
</tbody>
</table>

**Temperature Profile:**

| Initial formation temperature (deg C): | 24 |
| Maximum representative formation temperature (deg C): | 100 |
| Time to reach maximum representative temperature (days): | 53 |
| Duration of treatment at representative temperature (days): | 64 |

**Date** | **Temperature (deg C)**
--- | ---

Formation temperature immediately post-treatment:
- Unknown

Formation temperature post-treatment monitoring event 1:
- Unknown

Duration of post-treatment monitoring (days):
- Unknown

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Notes:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: 
- In Soil: 

At a 90% upper confidence limit, reduce TCE in soil to 0.4mg/kg. A 99% removal was needed.

Was the Remediation Goal Achieved:

- In Groundwater: 
  Comment: 

- In Soil: 
  Comment: yes, had a percent removal of 99.96%

General comments on the thermal application:

Took a data set on the dissolved organic carbon (DOC) in groundwater and found a 41 times higher amount of DOC in post-treatment samples. Which is important because it further substantiates that ERH creates favorable conditions for enhanced biodegradation by increasing the DOC content in groundwater making it more bio-available.

Lessons Learned:

- 
- 
- 
- 

Energy:

Total Energy Used: 607142 kWhr

- kWhr
- kWhr/m^3
- kWhr/yd^3

Total energy applied to treatment zone:

- kWhr/m^3
- kWhr/yd^3

Other energy:

- kWhr/m^3
- kWhr/yd^3

Please note other energy:

Cost:

Total Project Cost:

- Consultant Cost:
- Thermal Vendor Cost:
- Energy Cost:
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
<table>
<thead>
<tr>
<th>File Analyzed By</th>
<th>JT</th>
<th>PD</th>
<th>Date: 10/18/2006</th>
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<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam</td>
<td>ERH</td>
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<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
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<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
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<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
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<td>Start of Test:</td>
<td>7/11/2003</td>
<td>End of Test: 11/30/2003</td>
<td>Duration: 142 d</td>
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<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
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</table>

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>George's Conoco</th>
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<tbody>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Ronan, MT</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary point of contact:</th>
<th>Ken Manchester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>MSE Technology Applications</td>
</tr>
<tr>
<td>Address:</td>
<td>200 Technology Way</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Butte, MT</td>
</tr>
<tr>
<td>Phone #:</td>
<td>406-494-7397</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:ken.manchester@mse-ta.com">ken.manchester@mse-ta.com</a></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Other contacts or vendors who worked on site</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point of contact:</td>
<td>Jeffrey A. Kuhn</td>
</tr>
<tr>
<td>Type:</td>
<td>Vendor, Consultant</td>
</tr>
<tr>
<td>Organization:</td>
<td>Montana Dept. of Environmental Quality</td>
</tr>
<tr>
<td>Address:</td>
<td>PO Box 20090</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Helena, MT 59620-0901</td>
</tr>
<tr>
<td>Phone #:</td>
<td>406-841-5000</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:jkuhn@state.mt.us">jkuhn@state.mt.us</a></td>
</tr>
</tbody>
</table>

**QA/QC**

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
# General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __
- Width (ft.): __
- Thickness (ft.): __
- Impacted zone as defined by documentation: Unknown

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __
- Pre-treatment: None
- Post-treatment: None

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Number of wells relative to treatment zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-treatment In:</td>
</tr>
<tr>
<td></td>
<td>Post-treatment In:</td>
</tr>
</tbody>
</table>

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __
- Number of relevant soil borings with post-treatment data: __

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Chloroform</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>MTBE</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>TPH</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>TPH</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- 4,000 to 6,000 gallons of premium gasoline released
- All chemicals below detection limit in soil except for 1 xylene hit and the highest TPH Concentration at 35 ug/L

**Attachments:**

____________________________________________________________________________________________________________________________
Hydrogeologic Conceptual Model

Geology:

Vadose Zone:

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: _______ ft amsl _______ Unknown

Aquifer Characteristics:

Is more than 1 aquifer present? No _______ Yes (number): _______ Unknown (assume single aquifer)

Depth to water:

- low value (ft bgs): _______
- high value (ft bgs): _______
- Unknown: _______

Flow direction

- Horizontal hydraulic gradient (feet/foot):
- Vertical hydraulic gradient (feet/foot):

K range (ft/day)

- Measured using: Slug Test Laboratory Field data
- low: _______ 0.028 _______ _______
- high: _______ _______ _______

Transmissivity (ft²/day):

- Measured using: Slug Test Laboratory Field data
- low: _______ _______ _______
- high: _______ _______ _______

K = 10e-6 cm/s

16 ft was depth-to-water in the treatment zone.

Attachments:________________________________________________

Comments:

K = 10e-6 cm/s

16 ft was depth-to-water in the treatment zone.
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID: 0565</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td></td>
</tr>
<tr>
<td>- Conductive</td>
<td></td>
</tr>
<tr>
<td>- Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td>- 3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td>- AC power</td>
<td>DC power</td>
</tr>
<tr>
<td>- Steam</td>
<td>Steam + air</td>
</tr>
<tr>
<td>- Steam + O2</td>
<td>Steem + air</td>
</tr>
</tbody>
</table>

| **Type of Test:**        |                    |
| - Pilot test             | Full-scale System  |

| **Geology of Treatment Zone:** |                    |
| - Relatively homogeneous and permeable unconsolidated sediments |                    |
| - Relatively homogeneous and impermeable unconsolidated sediments |                    |
| - Largely permeable sediments with inter-bedded layers of lower permeability material |                    |
| - Largely permeable sediments with inter-bedded layers of higher permeability material |                    |
| - Competent, but fractured bedrock (i.e. crystalline rock) |                    |
| - Weatherbedrock, limestone, sandstone |                    |

| **Treatment Target Zone:** |                    |
| - Saturated only           | Vadose only        |
| - Both (Saturated and Vadose zones) |                    |

| **Start of Thermal Test:** | Duration: 140 d |
| 7/11/2003                 |                    |

| **Hydraulic Control:**    | Yes | No |
| - Yes                     | No  |    |

| **Treatment Cell Design:** |                    |
| - Size of target zone (ft²): | 6450 |
| - Thickness of target zone (ft): | 10   |
| - Depth to top of target zone (ft bgs): | 15   |
| - Thickness of target zone below water table (ft): | 9    |
| - Number of energy delivery points: | 12   |
| - Number of extraction points: | 6    |

| **Temperature Profile:** |                    |
| - Initial formation temperature (deg C): | 20 |
| - Maximum representative formation temperature (deg C): | Unknown |
| - Time to reach maximum representative temperature (days): | Unknown |
| - Duration of treatment at representative temperature (days): | Unknown |

<table>
<thead>
<tr>
<th><strong>Date</strong></th>
<th><strong>Temperature (deg C)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Formation temperature immediately post-treatment:** |                    |
| - Formation temperature post-treatment monitoring event 1: |                    |
| - Duration of post-treatment monitoring (days): |                    |

| **Mass of contaminant removed:** |                    |
| - Via liquid pumping: | lb | kg | Unknown |
| - In vapor stream: | lb | kg | Unknown |
| - Total: | 1574 | lb | kg | Unknown |

| **Notes:** |                    |
| - N/S spacing of 27.6 ft and a SW/NE spacing of 24.0 ft | Treated area - 2771 yd³ with effective treatment of 16 ft thick |

**Attachments:**

---

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Performance

Remediation Goal:

- In Groundwater:
  - MTBE - 30 ppb
  - Benzene - 5 ppb
  - Toluene - 1000 ppb
  - TPH (RBSL) - 1000 ug/L

- In Soil:
  - __________

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment: Yes, MTBE, benzene, toluene, ethylbenzene, were non-detect and xylene was below the MCL

- In Soil
  - Comment: __________

General comments on the thermal application:

- __________

$130/ cubic yard of effectively treated soil

Lessons Learned

- __________

- __________

- __________

- __________

- __________

- __________

- __________

- __________

- __________

- __________

Energy

Total Energy Used: 514120

- kWhr
- kWhr/m$^3$
- kWhr/yd$^3$

- Total energy applied to treatment zone: __________
- Other energy: __________

- Please note other energy: __________

Cost

Total Project Cost: 360800

- Consultant Cost: __________
- Thermal Vendor Cost: __________

- Energy Cost: 24404
- Other Cost 1: __________
- Other Cost 2: __________
- Other Cost 3: __________

- Please note other cost: __________
- Other Cost 1: __________
- Other Cost 2: __________
- Other Cost 3: __________
<table>
<thead>
<tr>
<th><strong>General Site Information</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Name: Eastern Montana</td>
</tr>
<tr>
<td>Type of treatment: Conductive Steam ERH Other: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
</tr>
<tr>
<td>Treatment Status: Active Post</td>
</tr>
<tr>
<td>Type of Test: Pilot Test Full Scale System</td>
</tr>
<tr>
<td>Type of Site: Non-DOD DoD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>QA/QC</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics of Interest</td>
</tr>
<tr>
<td>Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data</td>
</tr>
<tr>
<td>Good temperature profile vs. time information Flux assessment</td>
</tr>
<tr>
<td>Groundwater elevations Geologic cross-section</td>
</tr>
<tr>
<td>Hydraulic Conductivity information</td>
</tr>
</tbody>
</table>
### General Site Assessment Data

**Facility ID:** 0164

**Impacted Zone:**
- Length (parallel to flow direction ft.): __________
- Width (ft): __________
- Thickness (ft): __________
- Unknown
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: In: __________, Upgradient: __________, Downgradient: __________, Crossgradient: __________
  - Post-treatment: In: __________, Upgradient: __________, Downgradient: __________, Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Xylene</td>
<td>_</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>None</td>
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<td>None</td>
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<td>Ethylbenzene</td>
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<td>o-xylene</td>
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<td>None</td>
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<td>Vinyl Chloride</td>
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<td>_</td>
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<td>_</td>
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<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- ____________________________________________________
- ____________________________________________________
- ____________________________________________________

**Attachments:**

- ____________________________________________________
- ____________________________________________________
- ____________________________________________________
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone: ________ ft amsl ________ Unknown

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): ________</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow direction</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low value (ft bgs): ________</td>
</tr>
</tbody>
</table>

#### Horizontal hydraulic gradient (feet/foot):

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
</tr>
</thead>
</table>

#### Vertical hydraulic gradient (feet/foot):

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
<th>________</th>
</tr>
</thead>
</table>

#### K range (ft/day)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>high</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>high</td>
<td>________</td>
<td>________</td>
<td>________</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### Comments:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

#### Attachments:
Thermal Treatment - Design

Thermal treatment: [x] Conductive  [ ] Electrical Resistance

[ ] 3 phase  [ ] 6 phase  [ ] AC power  [ ] DC power

Steam

[ ] Steam  [ ] Steam + air  [ ] Steam + O2

[ ] Other (describe)

Type of Test: [ ] Pilot test  [ ] Full-scale System

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone: [ ] Saturated only  [ ] Vadose only  [ ] Both (Saturated and Vadose zones)

Start of Thermal Test: 11/4/2006  Duration: 824

Hydraulic Control: [ ] Yes  [ ] No

Treatment Cell Design:

Size of target zone (ft²): 1600
Thickness of target zone (ft): 20
Depth to top of target zone (ft bgs): 2
Thickness of target zone below water table (ft): 20
Number of energy delivery points: Unknown
Number of extraction points: Unknown

Temperature Profile:

Initial formation temperature (deg C): 13
Maximum representative formation temperature (deg C): 77
Time to reach maximum representative temperature (days): 25
Duration of treatment at representative temperature (days): 57

Formation temperature immediately post-treatment: Unknown
Formation temperature post-treatment monitoring event 1: Unknown
Duration of post-treatment monitoring (days): Unknown

Mass of contaminant removed:

Via liquid pumping: Unknown lb  kg
In vapor stream: Unknown lb  kg
Total: Unknown lb  kg

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Please note other energy:

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: 251616 x kWh x kWh/m³ x kWh/yd³

Total energy applied to treatment zone:

Other energy:

Other energy please note other energy:

Cost

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Other Cost please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
General Site Information

X File Analyzed By: JT  PD  
Type of treatment:   Conductive  Steam  ERH  Other:  
Type of Contaminant:  Chlorinated Solvents  Petroleum Hydrocarbons  Pesticides  Wood Treating  Other:  
Treatment Status:  Active  Post  
Type of Test:  Pilot Test  Full Scale System  
Type of Site:  Non-DOD  DoD  

X Facility Name:  Camp LeJeune  
Address:  
City, State, Zip Code:  Jacksonville, NC  
OU# or Site #:  Site 89  

X Primary point of contact:  Ron Kenyon  
Organization:  Shaw  
Address:  
City, State, Zip Code:  Alpharetta, GA  
Phone #:  770-663-1453  email: ronald.kenyon@shawgrp.com  

X Other contacts or vendors who worked on site:  None  
Point of contact:  Daniel Hood  
Type:  Vendor, Consultant  Vendor, Technical Applications  Other  
Organization:  Navy  
Address:  6506 Hampton Blvd  
City, State, Zip Code:  Norfolk, VA 23508-4530  
Phone #:  757-322-4630  email: daniel.r.hood@navy.mil  

QA/QC  

Characteristics of Interest  
Good pre- and post-treatment groundwater data  Good pre- and post-treatment soil data  
Good temperature profile vs. time information  Flux assessment  
Groundwater elevations  Geologic cross-section  
Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.):
- Width (ft.):
- Thickness (ft.):
- Impacted zone as defined by documentation:
- Alternative method for determining size of impacted zone (See source zone definition attachments):
- Map attachment:

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: None
- Pre-treatment: 27
- Post-treatment: 27
- Number of wells relative to treatment zone:
  - Pre-treatment: Upgradient: 27, Downgradient: 27, Crossgradient: 27
  - Post-treatment: Upgradient: 27, Downgradient: 27, Crossgradient: 27

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 27
- Number of relevant soil borings with post-treatment data: 27
- Number inside treatment zone: 27
- Number outside treatment zone: 0

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td></td>
<td>Crossgradient</td>
<td>500 mg/L</td>
<td>500 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>100 mg/L</td>
<td>50 mg/kg</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>50 mg/L</td>
<td>50 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td></td>
<td>0.5 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td></td>
<td></td>
<td></td>
<td>100 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>TCE - Deep</td>
<td></td>
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<td></td>
<td>10 mg/L</td>
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<tr>
<td>PCE - Deep</td>
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<tr>
<td>cis-12 DCE - Deep</td>
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<td></td>
<td>1 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>trans-12 DCE - Deep</td>
<td></td>
<td></td>
<td></td>
<td>0.5 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>1122 PCA - Deep</td>
<td></td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>VC - Deep</td>
<td></td>
<td></td>
<td></td>
<td>0.1 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

Shallow wells screened to 15 ft bgs. Deep wells screened to 25 ft bgs. Average post-treatment concentrations for 112 TCA - Deep, trans-12 DCE - Deep, and 1122 PCA - Deep are all 0.005 mg/L, but shown as 0.01 mg/Kg due to spreadsheet constraints.
Hydrogeologic Conceptual Model

X Geology: Zone
Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

X Ground surface elevation based on wells in or adjacent to treatment zone: ________ ft amsl ________ Unknown

---

Aquifer Characteristics:

Is more than 1 aquifer present? ______ Yes (number): _______ _______ Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs)</th>
<th>Low (ft bgs)</th>
<th>High (ft bgs)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X Flow direction SE

X Horizontal hydraulic gradient (feet/foot): 0.002

V Vertical hydraulic gradient (feet/foot): ___

X K range (ft/day) Measured using: Slug Test Laboratory Field data

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.4</td>
<td>64.6</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

X Transmissivity (ft²/day) Measured using: Slug Test Laboratory Field data

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Comments: ___________________________________________________________

Attachments: _________________________________________________________

Facility ID#: 0570
## Thermal Treatment - Design

<table>
<thead>
<tr>
<th><strong>Facility ID:</strong></th>
<th>0570</th>
</tr>
</thead>
</table>

### Thermal Treatment:

- **Thermal treatment:**
  - Conductive
  - Electrical Resistance

### Facility ID:

- **Facility ID:**
  - ____________

### Geology of Treatment Zone:

- **Geology of Treatment Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

### Treatment Target Zone:

- **Treatment Target Zone:**
  - Saturated only
  - Vadose only
  - Both (Saturated and Vadose zones)

### Start of Thermal Test:

- **Start of Thermal Test:**
  - 9/11/2003
  - Duration: 243 d

### Treatment Cell Design:

- **Hydraulic Control:**
  - Yes
  - No

### Temperature Profile:

- **Initial formation temperature (deg C):**
  - 20
  - Unknown
- **Maximum representative formation temperature (deg C):**
  - 100
  - Unknown
- **Time to reach maximum representative temperature (days):**
  - ~156
  - Unknown
- **Duration of treatment at representative temperature (days):**
  - ~86
  - Unknown

### Formation Temperature:

- **Formation temperature immediately post-treatment:**
- **Formation temperature post-treatment monitoring event 1:**
- **Duration of post-treatment monitoring (days):**
  - 1 yr

### Mass of Contaminant Removed:

- **Mass of contaminant removed:**
  - **Via liquid pumping:**
    - 428 lb
    - __kg
    - Unknown
  - **In vapor stream:**
    - 48000 lb
    - __kg
    - Unknown
  - **Total:**
    - 48428 lb
    - __kg
    - Unknown

### Notes:

- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
X  Performance

Remediation Goal:

X  In Groundwater: 95% reduction in groundwater.

X  In Soil: 95% reduction in soil.

Was the Remediation Goal Achieved:

X  In Groundwater

Comment:

99% in treatment zone and 97% in perimeter zone.

X  In Soil

Comment:

Yes.

General comments on the thermal application:

Objective: Evaluate effectiveness of ERH at reducing DNAPL within study area.

Lessons Learned

_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

X  Energy

Total Energy Used: 1,748,660

Total energy applied to treatment zone: _______ kWhr ______ kWhr/m³ ______ kWhr/yd³

Other energy: _______ kWhr ______ kWhr/m³ ______ kWhr/yd³

Please note other energy: _________________________________ kWhr/yd³ kWhr/m³

X  Cost

Total Project Cost: 2,105,215

Consultant Cost: ______ m³ ______ yd³

Thermal Vendor Cost: ______ m³ ______ yd³

Energy Cost: ______ m³ ______ yd³

Other Cost 1: 907,400

Other Cost 2: 672,550

Other Cost 3: 525,265

Please note other cost:

X  Other Cost 1: System O & M

X  Other Cost 2: System installation

X  Other Cost 3: prep, restoration, monitoring, and reporting (91,475, 329,910, 169,580)
X File Analyzed By: JT X PD Date: 10/18/2006
Type of treatment: ___ Conductive ___ Steam X ERH ___ Other: _______________________
Type of Contaminant: X Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides ___ Wood Treating ___ Other: _______________________
Treatment Status: ___ Active X Post
Type of Test: ___ Pilot Test ___ Full Scale System
Type of Site: X Non-DOD ___ DoD

X Facility Name: Confidential
Address: __________________________________________
City, State, Zip Code: NC
OU# or Site #: ______________________________________

X Primary point of contact: Brett Berra
Organization: URS Corp.
Address: __________________________________________
City, State, Zip Code: __________________________________
Phone #: 919-461-1290 email: brett_berra@urscorp.com

Other contacts or vendors who worked on site: ___ None
Point of contact: ___________________________________
Type: ___ Vendor, Consultant ___ Vendor, Technical Applications ___ Other ___
Organization: _____________________________________
Address: __________________________________________
City, State, Zip Code: __________________________________
Phone #: __________________________________________ email: ________________________________

QA/QC

Characteristics of Interest
___ Good pre- and post-treatment groundwater data ___ Good pre- and post-treatment soil data
___ Good temperature profile vs. time information ___ Flux assessment
___ Groundwater elevations ___ Geologic cross-section
___ Hydraulic Conductivity information
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Unknown

**Impacted zone as defined by documentation**
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________

**Number of wells relative to treatment zone:**
- Pre-treatment In: __________
- Upgradient: __________
- Downgradient: __________
- Crossgradient: __________
- Post-treatment In: __________
- Upgradient: __________
- Downgradient: __________
- Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil (mg/kg)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>X</td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>X</td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>X</td>
<td>cis,1,2-dichloroethene</td>
<td>Benezene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>m,p-xylene</td>
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</tr>
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<td>1,1,1-trichloroethane</td>
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<tr>
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<td>1,1,2-trichloroethane</td>
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<td>Vinyl Chloride</td>
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<tr>
<td>X</td>
<td>Carbon tetrachloride</td>
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<td>X</td>
<td>Chloroform</td>
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<td>Benzene</td>
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<td>X</td>
<td>Total VOC's</td>
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</tr>
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<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

__________________________________________________________________________________________

**Attachments:**

__________________________________________________________________________________________
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>X  Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X  Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X  Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>X  Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>X  Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>X  Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>X  Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X  Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X  Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>X  Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>X  Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>X  Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): X
  - Unknown (assume single aquifer)

- **Depth to water:**
  - Low (ft bgs): X
  - High (ft bgs): __________
  - Unknown: __________

- **Flow direction:**
  __________

- **Horizontal hydraulic gradient (feet/foot):**
  __________

- **Vertical hydraulic gradient (feet/foot):**
  __________

- **K range (ft/day):**
  Measured using:
  - Slug Test
  - Laboratory
  - Field data
  - Unknown

- **Transmissivity (ft^2/day):**
  Measured using:
  - Slug Test
  - Laboratory
  - Field data
  - Unknown

#### Ground surface elevation based on wells in or adjacent to treatment zone:

- __________ ft amsl
- __________ Unknown

#### Comments:

- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________

#### Attachments:

- ____________________________________________________________________________
- ____________________________________________________________________________
Thermal Treatment - Design

Facility ID#: 0573

Thermal treatment:  
- Conductive
- Electrical Resistance

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 12/4/2003  
Duration: 238 days

Hydraulic Control:  
- Yes
- No

Size of target zone (ft²): 12833  
Thickenes of target zone (ft): 12  
Depth to top of target zone (ft bgs): 2  
Thickenes of target zone below water table (ft): 10  
Number of energy delivery points: 62  
Number of extraction points: 22  

Initial formation temperature (deg C): 18  
Maximum representative formation temperature (deg C): 91  
Time to reach maximum representative temperature (days): -136  
Duration of treatment at representative temperature (days): -102

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:
- Via liquid pumping: 5429 lb, 12 kg, Unknown
- In vapor stream: 5429 lb, X kg, Unknown
- Total: 5429 lb, X kg, Unknown

Comments:  
- 
- 

Attachments:  
- 
- 

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: Remove source and eventually achieve MCLs after polishing agents were applied.
- In Soil: Same as above

Was the Remediation Goal Achieved:

- In Groundwater
- In Soil

Comment:

General comments on the thermal application:

95% reduction in total VOCs in GW. 80% reduction in total VOCs in soil.

Lessons Learned

Energy

Total Energy Used: kWhr kWh/m³ kWhr/m³ kWhr/yd³

Total energy applied to treatment zone: kWhr kWh/m³ kWhr/m³ kWhr/yd³

Other energy: kWhr kWh/m³ kWhr/m³ kWhr/yd³

Please note other energy:

Cost

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost: m³ yd³

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
General Site Information

File Analyzed By: JT PD Date: 11/1/2006
Type of treatment: Conductive Steam ERH Other: ____________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Wood Treating Other: ____________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: ____________ End of Test: ____________ Duration: ___ d
Type of Site: Non-DOD DoD

Facility Name: Total Petrochemicals USA, Inc. (Pilot)
Address: __________________________________________
City, State, Zip Code: Greensboro, NC
OU# or Site #: ______________________________________

Primary point of contact: Monty Bennett or Rusty Field
Organization: GES
Address: __________________________________________
City, State, Zip Code: ______________________________________
Phone #: 804-343-0700 email: rfield@gesonline.com

Other contacts or vendors who worked on site None
Point of contact: Dacre Bush
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: McMillan-McGee
Address: __________________________________________
City, State, Zip Code: ______________________________________
Phone #: 805-295-9071 email: dacre.bush@mcmillan-mcgee.com

QA/QC

Characteristics of Interest
Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data
Good temperature profile vs. time information Flux assessment
Groundwater elevations Geologic cross-section
Hydraulic Conductivity information
### Impacted Zone

- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells

- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- None
- Number of wells relative to treatment zone:
  - Pre-treatment
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________
  - Post-treatment
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________

### Soil Borings

- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Chemical</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>BTEX</td>
<td>Crossgradient</td>
<td>TBA</td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
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<tr>
<td></td>
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<td>Ethylbenzene</td>
<td></td>
<td></td>
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<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
<td></td>
<td></td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td></td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
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<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>None (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
</tbody>
</table>

### Comments:

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

### Attachments:

- __________
- __________
- __________
### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
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<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): __________</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Flow direction


### Horizontal hydraulic gradient (feet/foot):


### Vertical hydraulic gradient (feet/foot):


### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Transmissivity (ft²/day):

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments:


### Attachments:


Thermal Treatment: Design  

Thermal treatment:  
- Conductivesteam  
- Electrical Resistance:  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  
- Steam:  
  - Steam  
  - Steam + air  
  - Steam + O2  
- Other (describe):  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-beded layers of lower permeability material  
- Largely permeable sediments with inter-beded lenses of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  

Duration of treatment at representative temperature (days):  

Time to reach maximum representative temperature (days):  

Maximum representative formation temperature (deg C):  

Initial formation temperature (deg C):  

Temperature Profile:  

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mass of contaminant removed:  

- Via liquid pumping:  
  - Unknown  
- In vapor stream:  
  - Unknown  
- Total:  
  - 69000  

Comments:  

Attachments:  

23 foot spacing  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

Was the Remediation Goal Achieved:

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: 186 kWhr __________ kWhr/m^3 __________ kWhr/yd^3

Total energy applied to treatment zone: __________ kWhr/m^3 __________ kWhr/yd^3

Other energy: __________ kWhr/m^3 __________ kWhr/yd^3

Cost

Total Project Cost: __________

Consultant Cost: __________

Thermal Vendor Cost: __________

Energy Cost: __________ m^3 __________ yd^3

Other Cost 1: __________

Other Cost 2: __________

Other Cost 3: __________

Please note other cost: __________ Other Cost 1: __________

Other Cost 2: __________

Other Cost 3: __________
<table>
<thead>
<tr>
<th>General Site Information</th>
<th>Facility ID#: 0576</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Analyzed By: JT, PD</td>
<td>Date: 11/1/2006</td>
</tr>
<tr>
<td>Type of treatment:</td>
<td>Treatments Status:</td>
</tr>
<tr>
<td>Conductive</td>
<td>Steam</td>
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<tr>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
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<tr>
<td>Treatment Status:</td>
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<tr>
<td>Active</td>
<td>Post</td>
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<tr>
<td>Type of Test:</td>
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<tr>
<td>Pilot Test</td>
<td>Full Scale System</td>
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<tr>
<td>Type of Site:</td>
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<tr>
<td>Non-DOD</td>
<td>DoD</td>
</tr>
</tbody>
</table>

| Facility Name: Total Petrochemicals USA, Inc. (Full) |
| Address:  |
| City, State, Zip Code: Greensboro, NC |
| OU# or Site #:  |

| Primary point of contact: Monty Bennett or Rusty Field |
| Organization: GFS |
| Address:  |
| City, State, Zip Code:  |
| Phone #: 804-343-0700 email: rfield@gesonline.com |

| Other contacts or vendors who worked on site | None |
| Point of contact: Dacre Bush |
| Type: Vendor, Consultant Vendor, Technical Applications Other | |
| Organization: McMillan-McGee |
| Address:  |
| City, State, Zip Code:  |
| Phone #: 805-295-9071 email: dacre.bush@mcmillan-mcgee.com |

| QA/QC |
| Characteristics of Interest |
| Good pre- and post-treatment groundwater data | Good pre- and post-treatment soil data |
| Good temperature profile vs. time information | Flux assessment |
| Groundwater elevations | Geologic cross-section |
| Hydraulic Conductivity information |  |
General Site Assessment Data

### Impacted Zone
- Length (parallel to flow direction)(ft.): 
- Width (ft.): 
- Thickness (ft.): 
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells
- Number of relevant monitoring wells with groundwater data: 
  - Pre-treatment: 
  - Post-treatment: 
- None
  - Number of wells relative to treatment zone:
  - Pre-treatment: In: Upgradient: Downgradient: Crossgradient:
  - Post-treatment: In: Upgradient: Downgradient: Crossgradient:

### Soil Borings
- Number of relevant soil borings with pre-treatment data: 
- Number of relevant soil borings with post-treatment data: 
- Number inside treatment zone: 
- Number outside treatment zone: 

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuels</td>
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<td>1,1-dichloroethene</td>
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</tbody>
</table>

### Comments:
- 
- 
- 

### Attachments:
- 
- 
- 

---
### Hydrogeologic Conceptual Model

#### Geology:
- **Vadose Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Saturated Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

#### Ground Surface Elevation Based on Wells in or Adjacent to Treatment Zone:

- **Unknown ft amsl**

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - **No**
  - **Yes** (number): _____________
  - **Unknown (assume single aquifer)**

- **Depth to water:**
  - Low value (ft bgs): _____________
  - High value (ft bgs): _____________
  - Unknown: _____________

- **Flow direction:**

- **Horizontal hydraulic gradient (feet/foot):**

- **Vertical hydraulic gradient (feet/foot):**

- **K range (ft/day):**
  - Measured using:
    - Slug Test
    - Laboratory
    - Field data
  - Low: _____________
  - High: _____________

- **Transmissivity (ft²/day):**
  - Measured using:
    - Slug Test
    - Laboratory
    - Field data
  - Low: _____________
  - High: _____________

#### Comments:

- ________________________________________________________________________
- ________________________________________________________________________
- ________________________________________________________________________

#### Attachments:

- ________________________________________________________________________
- ________________________________________________________________________
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conduction</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 3 phase
- 6 phase
- AC power
- DC power

Steam + air
Steam + O2
Steam

- Other (describe)

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
</table>

- Geology of Treatment Zone:
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>Duration:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Hydraulic Control
  - Yes
  - No

| Size of target zone (ft²): | Unknown (| ft) |
|----------------------------|--------|
|                            |        |

<table>
<thead>
<tr>
<th>Thickness of target zone (ft):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth to target zone (ft bgs):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thickness of target zone below water table (ft):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of energy delivery points:</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of extraction points:</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
</tr>
</thead>
</table>

- Initial formation temperature (deg C): | Unknown |
|                                       |         |

- Maximum representative formation temperature (deg C): | Unknown |
|                                                    |         |

- Time to reach maximum representative temperature (days): | Unknown |
|                                                      |         |

- Duration of treatment at representative temperature (days): | Unknown |
|                                                          |         |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Formation temperature immediately post-treatment: |                     |
|                                                  |                     |

- Formation temperature post-treatment monitoring event 1: |                     |
|                                                       |                     |

- Duration of post-treatment monitoring (days): |                     |
|                                              |                     |

| Mass of contaminant removed: |

- Via liquid pumping: | lb  | kg  | Unknown |
|                     |     |     |         |

- In vapor stream:  | lb  | kg  | Unknown |
|                   |     |     |         |

- Total:  | lb  | kg  | Unknown |
|         |     |     |         |

<table>
<thead>
<tr>
<th>Comments:</th>
<th>23 foot spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater:
- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater
  Comment:
- In Soil
  Comment:

General comments on the thermal application:


Lessons Learned


Energy

Total Energy Used: **** kWhr m³ kWhr/yd³

- Total energy applied to treatment zone: **** kWhr m³ kWhr/yd³
- Other energy: **** kWhr m³ kWhr/yd³
  Please note other energy: ****

Cost

Total Project Cost:

- Consultant Cost:
- Thermal Vendor Cost:
- Energy Cost: **** m³ **** yd³
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:
  Please note other cost:
  Other Cost 1:
  Other Cost 2:
  Other Cost 3:
### General Site Information

<table>
<thead>
<tr>
<th>Type of treatment:</th>
<th>Conductive</th>
<th>Steam</th>
<th>ERH</th>
<th>Other:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
<td>Wood Treating</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start of Test:</td>
<td>10/1/2004</td>
<td>End of Test: 2/14/2004</td>
<td>Duration: 137 d</td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Cape Fear Wood Preserving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td>1219 South Reilly Rd</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Fayetteville, NC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary point of contact:</th>
<th>Chad Northington</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>WRS Infrastructure and Environment, Inc</td>
</tr>
<tr>
<td>Address:</td>
<td>221 Hobs St., Suite 108</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Tampa, FL 33619</td>
</tr>
<tr>
<td>Phone #:</td>
<td>813-383-0309</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:cnorthington@wrsie.com">cnorthington@wrsie.com</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other contacts or vendors who worked on site</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point of contact:</td>
<td>Dacre Bush</td>
</tr>
<tr>
<td>Type:</td>
<td>Vendor, Consultant</td>
</tr>
<tr>
<td>Organization:</td>
<td>McMillian-McGee</td>
</tr>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<td>805-295-9071</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:dacre.bush@mcmillian-mcgee.com">dacre.bush@mcmillian-mcgee.com</a></td>
</tr>
</tbody>
</table>

### QA/QC

- Characteristics of Interest
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
### General Site Assessment Data

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________
  - Width (ft.): __________
  - Thickness (ft.): __________
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: None
  - Pre-treatment: __________
  - Post-treatment: __________

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: __________
  - Number of relevant soil borings with post-treatment data: __________
  - Number inside treatment zone: __________
  - Number outside treatment zone: __________

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichlorobenzene</td>
<td>Ethylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichlorobenzene</td>
<td>m,p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Ethylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Ethylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:

The average total SVOC/VOC concentration in pre-treatment samples = 74,675 mg/kg and post-treatment average concentration of 471,542 mg/kg

Estimated DNAPL of 9,159 to 26,170 lbs
<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- **Geology:**

  - **Zone:**
    - Vadose Zone
    - Saturated Zone

  - **Unconsolidated Sediments:**
    - Relatively homogeneous and permeable unconsolidated sediments
    - Relatively homogeneous and impermeable unconsolidated sediments
    - Largely permeable sediments with inter-bedded lenses of lower permeability material
    - Largely impermeable sediments with inter-bedded layers of higher permeability material
    - Competent, but fractured bedrock (i.e. crystalline rock)
    - Weathered bedrock, limestone, sandstone

- **Ground surface elevation based on wells in or adjacent to treatment zone:** __________ ft amsl  
  - **Unknown:** __________ ft amsl

- **Aquifer Characteristics:**

  - **Is more than 1 aquifer present?**
    - **No**
    - **Yes (number):**
      - **Aquifer 1:**
      - **Aquifer 2:**
      - **Aquifer 3:**
      - **Unknown (assume single aquifer):**

  - **Depth to water:**
    - **low value (ft bgs):**
    - **high value (ft bgs):**
    - **Unknown:**

  - **Flow direction:**

  - **Horizontal hydraulic gradient (feet/foot):**
    - **Unknown:**
  - **Vertical hydraulic gradient (feet/foot):**
    - **Unknown:**

- **K range (ft/day):**
  - Measured using:
    - **Slug Test**
    - **Laboratory**
    - **Field data**
    - **low:**
    - **high:**
    - **Unknown:**

- **Transmissivity (ft²/day):**
  - Measured using:
    - **Slug Test**
    - **Laboratory**
    - **Field data**
    - **low:**
    - **high:**
    - **Unknown:**

- **Comments:**

- **Attachments:**
### Thermal Treatment - Design

**Thermal treatment:**
- **Conductive**
- **Electrical Resistance**

**Type of Test:**
- Pilot test

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- 10/1/2004

**Duration:**
- 137 d

**Hydraulic Control:**
- Yes
- No

**Size of target zone (ft²):**
- 7500

**Thickness of target zone (ft):**
- 16

**Depth to top of target zone (ft bgs):**
- 10

**Thickness of target zone below water table (ft):**
- Unknown

**Number of energy delivery points:**
- 9

**Number of extraction points:**
- 6

**Temperature Profile:**

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>90</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>64</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>73</td>
</tr>
</tbody>
</table>

**Formation temperature immediately post-treatment:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Formation temperature post-treatment monitoring event 1:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Duration of post-treatment monitoring (days):**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Method</th>
<th>Quantity (lb)</th>
<th>Quantity (kg)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>In vapor stream</td>
<td>4610.2</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4610.2</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**
- Treated 2200 yd³

**Attachments:**
- Spacing of 19.5 ft

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Performance

Remediation Goal:

x In Groundwater: Total PAH SPLP = <100 ug/L Naphthalene, <500 ug/L Phenol, < 2 times 2L std for all other compounds

x In Soil: Total PAH = 800 mg/kg

Was the Remediation Goal Achieved:

x In Groundwater

Comment: No

x In Soil

Comment: No

General comments on the thermal application:

__________________________________________
__________________________________________
__________________________________________
__________________________________________
__________________________________________
__________________________________________
__________________________________________

Lessons Learned

Problems associated with viscous NAPL clogging system

Energy

x Total Energy Used: 269481.77 kWh 170 kWh/m³ 12 kWh/yd³

x Total energy applied to treatment zone: 310 kWh/m³ 12 kWh/yd³

x Other energy:__________________________________________ kWh/m³ kWh/yd³

x Please note other energy:____________________________________________________________

Cost

Total Project Cost: 500000

- Consultant Cost:____________________________________

- Thermal Vendor Cost: 160000

- Energy Cost:____________________________________ m³ yd³

- Other Cost 1:____________________________________

- Other Cost 2:____________________________________

- Other Cost 3:____________________________________

- Please note other cost:____________________________________

- Other Cost 1:____________________________________

- Other Cost 2:____________________________________

- Other Cost 3:____________________________________
General Site Information

File Analyzed By: JT PD Date: 9/28/2006
Type of treatment: ___ Conductive ___ Steam X ERH ___ Other: ____________
Type of Contaminant: X Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides
___ Wood Treating ___ Other: ____________
Treatment Status: ___ Active X Post
Type of Test: ___ Pilot Test X Full Scale System
Type of Site: X Non-DOD ___ DoD

Facility Name: Charleston Naval Complex
Address: ________________________________________________________
City, State, Zip Code: South Carolina
OU# or Site #: AOC 607 in zone F
Primary point of contact: David Scaturo
Organization: SC Dept. of Health and Environmental Control
Address: ________________________________________________________
City, State, Zip Code: __________________________________________
Phone #: 803-896-4185 email: scaturodm@dhec.sc.gov
Other contacts or vendors who worked on site ___ None
Point of contact: Dean Williamson
Type: X Vendor, Consultant ___ Vendor, Technical Applications ___ Other
Organization: CH2M Hill
Address: ________________________________________________________
City, State, Zip Code: __________________________________________
Phone #: 352-335-5877, ext 52280 email: dean.williamson@ch2m.com

QA/QC

Characteristics of Interest
X Good pre- and post-treatment groundwater data ___ Good pre- and post-treatment soil data
X Good temperature profile vs. time information ___ Flux assessment
___ Groundwater elevations X Geologic cross-section
X Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0580

- **Thickness (ft):** ___
- **Types of Contaminants:**
- **Impacted zone as defined by documentation:**
- **Alternative method for determining size of impacted zone (See source zone definition attachments):**
- **Map attachment:**

#### Monitor Wells
- **Number of relevant monitoring wells with groundwater data:**
  - Pre-treatment: 28
  - Post-treatment: 41
- **Number of wells relative to treatment zone:**
  - Pre-treatment:
    - In: 14
    - Upgradient: ___
    - Downgradient: ___
    - Crossgradient: ___
  - Post-treatment:
    - In: 12
    - Upgradient: ___
    - Downgradient: ___
    - Crossgradient: ___

#### Soil Borings
- **Number of relevant soil borings with pre-treatment data:**
- **Number of relevant soil borings with post-treatment data:**
- **Number inside treatment zone:**
- **Number outside treatment zone:**

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>0.001 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>0.5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>0.005 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>α-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,2-DCE total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

- 
- 
- 

#### Attachments:

- 
- 
- 

---

Note: The contamination levels and data are indicative and should be cross-referenced with the actual site assessment data for accuracy.
Hydrogeologic Conceptual Model

X Geology: Zone
Vadose Zone: Relatively homogeneous and permeable unconsolidated sediments
Relatively homogeneous and impermeable unconsolidated sediments
Largely permeable sediments with inter-bedded lenses of lower permeability material
X Largely impermeable sediments with inter-bedded layers of higher permeability material
X Competent, but fractured bedrock (i.e. crystalline rock)
X Weathered bedrock, limestone, sandstone
Saturated Zone: Relatively homogeneous and permeable unconsolidated sediments
Relatively homogeneous and impermeable unconsolidated sediments
Largely permeable sediments with inter-bedded layers of higher permeability material
Largely impermeable sediments with inter-bedded layers of higher permeability material
Competent, but fractured bedrock (i.e. crystalline rock)
Weathered bedrock, limestone, sandstone

X Ground surface elevation based on wells in or adjacent to treatment zone: \(~8\) ft amsl
Unknown

X Aquifer Characteristics:
Is more than 1 aquifer present? No X Yes (number): Unknown (assume single aquifer)
Aquifer 1 Aquifer 2 Aquifer 3
Depth to water:
low value (ft bgs): ½ ½ ½
high value (ft bgs): ¼ ¼ ¼
Unknown:

X Flow direction: NE

X Horizontal hydraulic gradient (feet/foot): 0.0107 - 0.0133
Vertical hydraulic gradient (feet/foot): 0.0133
see attachment
Unknown

X K range (ft/day)
Measured using: Slug Test Laboratory Field data
low 0.194 0.45 0.0081
high 1.89 1.25 0.027

X Transmissivity (ft²/day):
Measured using: Slug Test Laboratory Field data
low
high

Comments:
GW velocities average 0.01 ft/day. Vertical permeability in clay unit (bottom) is 0.03 ft/day

Attachments:
see attachment AOC607.doc
Thermal Treatment - Design

Thermal treatment:  
- Conductive

Type of Test:  
- Pilot test

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 10/3/2001

Hydraulic Control:  
- Yes

Thermal Treatment Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²)</th>
<th>Thickness of target zone (ft)</th>
<th>Depth to top of target zone (ft bgs)</th>
<th>Thickness of target zone below water table (ft)</th>
<th>Number of energy delivery points</th>
<th>Number of extraction points</th>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16525</td>
<td>12</td>
<td>4</td>
<td>10</td>
<td>107</td>
<td>97</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Temperature Profile:

- Initial formation temperature (deg C): 26
- Maximum representative formation temperature (deg C): 95
- Time to reach maximum representative temperature (days): 163
- Duration of treatment at representative temperature (days): 114

Formation temperature immediately post-treatment:

Duration of post-treatment monitoring event 1: Jan-03 35.6

Mass of contaminant removed:

- Via liquid pumping: ___ lb ___ kg Unknown
- In vapor stream: ___ lb ___ kg Unknown
- Total: ___ lb ___ kg Unknown

Comments:

6 months post treatment monitoring and then another event at 22 months before the reductive dechlorination pilot study was performed in March 2004. Used 310 3/4" ground rods, 66 to 12 ft and 244 to 10 ft; 12 8" steel piles; 6 geoprobe electrodes (2")

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
1) Power cycled on 50 minutes and off 10 minutes to allow "re-wetting" of electrodes and to prevent area immediately around electrodes from drying out; 2) Last 2 months 23 electrodes, 5 sheet piles, 70 ground rods, and 6 geoprobe electrodes were not used because they reduce to 1 power unit; 3) 14' spacing originally then went to 7 ft using ground rods.

General comments on the thermal application:

1) 95% reduction of total chlorinated solvents in GW concentration in treatment zone; 2) Achieve 90% reduction of the total summation of chlorinated solvents in each shallow well in the treatment zone.

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment: No

- In Soil
  - Comment:

Lessons Learned

Total Energy Used: kWh, kWh/m³, kWh/yard³

Total energy applied to treatment zone: kWh/m³, kWh/yard³

Other energy: kWh/m³, kWh/yard³

Please note other energy:

Total Project Cost: $1,274,000 total

Consultant Cost: 

Thermal Vendor Cost: 

Energy Cost: m³, yard³

Other Cost 1: $50,000

Other Cost 2: 

Other Cost 3: 

Please note other cost: monitoring
General Site Information

File Analyzed By: JT PD ERH Date: 10/26/2006
Type of treatment: Conductive Steam ERH Other: 
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 
Treatment Status: Active Post 
Type of Test: Pilot Test Full Scale System 
Start of Test: 2/1/2005 End of Test: 11/1/2005 Duration: 9 months 
Type of Site: Non-DOD DoD 

Facility Name: Camlot Dry Cleaners 
Address: 
City, State, Zip Code: Fargo, ND 
OU# or Site #: 

Primary point of contact: Joyce Ackerman 
Organization: EPA 
Address: 
City, State, Zip Code: 
Phone #: 303-312-6822 email: ackerman.joyce@epa.gov 

Other contacts or vendors who worked on site None 
Point of contact: Gwen Christiansen 
Type: Vendor, Consultant Vendor, Technical Applications Other 
Organization: EPA 
Address: 
City, State, Zip Code: 
Phone #: 303-312-6463 email: 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data
Good temperature profile vs. time information Flux assessment
Groundwater elevations Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation: __________
- Alternative method for determining size of impacted zone (See source zone definition attachments): __________
- Map attachment: __________

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of wells relative to treatment zone:
  - Pre-treatment In: __________
  - Pre-treatment Upgradient: __________
  - Pre-treatment Downgradient: __________
  - Pre-treatment Crossgradient: __________
  - Post-treatment In: __________
  - Post-treatment Upgradient: __________
  - Post-treatment Downgradient: __________
  - Post-treatment Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Hexane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>=p-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>2,2-dichloroethene</td>
<td>1,2-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>n-xylene</td>
<td></td>
<td></td>
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<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
<td>1,2,2-trichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- ____________________________________________
- ____________________________________________
- ____________________________________________

**Attachments:**

- ____________________________________________
- ____________________________________________
### Hydrogeologic Conceptual Model

**Geology:**

- **Zone:**
  - **Vadose Zone:**
    - Relatively homogeneous and permeable unconsolidated sediments
    - Relatively homogeneous and impermeable unconsolidated sediments
    - Largely permeable sediments with inter-bedded lenses of lower permeability material
    - Largely impermeable sediments with inter-bedded layers of higher permeability material
    - Competent, but fractured bedrock (i.e. crystalline rock)
    - Weathered bedrock, limestone, sandstone
  - **Saturated Zone:**
    - Relatively homogeneous and permeable unconsolidated sediments
    - Relatively homogeneous and impermeable unconsolidated sediments
    - Largely permeable sediments with inter-bedded lenses of lower permeability material
    - Largely impermeable sediments with inter-bedded layers of higher permeability material
    - Competent, but fractured bedrock (i.e. crystalline rock)
    - Weathered bedrock, limestone, sandstone

**Ground surface elevation based on wells in or adjacent to treatment zone:**

- ft amsl
- Unknown

**Aquifer Characteristics:**

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): __________
  - Unknown (assume single aquifer)

#### Aquifer 1
- **Depth to water:**
  - Low value (ft bgs): __________
  - High value (ft bgs): __________
  - Unknown: __________

#### Aquifer 2
- **Flow direction:**
  - __________

#### Aquifer 3
- **Horizontal hydraulic gradient (feet/foot):**
  - __________
- **Vertical hydraulic gradient (feet/foot):**
  - __________

**K range (ft/day):**

- Measured using:
  - Slug Test
  - Laboratory
  - Field data
- Low: __________
- High: __________

**Transmissivity (ft²/day):**

- Measured using:
  - Slug Test
  - Laboratory
  - Field data
- Low: __________
- High: __________

**Conductivity - 5000 uS/cm**

**Attachments:**

- __________
- __________
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
2/1/2005
Duration: 9 months

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

Size of target zone (ft²): 10500
Thickness of target zone (ft): 56
Depth to top of target zone (ft bgs): 0
Thickness of target zone below water table (ft):
Number of energy delivery points: 56
Number of extraction points: 56

Temperature Profile:

Initial formation temperature (deg C): Unknown
Maximum representative formation temperature (deg C): Unknown
Time to reach maximum representative temperature (days): Unknown
Duration of treatment at representative temperature (days): Unknown

Date  Temperature (deg C)

Formation temperature immediately post-treatment:
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping:  
- lb  
- kg  
- Unknown

In vapor stream:  
- lb  
- kg  
- Unknown

Total: 5188

Notes:

Treated volume of 13800 yd³

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:
- In Groundwater: Total VOCs of 1 mg/L
- In Soil: PCE = 3 mg/kg

Was the Remediation Goal Achieved:
- In Groundwater: yes
- In Soil: Comment: Yes, except in 1 location that previous characterization indicated the contamination extended beyond the boundary of designated treatment area.

General comments on the thermal application:

Lessons Learned

Energy
- Total Energy Used: _______ kWh ______ kWh/m³ ______ kWh/yd³
- Total energy applied to treatment zone: 2.8 mW-hrs ______ kWh/m³ ______ kWh/yd³
- Other energy: ______ kWh/m³ ______ kWh/yd³
- Comment: Please note other energy: ________________________________

Cost
- Total Project Cost: ________________________________
- Consultant Cost: ________________________________
- Thermal Vendor Cost: ________________________________
- Energy Cost: ________________________________ m³ ______ yd³
- Other Cost 1: ________________________________
- Other Cost 2: ________________________________
- Other Cost 3: ________________________________
- Please note other cost: __ Other Cost 1: ________________________________
- __ Other Cost 2: ________________________________
- __ Other Cost 3: ________________________________
Facility ID#: 0585

Type of treatment: Conductive  Steam  ERH  Other: Hot gas
Type of Contaminant: Chlorinated Solvents  Petroleum Hydrocarbons  Pesticides  Wood Treating  Other: 
Treatment Status: Active  Post
Type of Test: Pilot Test  Full Scale System
Start of Test: 1992  End of Test: 1992  Duration: 90 hr
Type of Site: Non-DOD  DoD

Facility Name: Accutech demo
Address: ___________________________________________
City, State, Zip Code: Somerville, NJ
OU# or Site #: _________________________________________

Primary point of contact: EPA 540/AR-93?509 July 1993
Organization: _________________________________________
Address: ____________________________________________
City, State, Zip Code: _________________________________
Phone #: __________________________ email: ____________

Other contacts or vendors who worked on site: None
Point of contact: _____________________________________
Type: Vendor, Consultant  Vendor, Technical Applications  Other  __________
Organization: _________________________________________
Address: ____________________________________________
City, State, Zip Code: _________________________________
Phone #: __________________________ email: ____________

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data  Good pre- and post-treatment soil data
Good temperature profile vs. time information  Flux assessment
Groundwater elevations  Geologic cross-section
Hydraulic Conductivity information
**Impacted Zone**: Length (parallel to flow direction)(ft.): _______ Width (ft.): _______ Thickness (ft.): _______ Unknown

*Impacted zone as defined by documentation*
*Alternative method for determining size of impacted zone (See source zone definition attachments)*

**Monitor Wells**: Number of relevant monitoring wells with groundwater data: None

Number of wells relative to treatment zone:
Pre-treatment: In: _______ Upgradient: _______ Downgradient: _______ Crossgradient: _______
Post-treatment: In: _______ Upgradient: _______ Downgradient: _______ Crossgradient: _______

**Soil Borings**: Number of relevant soil borings with pre-treatment data: _______

Number of relevant soil borings with post-treatment data: _______

Number inside treatment zone: _______
Number outside treatment zone: _______

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>10 mg/L</td>
<td>None</td>
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<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethane</td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>1,1,2-trichloroethane</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,2,2-trichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>1,1,2-trichloroethane</td>
<td>mp-xylene</td>
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<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>Vinyl Chloride</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DCE</td>
<td></td>
<td></td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
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</tbody>
</table>

### Comments:

**Attachments:**
## Hydrogeologic Conceptual Model

### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>x Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>x Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>x Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>x Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

- Is more than 1 aquifer present? [ ] No [ ] Yes (number): [ ] Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>low value (ft bgs): 21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs): 25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
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<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Water Quality:

- Horizontal hydraulic gradient (feet/foot): [ ] Unknown
- Vertical hydraulic gradient (feet/foot): [ ] Unknown
- K range (ft/day): [ ] Unknown

### Site Information:

- Ground surface elevation based on wells in or adjacent to treatment zone: [ ] ft amsl [ ] Unknown
- Facility ID#: 0585
- Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Measured using:</th>
<th>K range (ft/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>Slug Test</td>
<td>[ ] Low [ ] High [ ] Unknown</td>
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<tr>
<td>Aquifer 2</td>
<td>Laboratory</td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td>Field data</td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

- 
- 

### Attachments:

- 
-
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
- Steam  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
- 1992  
- Duration: 90 hrs  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  
- Size of target zone (ft²):  
- Thickness of target zone (ft):  
- Depth to top of target zone (ft bgs):  
- Thickness of target zone below water table (ft):  
- Number of energy delivery points:  
- Number of extraction points:  

Temperature Profile:  
- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C):  
- Time to reach maximum representative temperature (days):  
- Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
- Via liquid pumping:  
- In vapor stream:  
- Total:  

Comments:  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: ______ kWh

____ kWh/m³

____ kWh/yd³

Total energy applied to treatment zone: ______ kWh/m³

____ kWh/yd³

Other energy: ______ kWh/m³

____ kWh/yd³

Please note other energy:

Cost

Total Project Cost:

Consultant Cost: ______

Thermal Vendor Cost: ______

Energy Cost: ______ m³

____ yd³

Other Cost 1:

____

Other Cost 2:

____

Other Cost 3:

____

Please note other cost:

Other Cost 1:

____

Other Cost 2:

____

Other Cost 3:
General Site Information

File Analyzed By: JT × PD ____ Date: 9/13/2006

Type of treatment: x Conductive ____ Steam ____ ERH ____ Other: ____________

Type of Contaminant: x Chlorinated Solvents x Petroleum Hydrocarbons ____ Pesticides

____ Wood Treating __ Other: ________________

Treatment Status: ____ Active __ Post

Type of Test: x Pilot Test ____ Full Scale System

Start of Test: 2001 End of Test: _____________ Duration: 100 hrs

Type of Site: ____ Non-DOD ____ DoD

______________________

__ Facility Name: Northern NJ

Address: ________________________________

City, State, Zip Code: NJ

OU# or Site #: ____________________________

______________________

__ Primary point of contact: Paper by Denis M. Conley, et al

Organization: Haley & Aldrich

Address: 200 town Centre Drive, Suite 2

City, State, Zip Code: Rochester, NY 14623

Phone #: 585-359-9000 email: dconley@haleyaldrich.com

______________________

__ Other contacts or vendors who worked on site __ None

Point of contact:

Type: ____ Vendor, Consultant ____ Vendor, Technical Applications ____ Other ________

Organization: ____________________________

Address: ________________________________

City, State, Zip Code: ______________________

Phone #: ______________________ email: ________________________________

QA/QC

______________________

__ Characteristics of Interest

____ Good pre- and post-treatment groundwater data ____ Good pre- and post-treatment soil data

____ Good temperature profile vs. time information ____ Flux assessment

____ Groundwater elevations ____ Geologic cross-section

____ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0007

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Hexane</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>Methylene chloride</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2,2-trichloroethane</td>
<td>Vinyl Chloride</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2,3-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>None</td>
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</tr>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

None

**Attachments:**

None
Hydrogeologic Conceptual Model

Facility ID#: 0587

Geology: Unconsolidated Sediments

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-beded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-beded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl  x  Unknown

Aquifer Characteristics:

Is more than 1 aquifer present?  x  No  Yes (number): ___________  ___________  ___________  Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction

Horizontal hydraulic gradient (feet/foot): ___________  ___________  ___________  x  Unknown

Vertical hydraulic gradient (feet/foot): ___________  ___________  ___________  x  Unknown

K range (ft/day) Measured using:  ____ Slug Test  ____ Laboratory  ____ Field data

<table>
<thead>
<tr>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.84</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Transmissivity (ft²/day): Measured using:  ____ Slug Test  ____ Laboratory  ____ Field data

<table>
<thead>
<tr>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Comments:

DTW had dropped to 10 feet (from 7 ft) within 24 hours of multi-phase extraction (MPE) only wells being on confining layer K=4.5(10^-6)cm/sec  Treatment Zone (upper) K=10^-3 cm/sec

Attachments: 

________________________________________________________________________

________________________________________________________________________
Thermal Treatment - Design

Thermal treatment: x Conductive

Electrical Resistance

____ 3 phase  ____ 6 phase  ____ AC power  ____ DC power

Steam

____ Steam  ____ Steam + air  ____ Steam + O2

____ Other (describe)

Type of Test: x Pilot test

____ Full-scale System

Geology of Treatment Zone:

x Relatively homogeneous and permeable unconsolidated sediments

____ Largely permeable sediments with inter-bedded lenses of lower permeability material

____ Largely impermeable sediments with inter-bedded layers of higher permeability material

____ Competent, but fractured bedrock (i.e. crystalline rock)

____ Weathered bedrock, limestone, sandstone

Treatment Target Zone:

____ Saturated only  x Vadose only  ____ Both (Saturated and Vadose zones)

Start of Thermal Test: 2001

Duration: 481 hours (~4 days)

Hydraulic Control

x Yes  ____ No

Treatment Cell Design:

Size of target zone (ft2):

481  ____ Unknown  ____ ( ____ x ____ ft)

Thickness of target zone (ft):

Unknown

Depth to top of target zone (ft bgs):

Unknown

Thickness of target zone below water table (ft):

Unknown

Number of energy delivery points:

1  ____ Unknown

Number of extraction points:

1  ____ Unknown

Temperature Profile:

Initial formation temperature (deg C):

10  ____ Unknown

Maximum representative formation temperature (deg C):

88  ____ Unknown

Time to reach maximum representative temperature (days):

1  ____ Unknown

Duration of treatment at representative temperature (days):

~3  ____ Unknown

Date  Temperature (deg C)

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping:

Unknown

In vapor stream:

Unknown

Total:

Unknown

Comments:

Spacing of 6ft on heaters and 3.5 ft from MPE Well

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater: ____________________________________________

In Soil: 1. Determine mass removal w/ MPE and thermally enhanced MPE; 2. Determine rate of energy use necessary to achieve appreciable accelerated mass removal; 3. Determine necessary hydraulic control system; 4. Determine cost benefit.

Was the Remediation Goal Achieved:

In Groundwater: ____________________________________________

Comment: ____________________________________________

In Soil: ____________________________________________

Comment: ____________________________________________

General comments on the thermal application:

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Lessons Learned

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Energy

Total Energy Used: ________________________________ kWhr kWhr/m³ kWhr/yd³

Total energy applied to treatment zone: ________________________________ kWhr/m³ kWhr/yd³

Other energy: ________________________________ kWhr/m³ kWhr/yd³

Please note other energy: ____________________________________________

Cost

Total Project Cost: ________________________________

Consultant Cost: ________________________________

Thermal Vendor Cost: ________________________________

Energy Cost: ________________________________ m³ yd³

Other Cost 1: ________________________________

Other Cost 2: ________________________________

Other Cost 3: ________________________________

Please note other cost: Other Cost 1: ________________________________

Other Cost 2: ________________________________

Other Cost 3: ________________________________
General Site Information

File Analyzed By: JT PD _______ Date: 10/30/2006
Type of treatment: ______ Conductive ______ Steam ______ ERH ______ Other: __________
Type of Contaminant: ______ Chlorinated Solvents ______ Petroleum Hydrocarbons ______ Pesticides
____ Wood Treating ________ Other: __________
Treatment Status: ______ Active ______ Post
Type of Test: ______ Pilot Test ______ Full Scale System
Start of Test: __________ End of Test: __________ Duration: __________
Type of Site: ______ Non-DOD ______ DoD

Facility Name: Paterson, NJ
Address: ______________________________
City, State, Zip Code: Paterson, NJ
OU# or Site #: ______________________________

Primary point of contact: David Fleming
Organization: TRS
Address: 7421-A Warren SE
City, State, Zip Code: Snoqualmie, WA 98065
Phone #: 425-396-4266 email: dfleming@thermals.com

Other contacts or vendors who worked on site ______ None
Point of contact: Mark Bowen
Type: x Vendor, Consultant ______ Vendor, Technical Applications ______ Other _______
Organization: Anderson Mulholland
Address: ______________________________
City, State, Zip Code: ______________________________
Phone #: 914-251-0400 x307 email: mbowen@amaconsult.com

QA/QC

____ Characteristics of Interest
____ Good pre- and post-treatment groundwater data ______ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information ______ Flux assessment
____ Groundwater elevations ______ Geologic cross-section
____ Hydraulic Conductivity information
### General Site Assessment Data

#### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Unknown

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________ Post-treatment: __________

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number inside treatment zone: __________
- Number outside treatment zone: __________

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical: Groundwater (mg/L) Soil (mg/kg)</th>
<th>Average Post-treatment Concentration per Chemical: Groundwater (mg/L) Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Cross:</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td></td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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</table>

#### Comments:

### Attachments:
### Hydrogeologic Conceptual Model

#### Facility ID#

0593

<table>
<thead>
<tr>
<th>geological zone</th>
<th>unconsolidated sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>saturated zone</th>
<th>unconsolidated sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone:

-  ft amsl
-  Unknown

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>is more than 1 aquifer present?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>depth to water (ft bgs):</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
</tr>
<tr>
<td>high</td>
</tr>
<tr>
<td>unknown</td>
</tr>
</tbody>
</table>

#### Flow direction

<table>
<thead>
<tr>
<th>horizontal hydraulic gradient (feet/foot):</th>
</tr>
</thead>
<tbody>
<tr>
<td>measured using:</td>
</tr>
<tr>
<td>Slug Test</td>
</tr>
<tr>
<td>Laboratory</td>
</tr>
<tr>
<td>Field data</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>vertical hydraulic gradient (feet/foot):</th>
</tr>
</thead>
<tbody>
<tr>
<td>measured using:</td>
</tr>
<tr>
<td>Slug Test</td>
</tr>
<tr>
<td>Laboratory</td>
</tr>
<tr>
<td>Field data</td>
</tr>
</tbody>
</table>

#### K range (ft/day)

| measured using: |
| Slug Test |
| Laboratory |
| Field data |

| transmissivity (ft2/day): |
| measured using: |
| Slug Test |
| Laboratory |
| Field data |

### Comments:

- 
- 
- 
- 

### Attachments:

- 
- 
- 
-
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>__ Conductive __</th>
<th>__ Electrical Resistance __</th>
</tr>
</thead>
<tbody>
<tr>
<td>x 3 phase</td>
<td>6 phase</td>
<td>AC power DC power Steam</td>
</tr>
<tr>
<td></td>
<td>Steam</td>
<td>__ Steam + air __ Steam + O2</td>
</tr>
<tr>
<td>Other (describe)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>__ Full-scale System __</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology of Treatment Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Treatment Target Zone: | Saturated only | Vadose only | Both (Saturated and Vadose zones) |
| Start of Thermal Test: | Date           | Duration:   |
| Hydraulic Control:    | Yes | No |

| Treatment Cell Design: | | |
| Size of target zone (ft²): | Unknown | (___ x ___ ft) |
| Thickness of target zone (ft): | Unknown |
| Depth to top of target zone (ft bgs): | Unknown |
| Thickness of target zone below water table (ft): | Unknown |
| Number of energy delivery points: | Unknown |
| Number of extraction points: | Unknown |

#### Temperature Profile:

| Initial formation temperature (deg C): | Unknown |
| Maximum representative formation temperature (deg C): | Unknown |
| Time to reach maximum representative temperature (days): | Unknown |
| Duration of treatment at representative temperature (days): | Unknown |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Formation temperature immediately post-treatment: |                     |
| Formation temperature post-treatment monitoring event 1: |                     |
| Duration of post-treatment monitoring (days): |                     |

| Mass of contaminant removed: | | |
| Via liquid pumping: | ___ lb ___ kg | Unknown |
| In vapor stream: | ___ lb ___ kg | Unknown |
| Total: | ___ lb ___ kg | Unknown |

#### Notes:

- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Performance

Remediation Goal:

- **In Groundwater:**
  - 
  -

- **In Soil:**
  - 
  -

Was the Remediation Goal Achieved:

- **In Groundwater**
  - Comment:

- **In Soil**
  - Comment:

### General comments on the thermal application:

- 
- 

### Lessons Learned

- 
- 

### Energy

**Total Energy Used:**

- **Total energy applied to treatment zone:** _______ kWh _______ kWh/m^3 _______ kWh/yd^3
- **Other energy:** _______ kWh _______ kWh/m^3 _______ kWh/yd^3

Please note other energy: ______________________________________________________

### Cost

**Total Project Cost:**

- **Consultant Cost:**
- **Thermal Vendor Cost:**
- **Energy Cost:** _______ m^3 _______ yd^3
- **Other Cost 1:**
- **Other Cost 2:**
- **Other Cost 3:**

Please note other cost: 

- **Other Cost 1:**
- **Other Cost 2:**
- **Other Cost 3:**
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th>10/30/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam</td>
<td>ERH</td>
<td>Other: RFH</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
<td>Wood Treating</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start of Test:</td>
<td>Jan-95</td>
<td>End of Test: Apr-95</td>
<td>Duration: 90 d</td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Facility Name:** Kirkland AFB

**Address:**

City, State, Zip Code: Albuquerque, NM

OU# or Site #: _______________________________

**Primary point of contact:** Guggilam Sresty

**Organization:** IIT Research Institute

**Address:** 10 W. 35th St

City, State, Zip Code: Chicago, IL 60616

Phone #: 312-567-4237 email: _______________________________

**Other contacts or vendors who worked on site:** None

Point of contact: James Phelan

**Type:** Vendor, Consultant Vendor, Technical Applications Other

**Organization:** Sandia National Laboratories

**Address:** PO Box 5800

City, State, Zip Code: Albuquerque, NM 87185-5800

Phone #: 505-845-9892 email: _______________________________

---

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0595

<table>
<thead>
<tr>
<th>Impacted Zone</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
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</thead>
</table>

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Chemical</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Hexane</td>
<td>Crossgradient</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
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<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
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<td>None</td>
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<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
<td></td>
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<td>None</td>
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<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
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<td>None</td>
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<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
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<td></td>
<td>None</td>
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**Comments:**

---

**Attachments:**

---
### Geology:  
<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>___ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>___ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>___ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>___ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>___ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>___ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Ground surface elevation based on wells in or adjacent to treatment zone: | _______ ft amsl | ______ Unknown |

### Aquifer Characteristics:  
<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>_______</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Flow direction  
| | | | |

### Horizontal hydraulic gradient (feet/foot):  
| | | | | Unknown |

### Vertical hydraulic gradient (feet/foot):  
| | | | | Unknown |

### K range (ft/day)  
<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
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</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Transmissivity (ft²/day):  
<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments:  
- ...
- ...
- ...

### Attachments:  
- ...
- ...
- ...
### Thermal Treatment - Design

**Thermal treatment:**

- [ ] Conductive
- [ ] Electrical Resistance

**Steam:**

- [ ] 3 phase
- [ ] 6 phase
- [ ] AC power
- [ ] DC power

**Other (describe):** RFH

**Type of Test:**

- [ ] Pilot test
- [x] Full-scale System

**Geology of Treatment Zone:**

- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely permeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**

- [ ] Saturated only
- [ ] Vadose only
- [ ] Both (Saturated and Vadose zones)

**Start of Thermal Test:**

- [x] Jan-95
- [ ] Duration: 90 d

**Hydraulic Control:**

- [ ] Yes
- [ ] No

**Treatment Cell Design:**

- [ ] Size of target zone (ft²):
- [ ] Thickness of target zone (ft):
- [ ] Depth to top of target zone (ft bgs):
- [ ] Thickness of target zone below water table (ft):
- [ ] Number of energy delivery points:
- [ ] Number of extraction points:

**Temperature Profile:**

- [ ] Initial formation temperature (deg C):
- [ ] Maximum representative formation temperature (deg C):
- [ ] Time to reach maximum representative temperature (days):
- [ ] Duration of treatment at representative temperature (days):

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Formation temperature immediately post-treatment:**

**Formation temperature post-treatment monitoring event 1:**

**Duration of post-treatment monitoring (days):**

**Mass of contaminant removed:**

- [ ] Via liquid pumping: ____________ lb ____________ kg ____________ Unknown
- [ ] In vapor stream: ____________ lb ____________ kg ____________ Unknown
- [ ] Total: ____________ lb ____________ kg ____________ Unknown

**Comments:**

______________

______________

_______________________

Attachments:

______________

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

In Groundwater: 

In Soil: 

Was the Remediation Goal Achieved:

In Groundwater

Comment: 

In Soil

Comment: 

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ___________ kWhr ___________ kWhr/m³ ___________ kWhr/yd³

Total energy applied to treatment zone: ___________ kWhr/m³ ___________ kWhr/yd³

Other energy: ___________ kWhr/m³ ___________ kWhr/yd³

Please note other energy: 

Cost

Total Project Cost: ___________

Consultant Cost: ___________

Thermal Vendor Cost: 

Energy Cost: ___________ m³ ___________ yd³

Other Cost 1: ___________

Other Cost 2: 

Other Cost 3: 

Please note other cost: Other Cost 1: 

Other Cost 2: 

Other Cost 3: 

Cost and Performance Facility ID#: 0595
File Analyzed By: JT x PD ____ Date: 10/19/2006
Type of treatment: ____ Conductive  ____ Steam  ____ ERH  x Other: ____________
Type of Contaminant: ____ Chlorinated Solvents  ____ Petroleum Hydrocarbons  ____ Pesticides
____ Wood Treating  x Other: SVOC's
Treatment Status:  ____ Active  x Post
Type of Test:  x Pilot Test  ____ Full Scale System
Start of Test:  Nov-94  End of Test: Jun-95  Duration: varied
Type of Site:  ____ Non-DOD  ____ DoD

Facility Name: Sandia National Lab
Address:________________________________________________________________________________________
City, State, Zip Code: Albuquerque, NM  87185
OU# or Site #: CLW

Primary point of contact: Sandia Report: SAND97-1251 UC-2010
Organization:____________________________________________________________________________________
Address:________________________________________________________________________________________
City, State, Zip Code:________________________________________________________________________________
Phone #: __________________________  email: __________________________

Other contacts or vendors who worked on site  ____ None
Point of contact:
Type:  ____ Vendor, Consultant  ____ Vendor, Technical Applications  ____ Other  ____________
Organization:____________________________________________________________________________________
Address:________________________________________________________________________________________
City, State, Zip Code:________________________________________________________________________________
Phone #: __________________________  email: __________________________

QA/QC

____ Characteristics of Interest
____ Good pre- and post-treatment groundwater data  ____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information  ____ Flux assessment
____ Groundwater elevations  ____ Geologic cross-section
____ Hydraulic Conductivity information
**General Site Assessment Data**

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________
  - Width (ft.): __________
  - Thickness (ft.): __________
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: __________
  - Pre-treatment: __________
  - Post-treatment: __________

  Number of wells relative to treatment zone:
  - Pre-treatment In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________
  - Post-treatment In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: __________
  - Number of relevant soil borings with post-treatment data: __________
  - Number inside treatment zone: __________
  - Number outside treatment zone: __________

- **Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Petroleum Hydrocarbons</th>
<th>Chlorinated Solvents</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Trimethylbenzene</td>
<td>Benzene</td>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td>1,2-dichloroethene</td>
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<td>None</td>
</tr>
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<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
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<td>None</td>
</tr>
<tr>
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<td>1,2,3-trichloroethane</td>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>Vinyl Chloride</td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
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<td>None</td>
</tr>
</tbody>
</table>

- **Comments:**

- **Attachments:**

- Facility ID#: (blank)
## Geology:

### Zone

**Vadose Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-beded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-beded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

---

## Aquifer Characteristics:

**Is more than 1 aquifer present?**
- No
- Yes (number):

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Depth to water:**
- Low value (ft bgs): 485
- High value (ft bgs): 
- Unknown:

**Flow direction:**

**Horizontal hydraulic gradient (feet/foot):**

**Vertical hydraulic gradient (feet/foot):**

**K range (ft/day):**
- Measured using:
  - Slug Test
  - Laboratory
  - Field data

- Low
- High

**Transmissivity (ft2/day):**
- Measured using:
  - Slug Test
  - Laboratory
  - Field data

- Low
- High

---

**Ground surface elevation based on wells in or adjacent to treatment zone:**

<table>
<thead>
<tr>
<th></th>
<th>ft amsl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

**Unknown**

---

**Facility ID#:** 0000

---

**Attachments:**

---

**Comments:**

---

---
Thermal Treatment - Design

Thermal treatment:

- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
- Steam
  - Steam + air
  - Steam + O2

Other (describe)

Type of Test:

- Pilot test
- Full-scale System

Geology of Treatment Zone:

- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of higher permeability material
- Relatively homogeneous and impermeable unconsolidated sediments
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone
- Largely impermeable sediments with inter-bedded layers of lower permeability material

Treatment Target Zone:

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:

- Nov-94
- Duration: 33 d

Hydraulic Control

- Yes
- No

Treatment Cell Design:

Size of target zone (ft^2):

- 720

Thickness of target zone (ft):

- 23

Depth to top of target zone (ft bgs):

- 0

Thickness of target zone below water table (ft):

- 0

Number of energy delivery points:

- 29

Number of extraction points:

- 6

Temperature Profile:

Initial formation temperature (deg C):

- 18

Maximum representative formation temperature (deg C):

- 90

Time to reach maximum representative temperature (days):

- 24

Duration of treatment at representative temperature (days):

- 9

Formation temperature immediately post-treatment:

- 85

Formation temperature post-treatment monitoring event 1:

- 55 days

Duration of post-treatment monitoring (days):

- 55 days

Mass of contaminant removed:

Via liquid pumping:

- lb

In vapor stream:

- lb

Total:

- lb

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
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<tbody>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td></td>
<td>AC power</td>
<td>DC power</td>
</tr>
<tr>
<td></td>
<td>Steam</td>
<td>Steam + air</td>
</tr>
<tr>
<td></td>
<td>Steam + O2</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
<th>Relatively homogeneous and permeable unconsolidated sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>May-95</th>
<th>Duration: 29 d</th>
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<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Hydraulic Control:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Cell Design:</th>
<th></th>
<th>720</th>
<th>Unknown</th>
<th>(16 x 45 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²):</td>
<td>720</td>
<td>Unknown</td>
<td>(16 x 45 ft)</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>23</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bg):</td>
<td>0</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>0</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>20</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>6</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
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<th>22</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
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<td></td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
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<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>22</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>9</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Formation temperature immediately post-treatment: | | 150 |
| Formation temperature post-treatment monitoring event 1: | | 55 days 80 |
| Duration of post-treatment monitoring (days): | | 55 days |

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
<td></td>
<td>lb</td>
<td>kg</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
<td>lb</td>
<td>kg</td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td>lb</td>
<td>kg</td>
</tr>
</tbody>
</table>

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

__ In Groundwater:________________________
__ In Soil:________________________

Was the Remediation Goal Achieved:

__ In Groundwater:________________________
__ In Soil:________________________

General comments on the thermal application:

____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Lessons Learned

Power Line - 45,000 kWhr
Radio Frequency - 30,000 kWhr
Price is based on the total treated area over the course of the heatings so 6000 yd3

\[ \times \] Energy

Total Energy Used: 75000 kWhr

\[ \times \] kWhr \[ \times \] kWhr/m^3 \[ \times \] kWhr/yd^3

__ Total energy applied to treatment zone:________________________
__ Other energy:________________________

\[ \times \] Please note other energy:________________________

\[ \times \] Cost

Total Project Cost: 151 /cubic yard

\[ \times \] Consultant Cost: _______________________
\[ \times \] Thermal Vendor Cost: _______________________

\[ \times \] Energy Cost: 14.87 m^3 \[ \times \] yd^3

\[ \times \] Other Cost 1: _______________________
\[ \times \] Other Cost 2: _______________________
\[ \times \] Other Cost 3: _______________________

\[ \times \] Please note other cost: _______________________
\[ \times \] Other Cost 1: _______________________
\[ \times \] Other Cost 2: _______________________
\[ \times \] Other Cost 3: _______________________
General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td>7/12/2007</td>
<td></td>
</tr>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
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<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
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<tr>
<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
</tr>
<tr>
<td>Start of Test:</td>
<td>Jan-91</td>
<td></td>
</tr>
<tr>
<td>End of Test:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
</tr>
</tbody>
</table>

Facility Name: Former AT&T Skokie Works

City, State, Zip Code: Skokie, IL

OU# or Site #: _________________________________

Primary point of contact: Dennis Sopcich

Organization: ENSR Corporation

Address: 1201 N. Grand Ave. E.

City, State, Zip Code: Springfield, IL 62794-9276

Phone #: 630-836-1700 email:Stan Komperda

Other contacts or vendors who worked on site: ____________

Point of contact: Stan Komperda

Organization: IL EPA

Address: 1201 N. Grand Ave. E.

City, State, Zip Code: Springfield, IL 62794-9276

Phone #: ____________________________ email:______________________________

QA/QC

Characteristics of Interest

____ Good pre- and post-treatment groundwater data
____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information
____ Flux assessment
____ Groundwater elevations
____ Geologic cross-section
____ Hydraulic Conductivity information
<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td></td>
<td>None</td>
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<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
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<td>None</td>
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<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
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<td>None</td>
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<td>trans,1,2-dichloroethene</td>
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<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
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<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>1,1,2-trichloroethane</td>
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<td>1,1,2,2-tetrachloroethane</td>
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<tr>
<td>Vinyl Chloride</td>
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<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Attachments:
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td></td>
</tr>
</tbody>
</table>
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  |
| Saturated Zone |  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  |

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow direction:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal hydraulic gradient (feet/foot):</td>
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<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
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<td></td>
<td>Unknown</td>
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<tr>
<td>K range (ft/day)</td>
<td>Measured using: Slug Test</td>
<td>Laboratory</td>
<td>Field data</td>
</tr>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmissivity (ft²/day):</td>
<td>Measured using: Slug Test</td>
<td>Laboratory</td>
<td>Field data</td>
</tr>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ground surface elevation based on wells in or adjacent to treatment zone:**

|  | ft amsl | Unknown |
|  |  |  |

**Comments:**

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Attachments:
## Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td></td>
<td>AC power</td>
<td>DC power</td>
</tr>
<tr>
<td></td>
<td>Steam</td>
<td>Steam + air</td>
</tr>
<tr>
<td></td>
<td>Steam + O2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology of Treatment Zone:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Thermal Test:</td>
<td>Jan-91</td>
<td>Duration:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>Unknown</th>
<th>( _ _ x _ _ ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>Unknown</td>
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</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

### Temperature Profile:

| Initial formation temperature (deg C): | Unknown |
| Maximum representative formation temperature (deg C): | Unknown |
| Time to reach maximum representative temperature (days): | Unknown |
| Duration of treatment at representative temperature (days): | Unknown |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Formation temperature immediately post-treatment: |                       |
| Formation temperature post-treatment monitoring event 1: |                       |
| Duration of post-treatment monitoring (days): |                       |

### Mass of contaminant removed:

| Via liquid pumping: | lb | kg | Unknown |
| In vapor stream:    | lb | kg | Unknown |
| Total:              | lb | kg | Unknown |

### Comments:

1st Phase - initiated 1991 and expanded in 1993. The system was closed via EPA-approval

### Attachments:

- [Attachment 1](#)
- [Attachment 2](#)
Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

___ In Groundwater: ____________________________

___ In Soil: ____________________________

Was the Remediation Goal Achieved:

___ In Groundwater

Comment: ____________________________

___ In Soil

Comment: ____________________________

General comments on the thermal application:

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

Lessons Learned

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

Energy

Total Energy Used: ___________ _______ kWhr _______ kWhr/m³ _______ kWhr/yd³

___ Total energy applied to treatment zone: ____________________________ _______ kWhr/m³ _______ kWhr/yd³

___ Other energy: ____________________________ _______ kWhr/m³ _______ kWhr/yd³

___ Please note other energy: ____________________________

Cost

Total Project Cost:

___ Consultant Cost: ____________________________

___ Thermal Vendor Cost: ____________________________

___ Energy Cost: ____________________________ _______ m³ _______ yd³

___ Other Cost 1: ____________________________

___ Other Cost 2: ____________________________

___ Other Cost 3: ____________________________

___ Please note other cost: ____________________________

___ Other Cost 1: ____________________________

___ Other Cost 2: ____________________________

___ Other Cost 3: ____________________________
General Site Information

File Analyzed By: JT PD

Date: 7/12/2007

Type of treatment: Conductive Steam ERH Other: __________

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: __________

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System


Type of Site: Non-DOD DoD

Facility Name: Former AT&T Skokie Works

City, State, Zip Code: Skokie, IL

OU# or Site #: __________

Primary point of contact: Dennis Sopcich

Organization: ENSR Corporation

Address: 1201 N. Grand Ave. E.

City, State, Zip Code: Springfield, IL 62794-9276

Phone #: 630-836-1700 email: ________________________________

Other contacts or vendors who worked on site None

Point of contact: Stan Komperda

Type: Vendor, Consultant Vendor, Technical Applications Other

Organization: IL EPA

Address: 1201 N. Grand Ave. E.

City, State, Zip Code: Springfield, IL 62794-9276

Phone #: ________________________________ email: ________________________________

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data

Good temperature profile vs. time information Flux assessment

Groundwater elevations Geologic cross-section

Hydraulic Conductivity information
### General Site Assessment Data

#### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

- Impacted zone as defined by documentation: Unknown
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: None

- Number of wells relative to treatment zone:
  - Pre-treatment In: __________ Upgradient: __________ Downgradient: __________ Crossgradient: __________
  - Post-treatment In: __________ Upgradient: __________ Downgradient: __________ Crossgradient: __________

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Creosote</td>
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<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>m+p-xylene</td>
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<tr>
<td>Vinyl Chloride</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:

Data from the 1st ERH - system. The system was shutdown in December 1998 to January 1999 to expand the system. The whole system was also down almost the whole month of October.

#### Attachments:

---

---

---

---
## Hydrogeologic Conceptual Model

### Geology: Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Saturated Zone:</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weathered bedrock, limestone, sandstone</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone:

- 2 ft amsl
- Unknown

### Aquifer Characteristics:

- Is more than 1 aquifer present? No
- Yes (number): Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Flow direction

- Horizontal hydraulic gradient (feet/foot): Unknown
- Vertical hydraulic gradient (feet/foot): Unknown

- K range (ft/day)
  - Measured using: Slug Test, Laboratory, Field data
  - low | Slug Test | Laboratory | Field data | Unknown
  - high | Slug Test | Laboratory | Field data | Unknown

- Transmissivity (ft²/day)
  - Measured using: Slug Test, Laboratory, Field data
  - low | Slug Test | Laboratory | Field data | Unknown
  - high | Slug Test | Laboratory | Field data | Unknown

### Comments:

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________

### Attachments:
<table>
<thead>
<tr>
<th>Facility ID#: 0611</th>
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</thead>
</table>

**Thermal Treatment - Design**

- **Thermal treatment:** [ ] Conductive  [ ] Electrical Resistance
- **Type of Test:** [ ] Pilot test  [x] Full-scale System
- **Geology of Treatment Zone:**
  - [ ] Relatively homogeneous and permeable unconsolidated sediments
  - [x] Relatively homogeneous and impermeable unconsolidated sediments
  - [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
  - [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
  - [ ] Competent, but fractured bedrock (i.e. crystalline rock)
  - [ ] Weathered bedrock, limestone, sandstone
- **Treatment Target Zone:**
  - [ ] Saturated only
  - [ ] Vadose only
  - [ ] Both (Saturated and Vadose zones)
- **Start of Thermal Test:** 6/4/1998  
  **Duration:** 8 months
  **Hydraulic Control:** [ ] Yes  [ ] No

**Treatment Cell Design:**

- **Size of target zone (ft2):** __Unknown__
- **Thickness of target zone (ft):** __Unknown__
- **Depth to top of target zone (ft bgs):** __Unknown__
- **Thickness of target zone below water table (ft):** __Unknown__
- **Number of energy delivery points:** __Unknown__
- **Number of extraction points:** __Unknown__

**Temperature Profile:**

- **Initial formation temperature (deg C):** __Unknown__
- **Maximum representative formation temperature (deg C):** __Unknown__
- **Time to reach maximum representative temperature (days):** __Unknown__
- **Duration of treatment at representative temperature (days):** __Unknown__

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Formation temperature immediately post-treatment:** __Unknown__
- **Formation temperature post-treatment monitoring event 1:** __Unknown__
- **Duration of post-treatment monitoring (days):** __Unknown__

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Method</th>
<th>Mass</th>
<th>Conversion (lb)</th>
<th>Conversion (kg)</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>Unknown</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td>27202</td>
<td>x</td>
<td>kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>66850</td>
<td>x</td>
<td>kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Comments:**

ERH by Battelle began in June of 1998 and expanded in 12/98 &1/99 and operated until April 1999

**Attachments:**

[ ]

[ ]
Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### General comments on the thermal application:

Site was closed after reaching the RBTCLs via IL EPA approval.

### Lessons Learned

### Energy

- **Total Energy Used:**
  - 1 kWh
  - 1 kWh/m³
  - 1 kWh/yd³

- **Total energy applied to treatment zone:**
  - 1 kWh/m²
  - 1 kWh/yd³

- **Other energy:**
  - 1 kWh/m³
  - 1 kWh/yd³

Please note other energy:

### Cost

- **Total Project Cost:**
  - 1

- **Consultant Cost:**
  - 1

- **Thermal Vendor Cost:**
  - 1

- **Energy Cost:**
  - 1 m³
  - 1 yd³

- **Other Cost 1:**
  - 1

- **Other Cost 2:**
  - 1

- **Other Cost 3:**
  - 1

Please note other cost:

- **Other Cost 1:**
  - 1

- **Other Cost 2:**
  - 1

- **Other Cost 3:**
  - 1
General Site Information

File Analyzed By: JT x PD ______ Date: 4/5/2005
Type of treatment: x Conductive ___ Steam ___ ERH ___ Other: ____________
Type of Contaminant: ___ Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides
___ Wood Treating ___ Other: PCBs
Treatment Status: ___ Active x Post
Type of Test: ___ Pilot Test x Full Scale System
Start of Test: Jan-96 End of Test: Mar-96 Duration: ~36 hours
Type of Site: ___ Non-DOD ___ DoD

Facility Name: South Glens Falls Dragstrip
Address: Route 9
City, State, Zip Code: Moreau, Saratoga County, New York
OU# or Site #: _______________________________________________________________________

Primary point of contact: RT Environmental Engineering
Organization: _______________________________________________________________________
Address: 215 W. Church Rd
City, State, Zip Code: King of Prussia, PA 19406
Phone #: ____________________ email: ________________________________________________

Other contacts or vendors who worked on site            ___ None
Point of contact: Ralph Baker
Type: x Vendor, Consultant ___ Vendor, Technical Applications ___ Other ____________
Organization: TerraTherm
Address: 10 Stevens Road
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: rbaker@terratherm.com

QA/QC

Characteristics of Interest
___ Good pre- and post-treatment groundwater data     x Good pre- and post-treatment soil data
x Good temperature profile vs. time information       ___ Flux assessment
___ Groundwater elevations                             ___ Geologic cross-section
___ Hydraulic Conductivity information
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td></td>
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<td></td>
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<td>None</td>
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<tr>
<td>trans,1,2-dichloroethene</td>
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<td></td>
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<td>None</td>
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<tr>
<td>1,1-dichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
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</tr>
<tr>
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<td>None</td>
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<td></td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
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<td></td>
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<td>None</td>
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<tr>
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<tr>
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<td></td>
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<td>None</td>
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<tr>
<td>1,2-dichloroethane</td>
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<td></td>
<td></td>
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</tr>
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<td></td>
<td></td>
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<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- None

### Attachments:

- None
### Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td>Relative homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relative homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone:
- [ ] Unknown ft amsl
- [ ] 28 ft amsl

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Depth to water:
  - Low value (ft bgs): 22 ft
  - High value (ft bgs): 24 ft
  - Unknown:

- Flow direction:

- Horizontal hydraulic gradient (feet/foot):
- Vertical hydraulic gradient (feet/foot):

- K range (ft/day):
  - Measured using: Slug Test, Laboratory, Field data
  - Low:
  - High:

- Transmissivity (ft²/day):
  - Measured using: Slug Test, Laboratory, Field data
  - Low:
  - High:

### Comments:

### Attachments:
The good temperature profile data are found in the ES&T article, Iben et al. 1996, Vol. 30 No. 11, pp. 3144-3154, Fig. 3 a,b.
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID: 0620</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td></td>
</tr>
<tr>
<td>x  Conductive</td>
<td>x</td>
</tr>
<tr>
<td>x  Thermal Blankets</td>
<td></td>
</tr>
<tr>
<td>x  Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td>x  3 phase</td>
<td></td>
</tr>
<tr>
<td>x  6 phase</td>
<td></td>
</tr>
<tr>
<td>x  AC power</td>
<td></td>
</tr>
<tr>
<td>x  DC power</td>
<td></td>
</tr>
<tr>
<td>x  Steam</td>
<td></td>
</tr>
<tr>
<td>x  6 phase AC power</td>
<td></td>
</tr>
<tr>
<td>x  3 phase DC power</td>
<td></td>
</tr>
<tr>
<td>x  Steam + air</td>
<td></td>
</tr>
<tr>
<td>x  Steam + O2</td>
<td></td>
</tr>
<tr>
<td>x  Other (describe)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>x  Pilot test</th>
<th>x  Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology of Treatment Zone:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x  Relatively homogeneous and permeable unconsolidated sediments</td>
<td>x  Largely permeable sediments with inter-bedded layers of lower permeability material</td>
<td>x  Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>x  Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x  Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x  Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x  Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>x  Vadose only</th>
<th>x  Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Thermal Test:</td>
<td>Jan-96</td>
<td>Duration: 36 hours</td>
<td></td>
</tr>
<tr>
<td>Hydraulic Control:</td>
<td>x  Yes</td>
<td>x  No</td>
<td></td>
</tr>
</tbody>
</table>

| Treatment Cell Design: |                   |
| Size of target zone (ft²): | 4800 | Unknown ( 20 x 40 ft) |
| Thickness of target zone (ft): | 1 | Unknown |
| Depth to top of target zone (ft bgs): | 0 | Unknown |
| Thickness of target zone below water table (ft): | 0 | Unknown |
| Number of energy delivery points: | 6 | Unknown |
| Number of extraction points: | N/A | Unknown |

| Temperature Profile: |                   |
| Initial formation temperature (deg C): | Unknown |
| Maximum representative formation temperature (deg C): | 220 | Unknown |
| Time to reach maximum representative temperature (days): | 1 | Unknown |
| Duration of treatment at representative temperature (days): | >1 | Unknown |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Formation temperature immediately post-treatment:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Formation temperature post-treatment monitoring event 1:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
</tr>
</tbody>
</table>

| Mass of contaminant removed: |                   |
| Via liquid pumping: |                       |
| In vapor stream: | 60.2 lb  x  kg | Unknown |
| Total: |                       |

| Comments: |                   |
| 6 treatment cells: | 1A - 35 hours (1/29/96 to 1/31/96); 1B - 26 hours (1/31/96-2/2/96); 2A - 29 hours (2/4/96 - 2/5/96); 2B - 34 hours (2/5/96 - 2/7/96); 3A - 36 hours (2/8/96 - 2/9/96); 3B - 39 hours (2/8/96 - 2/10/96) | Estimated & report amounts removed total |

<table>
<thead>
<tr>
<th>Attachments:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.</td>
<td></td>
</tr>
</tbody>
</table>
Remediation Goal:

- In Groundwater: Show effectiveness of ISTD in surface soils on PCBs and show no impact on human health
- In Soil: Show effectiveness of ISTD in surface soils on PCBs and show no impact on human health

Was the Remediation Goal Achieved:

- In Groundwater

  Comment:

- In Soil

  Comment: Yes, below 2ppm to 18 inches. No high emissions

General comments on the thermal application:


Lessons Learned


Energy

Total Energy Used: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

- Total energy applied to treatment zone: 5.5 GJ* ___________ kWh/m³ ___________ kWh/yd³
- Other energy: ___________ kWh/m³ ___________ kWh/yd³

Please note other energy: * from Iben et al. 1996 ES&T paper, Table 5.

Cost

Total Project Cost: ___________

- Consultant Cost: ___________
- Thermal Vendor Cost: ___________
- Energy Cost: ___________ m³ ___________ yd³
- Other Cost 1: ___________
- Other Cost 2: ___________
- Other Cost 3: ___________

Please note other cost: Other Cost 1: ___________

Other Cost 2: ___________

Other Cost 3: ___________
General Site Information

File Analyzed By: JT PD Date: 11/4/2006

Type of treatment: _____ Conductive _____ Steam _____ ERH _____ Other: _______________
Type of Contaminant: x Chlorinated Solvents _____ Petroleum Hydrocarbons _____ Pesticides _____ Wood Treating _____ Other: _______________
Treatment Status: _____ Active x Post
Type of Test: _____ Pilot Test x Full Scale System
Start of Test: ___________________ End of Test: ___________________ Duration: ___________
Type of Site: x Non-DOD _____ DoD

Facility Name: West Side Corporation Site

Address: __________________________________________________________
City, State, Zip Code: Jamaica, New York
OU# or Site #: ___________________________________________________

Primary point of contact: Jon Sundquist

Organization: URS

Address: Remedial Bureau E, 12th Floor, 625 Broadway
City, State, Zip Code: Albany, NY 12233-7017
Phone #: 518-402-9814 email: __________________________________________

Other contacts or vendors who worked on site: x None

Point of contact: ___________________________________________________
Type: _____ Vendor, Consultant _____ Vendor, Technical Applications _____ Other: ___________
Organization: New York Department of Environmental Conservation
Address: __________________________________________________________
City, State, Zip Code: _____________________________________________
Phone #: _______________________________________________________

QA/QC

Characteristics of Interest

_____ Good pre- and post-treatment groundwater data _____ Good pre- and post-treatment soil data
_____ Good temperature profile vs. time information _____ Flux assessment
_____ Groundwater elevations _____ Geologic cross-section
_____ Hydraulic Conductivity information
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
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<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
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<tr>
<td>Edible Oils</td>
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<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- Additional comments can be added here.

---

### Attachments:

- Additional attachments can be included here.
### Geology:

#### Zone

<table>
<thead>
<tr>
<th>Vadose Zone</th>
<th>Saturated Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
</tbody>
</table>

#### Unconsolidated Sediments

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Aquifer Characteristics:

**Is more than 1 aquifer present?**

- No
- Yes (number): ____________

**Depth to water:**

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low (ft bgs): 15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flow direction:**

- Unknown

**Horizontal hydraulic gradient (feet/foot):**

- Unknown

**Vertical hydraulic gradient (feet/foot):**

- Unknown

**K range (ft/day):**

- Measured using: Slug Test  Laboratory  Field data
- low: | |
- high: | |

**Transmissivity (ft²/day):**

- Measured using: Slug Test  Laboratory  Field data
- low: | |
- high: | |

**Ground surface elevation based on wells in or adjacent to treatment zone:** __________ ft amsl  __________ Unknown

**Comments:**

| ![Image](image3.png) |

**Attachments:**

| ![Image](image4.png) |
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td></td>
<td>AC power</td>
<td>DC power</td>
</tr>
<tr>
<td>Steam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steam + air</td>
<td>Steam + O2</td>
</tr>
<tr>
<td>Other (describe)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology of Treatment Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Thermal Test:</td>
<td></td>
<td>Duration:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydraulic Control:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Treatment Cell Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²):</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
</tr>
<tr>
<td>Number of extraction points:</td>
</tr>
</tbody>
</table>

Temperature Profile:

| Initial formation temperature (deg C): | Unknown |
| Maximum representative formation temperature (deg C): | Unknown |
| Time to reach maximum representative temperature (days): | Unknown |
| Duration of treatment at representative temperature (days): | Unknown |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Formation temperature immediately post-treatment: |  |
| Formation temperature post-treatment monitoring event 1: |  |
| Duration of post-treatment monitoring (days): |  |

Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th></th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td></td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Comments:  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Objective - Reduce the mass of contaminants in source areas as much as practicable, so that when off-site GW extraction begins there is less source contamination contributing to the plume.

Lessons Learned

General comments on the thermal application:

____________________
____________________
____________________
____________________
____________________
____________________
____________________
____________________

Cost and Performance

Remediation Goal:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

Total energy applied to treatment zone:

Other energy:

Please note other energy:

Total Energy Used:

Other energy:

Please note other energy:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Other Cost 4:

Other Cost 5:

Other Cost 6:

Other Cost 7:

Other Cost 8:

Other Cost 9:

Other Cost 10:

Objective - Reduce the mass of contaminants in source areas as much as practicable, so that when off-site GW extraction begins there is less source contamination contributing to the plume.

Lessons Learned

General comments on the thermal application:

____________________
____________________
____________________
____________________
____________________
____________________
____________________
____________________

Cost and Performance

Remediation Goal:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

Total energy applied to treatment zone:

Other energy:

Please note other energy:

Total Energy Used:

Other energy:

Please note other energy:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Other Cost 4:

Other Cost 5:

Other Cost 6:

Other Cost 7:

Other Cost 8:

Other Cost 9:

Other Cost 10:
**General Site Information**

- **File Analyzed By:** JT
- **PD**
- **Date:** 10/26/2006
- **Type of treatment:**
  - Conductive
  - Steam
  - ERH
  - Other:
- **Type of Contaminant:**
  - Chlorinated Solvents
  - Petroleum Hydrocarbons
  - Pesticides
  - Wood Treating
  - Other:
- **Treatment Status:**
  - Active
  - Post
- **Type of Test:**
  - Pilot Test
  - Full Scale System
- **Start of Test:**
- **End of Test:**
- **Duration:**
- **Type of Site:**
  - Non-DOD
  - DoD

- **Facility Name:** Former Chemical Manufacturing Facility
- **Address:**
- **City, State, Zip Code:** Brooklynn, NY
- **OU# or Site #:**

- **Primary point of contact:** Todd M. Musterait
  - **Organization:** Environmental Strategies Consulting LLC
  - **Address:** 70 Graystone Lane
  - **City, State, Zip Code:** Orchard Park, NY 14127
  - **Phone #:** 716-662-5128
  - **email:** tmusterait@esc-ny.com

- **Other contacts or vendors who worked on site:** None

  - **Point of contact:**
    - **Type:** Vendor, Consultant
    - **Vendor, Technical Applications**
    - **Other**
    - **Organization:**
    - **Address:**
    - **City, State, Zip Code:**
    - **Phone #:**
    - **email:**

**QA/QC**

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
## General Site Assessment Data

### Impacted Zone:
- Length (parallel to flow direction)(ft.): **below**
- Width (ft.): __________
- Thickness (ft.): __________
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: _None_
- Number of relevant soil borings with post-treatment data: _Unknown_
- Number of relevant soil borings with pre-treatment data: _Unknown_
- Number inside treatment zone: _Unknown_
- Number outside treatment zone: _Unknown_

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: _Unknown_

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>BTEX</td>
<td>Crossgradient</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Hexane</td>
<td>Ethylbenzene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>1,2-dichloroethene</td>
<td>m+p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>1,1,1-trichloroethane</td>
<td>1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Acetone</td>
<td>1,1,2,2-tetrachloroethane</td>
<td>phenol</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Methanol</td>
<td>Benzene</td>
<td>xylenes</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

1.6 acres - impacted

### Attachments:

---
### Hydrogeologic Conceptual Model

#### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone:  __________ ft amsl  __________ Unknown

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): __________</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Flow direction

|                                |                                |                                |                                |

#### Horizontal hydraulic gradient (feet/foot):

|                                |                                |                                |                                |

#### Vertical hydraulic gradient (feet/foot):

|                                |                                |                                |                                |

#### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft2/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

#### Attachments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment:  Conductive

Electrical Resistance

3 phase  6 phase  AC power  DC power

Steam  Pilot

Steam  Steam + air  Steam + O2

Other (describe)

Type of Test:  Pilot test

Full-scale System

Geology of Treatment Zone:

Relatively homogeneous and permeable unconsolidated sediments
Relatively homogeneous and impermeable unconsolidated sediments
Largely permeable sediments with inter-bedded lenses of lower permeability material
Largely impermeable sediments with inter-bedded layers of higher permeability material
Competent, but fractured bedrock (i.e. crystalline rock)
Weathered bedrock, limestone, sandstone

Treatment Target Zone:

Saturated only  Vadose only  Both (Saturated and Vadose zones)

Start of Thermal Test:

Duration:

Hydraulic Control  Yes  No

Treatment Cell Design:

Size of target zone (ft2):

Thickness of target zone (ft):

Depth to top of target zone (ft bgs):

Thickness of target zone below water table (ft):

Number of extraction points:

Number of energy delivery points:

Thickness of target zone (ft):

Temperature Profile:

Initial formation temperature (deg C):

Maximum representative formation temperature (deg C):

Time to reach maximum representative temperature (days):

Duration of treatment at representative temperature (days):

Date  Temperature (deg C)

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping:  lb  kg  Unknown

In vapor stream:  lb  kg  Unknown

Total:  lb  kg  Unknown

Notes:

When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

__ In Groundwater:

__ In Soil:

Was the Remediation Goal Achieved:

__ In Groundwater

Comment:

__ In Soil

Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

__ Energy

Total Energy Used: ____________ ____________ ____________ ____________ kWhr kWhr/m^3 kWhr/yd^3

__ Total energy applied to treatment zone: ____________ ____________ ____________ ____________ kWhr/m^3 kWhr/yd^3

__ Other energy: ____________ ____________ ____________ ____________ kWhr/m^3 kWhr/yd^3

Please note other energy: __________________________________________________________

__ Cost

Total Project Cost:

__ Consultant Cost: ____________

__ Thermal Vendor Cost: ____________

__ Energy Cost: ____________ m^3 ____________ yd^3

__ Other Cost 1: ____________

__ Other Cost 2: ____________

__ Other Cost 3: ____________

Please note other cost: ____________

__ Other Cost 1: ____________

__ Other Cost 2: ____________

__ Other Cost 3: ____________
General Site Information

File Analyzed By: JT x PD x ERH x ERH Date: 10/26/2006

Type of treatment: x Conductive x Steam x ERH x Other: __________

Type of Contaminant: x Chlorinated Solvents x Petroleum Hydrocarbons x Pesticides

Wood Treating x Other: __________

Treatment Status: x Active x Post

Type of Test: x Pilot Test x Full Scale System

Start of Test: Jul-04 End of Test: __________ Duration: __________

Type of Site: x Non-DOD x DoD

Facility Name: Former Chemical Manufacturing Facility

Address: __________________________________________________________________________

City, State, Zip Code: Brooklynn, NY

OU# or Site #: ______________________________________________________________________

Primary point of contact: Todd M. Musterait

Organization: Environmental Strategies Consulting LLC

Address: 70 Graystone Lane

City, State, Zip Code: Orchard Park, NY 14127

Phone #: 716-662-5128 email: tmusterait@esc-ny.com

Other contacts or vendors who worked on site: None

Point of contact: _____________________________________________________________________

Type: Vendor, Consultant Vendor, Technical Applications Other __________

Organization: ______________________________________________________________________

Address: __________________________________________________________________________

City, State, Zip Code: __________________________________________________________________

Phone #: email: _______________________________________________________________________

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): below
- Width (ft): ______
- Thickness (ft): ______
- Impacted zone as defined by documentation: ______
- Alternative method for determining size of impacted zone (See source zone definition attachments): ______
- Map attachment: ______

**Monitor Wells:**
- Number of wells relative to treatment zone:
  - Pre-treatment: ______
  - Post-treatment: ______
- Number of wells with groundwater data:
  - Pre-treatment: ______
  - Post-treatment: ______

**Soil Borings:**
- Number of soil borings with pre-treatment data:
- Number of soil borings with post-treatment data:
- Number inside treatment zone:
- Number outside treatment zone:

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
</tbody>
</table>

- **Trichloroethene (C2)**
- **Tetrachloroethene (C2)**
- **1,1-dichloroethene (C2)**
- **cis-1,2-dichloroethene (C2)**
- **trans-1,2-dichloroethene (C2)**
- **1,1-dichloroethane (C2)**
- **1,2-dichloroethlene (C2)**
- **1,1,1-trichloroethane (C3)**
- **1,2-dichloroethane (C3)**
- **Naphthalene (Naphtha)**
- **Benzene (Benzene)**
- **Toluene (Toluene)**
- **Ethylbenzene (Ethylbenzene)**
- **m/p-xylene (xylene)**
- **o-xylene (xylene)**
- **Phenol (Phenol)**
- **Xylene (Xylene)**
- **Creosote (Creosote)**
- **Acetone (Acetone)**
- **Methylene Chloride (Methylene Chloride)**

**Comments:**

1.6 acres - impacted

**Attachments:**

________________________

________________________
<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

**Vadose Zone:**

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Saturated Zone:**

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Flow direction**

<table>
<thead>
<tr>
<th></th>
<th>Unknown</th>
</tr>
</thead>
</table>

**Ground surface elevation based on wells in or adjacent to treatment zone:**

<table>
<thead>
<tr>
<th></th>
<th>ft amsl</th>
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</thead>
</table>

**Aquifer Characteristics:**

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aquifer 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Aquifer 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Aquifer 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Horizontal hydraulic gradient (feet/foot):**

| | | | Unknown |
|-------------------------------|---|---|

**Vertical hydraulic gradient (feet/foot):**

| | | | Unknown |
|-------------------------------|---|---|

**K range (ft/day):**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>measured using:</td>
<td>Slug Test</td>
<td>Laboratory</td>
<td>Field data</td>
</tr>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Transmissivity (ft²/day):**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>measured using:</td>
<td>Slug Test</td>
<td>Laboratory</td>
<td>Field data</td>
</tr>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

**Attachments:**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
Thermal Treatment - Design

Thermal treatment: [ ] Conductive [ ] Electrical Resistance

[ ] 3 phase [ ] 6 phase [ ] AC power [ ] DC power

Steam [ ] Full

[ ] Steam [ ] Steam + air [ ] Steam + O2

Other (describe)

Type of Test: [ ] Pilot test [ ] Full-scale System

Geology of Treatment Zone:
[ ] Relatively homogeneous and permeable unconsolidated sediments
[ ] Relatively homogeneous and impermeable unconsolidated sediments
[ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
[ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
[ ] Competent, but fractured bedrock (i.e. crystalline rock)
[ ] Weathered bedrock, limestone, sandstone

Treatment Target Zone: [ ] Saturated only [ ] Vadose only [ ] Both (Saturated and Vadose zones)

Start of Thermal Test: [ ] July-04 Duration: 

Hydraulic Control [ ] Yes [ ] No

Treatment Cell Design:

Size of target zone (ft2): 

Thickess of target zone (ft): 

Depth to top of target zone (ft bgs): 

Thickess of target zone below water table (ft): 

Number of energy delivery points: 47

Number of extraction points: 44

Temperature Profile:

Initial formation temperature (deg C): 

Maximum representative formation temperature (deg C): 

Time to reach maximum representative temperature (days): 

Duration of treatment at representative temperature (days): 

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days): 

Mass of contaminant removed:

Via liquid pumping: Unknown ( ___ x ___ ft)

In vapor stream: Unknown

Total: Unknown

Durations:

Start of Thermal Test:

Duration of treatment at representative temperature (days):

Duration of post-treatment monitoring (days):

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
**Performance**

Remediation Goal:

- In Groundwater: 
  - Comment:

- In Soil: 
  - Comment:

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment:

- In Soil
  - Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

**Lessons Learned**

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

**Energy**

Total Energy Used: 

- Total energy applied to treatment zone: 
  - Other energy: 
    - Please note other energy:

**Cost**

Total Project Cost: 

- Consultant Cost: 
- Thermal Vendor Cost: 
- Energy Cost: 
- Other Cost 1: 
- Other Cost 2: 
- Other Cost 3: 

- Please note other cost: 
  - Other Cost 1: 
  - Other Cost 2: 
  - Other Cost 3: 

Please note other energy:

---

Energy Cost: 

KWhr/yd³

KWhr/m³

Lessons Learned

General comments on the thermal application:

Please note other energy:
Facility Name: Niagara Falls International Airport Air Reserve
Address: 2405 Franklin Drive, Niagara Falls, NY 14304-5063
Primary point of contact: Gerald Hromowyk, 716-236-3126; email: gerald.hromowyk@niagarafalls.af.mil

Type of treatment: Conductive, Steam, ERH, Other: __________
Type of Contaminant: Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides, Wood Treating, Other: __________
Treatment Status: Active, Post
Type of Test: Pilot Test, Full Scale System
Type of Site: Non-DOD, DoD

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
**General Site Assessment Data**

<table>
<thead>
<tr>
<th>Impact zone as defined by documentation</th>
<th>Alternative method for determining size of impacted zone (See source zone definition attachments)</th>
<th>Map attachment</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Monitor Wells:</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>Number of relevant soil borings with post-treatment data:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Types of Contaminants</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td></td>
<td>1 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>None</td>
<td>0.03 mg/kg</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>MEK (2-butanone)</td>
<td></td>
<td></td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Acetone</td>
<td></td>
<td></td>
<td>None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>Chloroform</td>
<td>Carbon disulfide</td>
<td></td>
<td></td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Methylene chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Glycol Ether</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

Chloroform pre soil concentration was actually 0.001 mg/kg and chloroform and carbon disulfide post soil concentrations were 0.005 mg/kg

**Attachments:**

____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________

___________________________________

Chloroform pre soil concentration was actually 0.001 mg/kg and chloroform and carbon disulfide post soil concentrations were 0.005 mg/kg
### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Zone</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Zone</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Zone</td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Zone</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Zone</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone:
- ft amsl
- Unknown

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Depth to water:                  |    |              |                                |
| low value (ft bgs):              |    |              |                                |
| high value (ft bgs):             |    |              |                                |
| Unknown:                         |    |              |                                |

| Flow direction:                  |    |              |                                |

| Horizontal hydraulic gradient (feet/foot): |    |              |                                |
| Vertical hydraulic gradient (feet/foot):   |    |              |                                |

### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>K range (ft/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td>0.85</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Transmissivity (ft²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Field data

**Facility ID#: 0640**

**Attachments:**

- Comments:

- Transmissivity (ft²/day):

- K range (ft/day):

- Flow direction:

- Ground surface elevation based on wells in or adjacent to treatment zone:

- Depth to water:

- Horizontal hydraulic gradient (feet/foot):

- Vertical hydraulic gradient (feet/foot):

- K range (ft/day):

- Laboratory:

- Field data:

- Slug Test:

- Unknown:
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3 phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam</td>
</tr>
</tbody>
</table>

Type of Test: Pilot test

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-beded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 8/26/1996

Hydraulic Control: Yes

Treatment Cell Design:
- Size of target zone (ft2): 9560
- Thickness of target zone (ft): 9
- Depth to top of target zone (ft bgs): 1
- Thickness of target zone below water table (ft): 7.5
- Number of energy delivery points: 20
- Number of extraction points: 5

Temperature Profile:
- Initial formation temperature (deg C): 15
- Maximum representative formation temperature (deg C): 82
- Time to reach maximum representative temperature (days): 25
- Duration of treatment at representative temperature (days): 330

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/25/1996</td>
<td>75</td>
</tr>
<tr>
<td>10/15/1996</td>
<td>40</td>
</tr>
</tbody>
</table>

Mass of contaminant removed:
- Via liquid pumping: Unknown
- In vapor stream: Unknown
- Total: 643 lb 6 kg

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Objective: Reduce VOC concentrations in the saturated and unsaturated soils at site 10

Lessons Learned

General comments on the thermal application:

Energy

Total Energy Used: 336000 kWhr

x Total energy applied to treatment zone: 140000 kWhr

x Other energy: Please note other energy:

Cost

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
Type of treatment: x Conductive  ___ Steam  ___ ERH  ___ Other:  
Type of Contaminant: x Chlorinated Solvents  ___ Petroleum Hydrocarbons  ___ Pesticides  
___ Wood Treating  ___ Other:  
Treatment Status: x Active  ___ Post  
Type of Test:  ___ Pilot Test  x Full Scale System  
Start of Test:  Nov-06  
End of Test:  
Type of Site:  ___ Non-DOD  ___ DoD  
QA/QC  
Characteristics of Interest  
___ Good pre- and post-treatment groundwater data  
___ Good pre- and post-treatment soil data  
___ Good temperature profile vs. time information  
___ Flux assessment  
___ Groundwater elevations  
___ Geologic cross-section  
___ Hydraulic Conductivity information  

General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

Alternative method for determining size of impacted zone (See source zone definition attachments)

**Map attachment**

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________

Number of wells relative to treatment zone:
- Pre-treatment In: __________
- Upgradient: __________
- Downgradient: __________
- Crossgradient: __________

Number of wells relative to treatment zone:
- Post-treatment In: __________
- Upgradient: __________
- Downgradient: __________
- Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td>Trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

See IRM Work Plan and final report when it becomes available. Treating 3 source zones totalling 16,200 cubic yards, avg. depth 20 ft

**Attachments:**

Map showing 3 DNAPL treatment zones
<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- Aquifer 1
- Aquifer 2
- Aquifer 3

- Is more than 1 aquifer present? x No

- Depth to water:
  - low value (ft bgs): 1
  - high value (ft bgs): 0
  - Unknown:

- Flow direction: south

- Horizontal hydraulic gradient (feet/foot): 0.001
- Vertical hydraulic gradient (feet/foot): unknown

- K range (ft/day): measured using: x Slug Test
  - low K: 0.1
  - high K: unknown

- Transmissivity (ft²/day): measured using: Slug Test
  - low T: unknown
  - high T: unknown

- Ground surface elevation based on wells in or adjacent to treatment zone: 3 ft below grade

- Facility ID# 0645

- Comments: 

- Attachments:
Thermal Treatment - Design

Thermal treatment: x Conductive
                        Electrical Resistance
                        _______ 3 phase _______ 6 phase _______ AC power _______ DC power
                        _______ Steam _______ Steam + air _______ Steam + O2
                        _______ Other (describe)

Type of Test: x Pilot test x Full-scale System

Geology of Treatment Zone:
                        Relatively homogeneous and permeable unconsolidated sediments
                        Relatively homogeneous and impermeable unconsolidated sediments
                        Largely permeable sediments with inter-bedded lenses of lower permeability material
                        Largely impermeable sediments with inter-bedded layers of higher permeability material
                        Competent, but fractured bedrock (i.e. crystalline rock)
                        Weathered bedrock, limestone, sandstone

Treatment Target Zone:
                        ____ Saturated only
                        ____ Vadose only
                        ____ Both (Saturated and Vadose zones)

Start of Thermal Test: Nov-06 Duration: 6 months

Hydraulic Control x Yes No

Treatment Cell Design:

Size of target zone (ft²): 21870 ____________ Unknown ( _______ x _______ ft)
Thickness of target zone (ft): 12-27 ____________ Unknown
Depth to top of target zone (ft bgs): 0 ____________ Unknown
Thickness of target zone below water table (ft): 17-24 ____________ Unknown
Number of energy delivery points: 211 ____________ Unknown
Number of extraction points: 17 horizontal collectors ____________ Unknown

Temperature Profile:

Initial formation temperature (deg C): 10 ____________ Unknown
Maximum representative formation temperature (deg C): 110 ____________ Unknown
Time to reach maximum representative temperature (days): 200 ____________ Unknown
Duration of treatment at representative temperature (days): 60 ____________ Unknown

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping: ____________ lb ____________ kg ____________ Unknown
In vapor stream: ____________ lb ____________ kg ____________ Unknown
Total: ____________ lb ____________ kg ____________ Unknown

Date  Temperature (deg C)

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal: In Soil: 5,600 μg/kg for PCE; 2,800 μg/kg for TCE; 1,200 μg/kg for trans-1,1-dichloroethene; and 800 μg/kg for vinyl chloride

Was the Remediation Goal Achieved:

In Groundwater: Comment:

In Soil: Comment:

General comments on the thermal application:

Lessons Learned:

Energy
Total Energy Used: _____ kWhr _____ kWhr/m³ _____ kWhr/yd³

Total energy applied to treatment zone: _____ kWhr/m³ _____ kWhr/yd³

Other energy: _____ kWhr/m³ _____ kWhr/yd³

Please note other energy: 

Cost
Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost: _____ m³ _____ yd³

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
| Type of treatment: |  | Conductive |  |  | ERH |  | Other: |  |  |
| Type of Contaminant: |  | Chlorinated Solvents |  | Petroleum Hydrocarbons |  | Pesticides |  | Wood Treating |  | Other: |
| Treatment Status: |  | Active |  | Post |  |  |  |  |  |  |
| Type of Test: |  | Pilot Test |  | Full Scale System |  |  |  |  |  |  |
| Start of Test: |  | Jul-98 |  |  | End of Test: | Aug-99 |  | Duration: | 1 year |  |
| Type of Site: |  | Non-DOD |  | DoD |  |  |  |  |  |  |

**General Site Information**

| Facility Name: | DOE Portsmouth Gaseous Diffusion Facility |
| Address: |  |
| City, State, Zip Code: | Ohio |
| OU# or Site #: |  |

**Primary point of contact:** Sandy Childer

| Organization: | Bechtel-jacobs |
| Address: |  |
| City, State, Zip Code: |  |
| Phone #: | 740-897-2336 |
| email: | y84@bechtel.jacobs.org |

**Other contacts or vendors who worked on site:** None

| Type of contact: |  | Vendor, Consultant |  | Vendor, Technical Applications |  | Other |  |
| Organization: |  | Bechtel-Jacobs |
| Address: |  |
| City, State, Zip Code: | OH |
| Phone #: |  |  |  |
| email: |  |  |  |

**QA/QC**

**Characteristics of Interest**

- __Good pre- and post-treatment groundwater data__
- __Good pre- and post-treatment soil data__
- __Good temperature profile vs. time information__
- __Flux assessment__
- __Groundwater elevations__
- __Geologic cross-section__
- __Hydraulic Conductivity information__
**General Site Assessment Data**

**Facility ID:**

### Impacted Zone:
- **Length (parallel to flow direction)(ft.):** 2080
- **Width (ft.):**
- **Thickness (ft.):**
- **Map attachment:**
- **Alternative method for determining size of impacted zone (See source zone definition attachments)**

### Monitor Wells:
- **Number of relevant monitoring wells with groundwater data:**
  - Pre-treatment: 6
  - Post-treatment: 6
- **Number of wells relative to treatment zone:**
  - Pre-treatment: 6
  - Upgradient: None
  - Downgradient: None
  - Crossgradient: None
  - Number of relevant monitoring wells with post-treatment data:
    - Number inside treatment zone: None
    - Number outside treatment zone: None

### Soil Borings:
- **Number of relevant soil borings with pre-treatment data:**
  - Number of wells relative to treatment zone:
  - Number of relevant soil borings with post-treatment data:
  - Number inside treatment zone:
  - Number outside treatment zone:

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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<tbody>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossdrift</td>
<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
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<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m+p-xylene</td>
<td></td>
<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>1,2,2-trichloroethane</td>
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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylene</td>
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<td>Methane</td>
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<td>Other</td>
<td>Average Pre-treatment Concentration per Chemical</td>
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<td>None</td>
</tr>
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<td>1,2,2-trichloroethane</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>None</td>
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</tr>
<tr>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>Methane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Propane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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### Comments:

- None

### Attachments:

- None
# Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology: Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>□ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>□ Largely permeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>□ Largely impermeable sediments with inter-bedded layers of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>□ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>□ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>□ Largely permeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>□ Largely impermeable sediments with inter-bedded layers of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>□ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Ground surface elevation based on wells in or adjacent to treatment zone: | --------- ft amsl | □ Unknown |

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>No</td>
</tr>
<tr>
<td>Aquifer 1</td>
<td>Aquifer 2</td>
</tr>
<tr>
<td>Depth to water:</td>
<td>low value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
</tr>
<tr>
<td>Flow direction:</td>
<td>□ E</td>
</tr>
<tr>
<td>Horizontal hydraulic gradient (feet/foot):</td>
<td></td>
</tr>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td>□ Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmissivity (ft²/day):</td>
<td>Measured using:</td>
<td>Slug Test</td>
<td>Laboratory</td>
<td>Field data</td>
</tr>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

- intrinsic permeability = 5 darcy (5e-3 cm/s)

Attachments:

- [Attachment 1](#)
- [Attachment 2](#)
- [Attachment 3](#)
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power

Steam + O2  
Steam + air  
Steam + H20

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded layers of lower permeability material  
- Largely permeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- Jul-98  
- Duration:  
- 1 year

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

Size of target zone (ft²):  
- Unknown  
- (180 x 120 ft)

Thickness of target zone (ft):  
- Unknown

Depth to top of target zone (ft bgs):  
- Unknown

Thickness of target zone below water table (ft):  
- Unknown

Number of energy delivery points:  
- Unknown

Number of extraction points:  
- Unknown

Temperature Profile:

Initial formation temperature (deg C):  
- 18  
- Unknown

Maximum representative formation temperature (deg C):  
- 100  
- Unknown

Time to reach maximum representative temperature (days):  
- 112  
- Unknown

Duration of treatment at representative temperature (days):  
- Unknown

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping:

In vapor stream:

Total:

Comments:

Attachments:

---

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater:
- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater
- Comment:
- In Soil
- Comment:

General comments on the thermal application:

SteamTech (vendor) published a final report with DOE as Document no. DOE/OR/11-3032, but I could not obtain this document.

Lessons Learned

- Consultant Cost:
- Thermal Vendor Cost:
- Energy Cost:
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:

Please note other cost:

- Other Cost 1:
- Other Cost 2:
- Other Cost 3:

Energy

Total Energy Used: ____________________________ kWhr __________ kWhr/m³ __________ kWhr/yd³

- Total energy applied to treatment zone: ____________________________ kWhr/m³ __________ kWhr/yd³
- Other energy: ____________________________ kWhr/m³ __________ kWhr/yd³

Please note other energy:

Cost

Total Project Cost: 1,000,000

- Consultant Cost:
- Thermal Vendor Cost:
- Energy Cost:
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:

Please note other cost:

- Other Cost 1:
- Other Cost 2:
- Other Cost 3:
General Site Information

File Analyzed By: JT PD Date: 10/18/2006
Type of treatment: Conductive Steam ERH Other: __________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: __________
Treatment Status: Active Post __________
Type of Test: Pilot Test Full Scale System __________
Start of Test: 10/19/1998 End of Test: 11/20/1998 Duration: 42 d
Type of Site: Non-DOD DoD __________

Facility Name: Confidential Midwest
Address: ____________________________
City, State, Zip Code: Ohio
OU# or Site #: ____________________________

Primary point of contact: Mark Lyverse
Organization: ____________________________
Address: ____________________________
City, State, Zip Code: ____________________________
Phone #: ____________________________ email: ____________________________

Other contacts or vendors who worked on site: None
Point of contact: ____________________________
Type: Vendor, Consultant Vendor, Technical Applications Other __________
Organization: ____________________________
Address: ____________________________
City, State, Zip Code: ____________________________
Phone #: ____________________________ email: ____________________________

QA/QC

Characteristics of Interest

____ Good pre- and post-treatment groundwater data
____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information
____ Flux assessment
____ Groundwater elevations
____ Geologic cross-section
____ Hydraulic Conductivity information
**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
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<td></td>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethylene</td>
<td>Benzene</td>
<td></td>
<td>0.5 mg/L</td>
<td>5 mg/kg</td>
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<td>trans-1,2-dichloroethylene</td>
<td>Toluene</td>
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<td>None</td>
</tr>
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<td>1,1-dichloroethane</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

*Estimated 60,000 lbs of TCE in the soil.*

Attachments:

______________________________________________

______________________________________________

______________________________________________
### Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
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</tr>
<tr>
<td></td>
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<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
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<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Ground surface elevation based on wells in or adjacent to treatment zone: | 474 ft amsl |

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
</tr>
<tr>
<td>Depth to water:</td>
</tr>
<tr>
<td>low value (ft bgs):</td>
</tr>
<tr>
<td>high value (ft bgs):</td>
</tr>
<tr>
<td>Unknown:</td>
</tr>
</tbody>
</table>

| Flow direction | S to SE |

| Horizontal hydraulic gradient (feet/foot): | | | Unknown |
| Vertical hydraulic gradient (feet/foot): | | | Unknown |

| K range (ft/day): | Measured using: | Slug Test | Laboratory | Field data |
| low: | | | | Unknown |
| high: | | | | |
| Transmissivity (ft2/day): | Measured using: | Slug Test | Laboratory | Field data |
| low: | | | | Unknown |
| high: | | | | |

**Comments:**

**Attachments:**

---

Facility ID#: 0670
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
  - Steam
  - Steam + air
  - Steam + O2
  - Other (describe)

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 10/19/1998
- Duration: 42 d

Hydraulic Control:  
- Yes
- No

Hydraulic Cell Design:

Size of target zone (ft²):  
- Unknown

Thickness of target zone (ft):  
- 20.5
- Unknown

Depth to top of target zone (ft bgs):  
- 3.5
- Unknown

Thickness of target zone below water table (ft):  
- 19
- Unknown

Number of energy delivery points:  
- 6
- Unknown

Number of extraction points:  
- 1
- Unknown

Temperature Profile:

Initial formation temperature (deg C):  
- 23
- Unknown

Maximum representative formation temperature (deg C):  
- 95
- Unknown

Time to reach maximum representative temperature (days):  
- 15
- Unknown

Duration of treatment at representative temperature (days):  
- 27
- Unknown

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:

Via liquid pumping:  
- 265 gal
- lb
- kg
- Unknown

In vapor stream:  
- 3890 gal
- x lb
- x kg
- Unknown

Total:  
- Unknown

Date
<table>
<thead>
<tr>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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Comments:

Attachments:

Total volume heated - 1800 yd³

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater: 98% removal of benzene
- In Soil: 98% removal of benzene

Was the Remediation Goal Achieved:

- In Groundwater
- In Soil

General comments on the thermal application:

Goal to reach boiling point of water in subsurface and maintain for 60 days

Lessons Learned

Energy

Total Energy Used:

- Total energy applied to treatment zone: __________ kWhr/m^3 __________ kWhr/yd^3
- Other energy: __________ kWhr/m^3 __________ kWhr/yd^3

Please note other energy: __________________________________________

Cost

Total Project Cost:

- Consultant Cost: __________
- Thermal Vendor Cost: __________
- Energy Cost: __________ m^3 __________ yd^3
- Other Cost 1: __________
- Other Cost 2: __________
- Other Cost 3: __________

Please note other cost: __________ Other Cost 1: __________

Other Cost 2: __________

Other Cost 3: __________
**General Site Information**

- **File Analyzed By:** JT PD
- **Date:** 10/30/2006
- **Type of treatment:**
  - Conductive
  - Steam
  - ERH
  - Other:
- **Type of Contaminant:**
  - Chlorinated Solvents
  - Petroleum Hydrocarbons
  - Pesticides
  - Wood Treating
  - Other:
- **Treatment Status:**
  - Active
  - Post
- **Type of Test:**
  - Pilot Test
  - Full Scale System
- **Start of Test:** Jul-06
- **End of Test:** Nov-06
- **Duration:** 138 days
- **Type of Site:**
  - Non-DOD
  - DoD

- **Facility Name:** Bedford, OH
- **Address:**
- **City, State, Zip Code:** Bedford, OH
- **OU# or Site #:**

- **Primary point of contact:** David Fleming
  - **Organization:** TRS
  - **Address:** 7421-A Warren SE
  - **City, State, Zip Code:** Snoqualmie, WA 98065
  - **Phone #:** 425-396-4266
  - **email:** dfleming@thermalrs.com

- **Other contacts or vendors who worked on site:** None
  - **Point of contact:** Jeff Cossel
  - **Type:** Vendor, Consultant
  - **Organization:** Visconsi Company
  - **Address:**
  - **City, State, Zip Code:** Pepper Pike, IL
  - **Phone #:** 213-464-3580
  - **email:**

**QA/QC**

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
## General Site Assessment Data

### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- None
- Number of wells relative to treatment zone:
  - Pre-treatment:
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________
  - Post-treatment:
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
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<tr>
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<td>Jet Fuel</td>
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### Comments:

________________________________________________________________________

### Attachments:

________________________________________________________________________
### Hydrogeologic Conceptual Model

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<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<tr>
<td>Vadose Zone:</td>
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<tr>
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<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
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<td>Saturated Zone:</td>
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<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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<td></td>
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</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: ___________ ft amsl  ___________ Unknown

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th></th>
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</thead>
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<tr>
<td>Is more than 1 aquifer present?</td>
<td>No  Yes (number): ___________ Unknown (assume single aquifer)</td>
</tr>
<tr>
<td>Depth to water:</td>
<td>Aquifer 1  Aquifer 2  Aquifer 3</td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>___________  ___________  ___________</td>
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<tr>
<td>high value (ft bgs):</td>
<td>___________  ___________  ___________</td>
</tr>
<tr>
<td>Unknown:</td>
<td>___________  ___________  ___________</td>
</tr>
</tbody>
</table>

Flow direction: ___________

Horizontal hydraulic gradient (feet/foot): ___________  ___________  ___________  ___________  Unknown

Vertical hydraulic gradient (feet/foot): ___________  ___________  ___________  ___________  Unknown

K range (ft/day): Measured using: Slug Test  Laboratory  Field data
| low | ___________  ___________  ___________  ___________  Unknown |
| high | ___________  ___________  ___________  ___________  Unknown |

Transmissivity (ft²/day): Measured using: Slug Test  Laboratory  Field data
| low | ___________  ___________  ___________  ___________  Unknown |
| high | ___________  ___________  ___________  ___________  Unknown |

Comments: ___________________________________________________________________

Attachments: __________________________________________________________________
Thermal Treatment - Design

Thermal treatment: ___ Conductive ___ Electrical Resistance

___ 3 phase ___ 6 phase ___ AC power ___ DC power

Steam ___ Steam + air ___ Steam + O2

Other (describe)

Type of Test: ___ Pilot test ___ Full-scale System

Geology of Treatment Zone:
___ Relatively homogeneous and permeable unconsolidated sediments
___ Largely permeable sediments with inter-bedded layers of lower permeability material
___ Largely permeable sediments with inter-bedded layers of lower permeability material
___ Largely permeable sediments with inter-bedded layers of higher permeability material
___ Competent, but fractured bedrock (i.e. crystalline rock)
___ Weathered bedrock, limestone, sandstone

Treatment Target Zone: ___ Saturated only ___ Vadose only ___ Both (Saturated and Vadose zones)

Start of Thermal Test: Jul-06 Duration: 138 days

Hydraulic Control: ___ Yes ___ No

Treatment Cell Design:

Size of target zone (ft2): 5800 ___ Unknown (___ x ___ ft)

Thickness of target zone (ft): 24 ___ Unknown

Depth to top of target zone (ft bgs): 7 ___ Unknown

Thickness of target zone below water table (ft): 16 ___ Unknown

Number of energy delivery points: 10 ___ Unknown

Number of extraction points: 10 ___ Unknown

Temperature Profile:

Initial formation temperature (deg C): 15 ___ Unknown

Maximum representative formation temperature (deg C): 92 ___ Unknown

Time to reach maximum representative temperature (days): 84 ___ Unknown

Duration of treatment at representative temperature (days): 28 ___ Unknown

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping: ___ lb ___ kg ___ Unknown

In vapor stream: ___ lb ___ kg ___ Unknown

Total: 3390 ___ lb ___ kg ___ Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: Remove measurable free product
- In Soil: Reduce benzene to less than 5 mg/kg, revised to 32 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment: No measurable free product
- In Soil
  - Comment: 17 of 21 samples below 5 mg/kg and all below 32 mg/kg

General comments on the thermal application:

_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________

Lessons Learned

_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________

Energy

- Total Energy Used: _______ kWhr _______ kWhr/m³ _______ kWhr/yd³
- Total energy applied to treatment zone: 839281 kw-hrs _______ kWhr/m³ _______ kWhr/yd³
- Other energy: ___________________________ _______ kWhr/m³ _______ kWhr/yd³
  - Comment: Please note other energy: ______________________________________________________________

Cost

- Total Project Cost: __________________________
- Consultant Cost: __________________________
- Thermal Vendor Cost: ________________________
- Energy Cost: ___________________________ _______ m³ _______ yd³
- Other Cost 1: ____________________________
- Other Cost 2: ____________________________
- Other Cost 3: ____________________________
  - Please note other cost: ___________ Other Cost 1: __________________________
  - ___________ Other Cost 2: __________________________
  - ___________ Other Cost 3: __________________________
Facility Name: Confidential Midwest
Address: 
City, State, Zip Code: Midwest
OU# or Site #: 

Primary point of contact: Ralph S. Baker, Ph.D.
Organization: TerraTherm, Inc.
Address: 10 Stevens Rd.
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: rbaker@terratherm.com

Other contacts or vendors who worked on site: None
Point of contact: Michael L. Woodruff, CPG
Type: Vendor, Consultant Vendor, Technical Applications Other Oversight consultant
Organization: The Payne Firm, Inc.
Address: 11231 Cornell Park Dr.
City, State, Zip Code: Cincinnati, OH 45242
Phone #: 513-489-2255 email: mlw@paynefirm.com

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good temperature profile vs. time information
Groundwater elevations
Hydraulic Conductivity information

Good pre- and post-treatment soil data
Flux assessment
Geologic cross-section
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 240
- Width (ft.): 40
- Thickness (ft.): 13

**Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: None

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 45
- Number of relevant soil borings with post-treatment data: 14

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
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<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Hexadecane</td>
<td>Crossgradient</td>
<td>None</td>
<td>100 mg/kg</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>Hexane</td>
<td>None</td>
<td>None</td>
<td>1 mg/kg</td>
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<tr>
<td>1,1-dichloroethene</td>
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</tbody>
</table>

**Comments:**

This treatment area was known as Parking Lot Area 1.

**Attachments:**
General Site Assessment Data

Impact Zone:
- Length (parallel to flow direction) (ft.): ______________
- Width (ft.): __________________
- Thickness (ft.): __________________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

Monitor Wells:
- Number of relevant monitoring wells with groundwater data: ______________
- Pre-treatment: ______________
- Post-treatment: ______________

- Number of wells relative to treatment zone:
  - Pre-treatment: ______________
  - In: ______________
  - Upgradient: ______________
  - Downgradient: ______________
  - Crossgradient: ______________
  - Post-treatment: ______________
  - In: ______________
  - Upgradient: ______________
  - Downgradient: ______________
  - Crossgradient: ______________

Soil Borings:
- Number of relevant soil borings with pre-treatment data: ______________
- Number of relevant soil borings with post-treatment data: ______________
- Number inside treatment zone: ______________
- Number outside treatment zone: ______________

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<th>Soil (mg/kg)</th>
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<td>None</td>
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<td>None</td>
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</tr>
</tbody>
</table>

Comments:

This treatment area is known as Parking Lot Area 2.

Attachments:
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 38
- Width (ft.): 12
- Thickness (ft.): 13
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: None
  - Pre-treatment: None
  - Post-treatment: None

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 37
- Number of relevant soil borings with post-treatment data: 38
- Number inside treatment zone: 37
- Number outside treatment zone: 38

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossvit</td>
<td>None</td>
<td>1 mg/kg None</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>0.01 mg/kg None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
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<tr>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None None</td>
<td>None</td>
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<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
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<td>1,4-benzenes</td>
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<td>1,4-xylene</td>
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<td>Vinyl Chloride</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

This treatment area is known as the Former waste water basin.

**Attachments:**

---

This is a description of a site assessment related to contaminated soil and groundwater. The report details the dimensions of the impacted zone, the number of relevant monitoring wells and soil borings with pre and post-treatment data, and the types and concentrations of contaminants found. The attached map and additional source zone definition attachments provide further context for the documentation. The site is particularly noted for its treatment area, previously identified as the Former waste water basin.
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td><img src="image1.png" alt="Image" /> Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td><img src="image2.png" alt="Image" /> Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td><img src="image3.png" alt="Image" /> Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td><img src="image4.png" alt="Image" /> Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td><img src="image5.png" alt="Image" /> Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td><img src="image6.png" alt="Image" /> Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td><img src="image7.png" alt="Image" /> Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td><img src="image8.png" alt="Image" /> Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl  x Unknown

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): _____________</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>30*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Flow direction: SW

#### Horizontal hydraulic gradient (feet/foot):

#### Vertical hydraulic gradient (feet/foot): x Unknown

#### K range (ft/day):

<table>
<thead>
<tr>
<th>Measured using: Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>K range (ft/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>2.83(10^-5)</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft²/day):

<table>
<thead>
<tr>
<th>Measured using: Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Transmissivity (ft²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td>x Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

* Water was at 3 ft in a perched aquifer at Parking lot Area 1.

#### Attachments:

---

---

---
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance
  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power

- Steam
  
  - Steam  
  - Steam + air  
  - Steam + O2

- Other (describe)

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 5/19/2003  
- Duration: 195 days

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

Size of target zone (ft²): 14187  
- Unknown  
- (  x  x  ft)

Thickness of target zone (ft): 15  
- Unknown

Depth to top of target zone (ft bgs): 6  
- Unknown

Thickness of target zone below water table (ft): 6  
- Unknown

Number of energy delivery points: 168  
- Unknown

Number of extraction points: 36  
- Unknown

Temperature Profile:

Initial formation temperature (deg C): -13  
- Unknown

Maximum representative formation temperature (deg C): at least 100  
- Unknown

Time to reach maximum representative temperature (days): 150  
- Unknown

Duration of treatment at representative temperature (days): x  
- Unknown

Formation temperature immediately post-treatment:  
- Date  
- Temperature (deg C)

Formation temperature post-treatment monitoring event 1:  
- Date  
- Temperature (deg C)

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping: unknown  
- lb  
- kg  
- Unknown

In vapor stream: unknown  
- lb  
- kg  
- Unknown

Total: unknown  
- lb  
- kg  
- Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment - Design

| Facility ID# | 0685 |

Thermal treatment:  
- Conductive  
- Electrical Resistance

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 5/19/2003  
- Duration: 205 days

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

| Size of target zone (ft²): | 3115 | Unknown | (  x  x  ft²) |
| Thickness of target zone (ft): | 15 | Unknown |
| Depth to top of target zone (ft bgs): | 0 | Unknown |
| Thickness of target zone below water table (ft): | 0 | Unknown |
| Number of energy delivery points: | 16 | Unknown |
| Number of extraction points: | 5 | Unknown |

Temperature Profile:

| Initial formation temperature (deg C): | 13 | Unknown |
| Maximum representative formation temperature (deg C): | at least 100 | Unknown |
| Time to reach maximum representative temperature (days): | 70 | Unknown |
| Duration of treatment at representative temperature (days): | Unknown |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature immediately post-treatment:  
- Unknown

Formation temperature post-treatment monitoring event 1:  
- Unknown

Duration of post-treatment monitoring (days):  
- Unknown

Mass of contaminant removed:

- Via liquid pumping:  
- In vapor stream:  
- Total:  

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID#: 0685</th>
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</thead>
<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td><strong>Facility ID#:</strong> 0685</td>
</tr>
<tr>
<td>x Conductive</td>
<td>Former Waste Water Basin</td>
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<tr>
<td>Electrical Resistance</td>
<td>__________</td>
</tr>
<tr>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td>Steam</td>
<td>Steam</td>
</tr>
<tr>
<td>Other (describe)</td>
<td>__________</td>
</tr>
</tbody>
</table>

**Type of Test:**
- x Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- x Relatively homogeneous and permeable unconsolidated sediments
- x Relatively homogeneous and impermeable unconsolidated sediments
- x Largely permeable sediments with inter-bedded lenses of lower permeability material
- x Largely impermeable sediments with inter-bedded layers of higher permeability material
- x Competent, but fractured bedrock (i.e. crystalline rock)
- x Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- x Saturated only
- x Vadose only
- x Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- 5/19/2003
- Duration: 190 days

**Hydraulic Control:**
- x Yes
- No

**Treatment Cell Design:**
- x Yes
- No

**Size of target zone (ft^2):** 2899
- Thickness of target zone (ft): 15
- Depth to top of target zone (ft bgs): 0
- Thickness of target zone below water table (ft): 0
- Number of energy delivery points: 12
- Number of extraction points: 4

**Temperature Profile:**
- Initial formation temperature (deg C): -13
- Maximum representative formation temperature (deg C): atleast 100
- Time to reach maximum representative temperature (days): 135
- Duration of treatment at representative temperature (days): x

**Formation temperature immediately post-treatment:**
- Date: __________
- Temperature (deg C): __________

**Formation temperature post-treatment monitoring event 1:**
- Date: __________
- Temperature (deg C): __________

**Duration of post-treatment monitoring (days):**
- __________

**Mass of contaminant removed:**
- Via liquid pumping: __________ lb __________ kg x
- Unknown
- In vapor stream: __________ lb __________ kg x
- Unknown
- Total: __________ lb __________ kg x
- Unknown

**Comments:**
- __________

**Attachments:**
- __________

*Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.*
Cost and Performance

Remediation Goal:

- In Groundwater:

- In Soil:
  - TCE - 1.056 mg/kg; PCE - 5.94 mg/kg; 1,1,1-TCA - 28.6 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment:

- In Soil
  - Comment: yes

General comments on the thermal application:

- Lessons Learned

Energy

Total Energy Used: 3,000,000 kWhr

- Total energy applied to treatment zone:
  - kWhr/m³
  - kWhr/yd³

- Other energy:
  - kWhr/m³
  - kWhr/yd³

Please note other energy:

Cost

Total Project Cost:

- Consultant Cost:

- Thermal Vendor Cost: 1,300,000

- Energy Cost:

- Other Cost 1:

- Other Cost 2:

- Other Cost 3:

Please note other cost:

- Other Cost 1:

- Other Cost 2:

- Other Cost 3:
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<th>JT</th>
<th>PD</th>
<th>Date:</th>
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<td>Conductive</td>
<td>Steam</td>
<td>ERH</td>
<td>Other:</td>
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<td>Pesticides</td>
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<td>Wood Treating</td>
<td>Other:</td>
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<td>Pilot Test</td>
<td>Full Scale System</td>
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<td><strong>Address:</strong></td>
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<tr>
<td><strong>City, State, Zip Code:</strong></td>
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<tr>
<td><strong>OU# or Site #:</strong></td>
<td>____________________</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Primary point of contact:</strong></th>
<th>Bill Heath</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization:</strong></td>
<td>CES</td>
</tr>
<tr>
<td><strong>Address:</strong></td>
<td>419 W. Entiat St</td>
</tr>
<tr>
<td><strong>City, State, Zip Code:</strong></td>
<td>Kennewick, WA 99336</td>
</tr>
<tr>
<td><strong>Phone #:</strong></td>
<td>509-727-4276</td>
</tr>
<tr>
<td><strong>email:</strong></td>
<td><a href="mailto:bhi@cesiweb.com">bhi@cesiweb.com</a></td>
</tr>
</tbody>
</table>

| **Other contacts or vendors who worked on site:** | ____ None |
| **Point of contact:** | ____________________ |
| **Type:** | Vendor, Consultant |
| **Organization:** | Vendor, Technical Applications |
| **Address:** | ____________________ |
| **City, State, Zip Code:** | ____________________ |
| **Phone #:** | | |
| **email:** | ____________________ |

<table>
<thead>
<tr>
<th><strong>QA/QC</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristics of Interest</strong></td>
</tr>
<tr>
<td>____ Good pre- and post-treatment groundwater data</td>
</tr>
<tr>
<td>____ Good temperature profile vs. time information</td>
</tr>
<tr>
<td>____ Groundwater elevations</td>
</tr>
<tr>
<td>____ Hydraulic Conductivity information</td>
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<table>
<thead>
<tr>
<th><strong>General Site Information</strong></th>
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<tbody>
<tr>
<td><strong>File Analyzed By:</strong></td>
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<td><strong>Type of treatment:</strong></td>
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<tr>
<td>Chemicals of Concern</td>
</tr>
<tr>
<td>------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
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<tr>
<td>1,1,2,2-tetrachloroethene</td>
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<tr>
<td>Vinyl Chloride</td>
</tr>
</tbody>
</table>

Comments:

Attachments:
### Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
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<tr>
<td>Saturated Zone:</td>
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<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl  
  Unknown

-- Aquifer Characteristics: 

- Is more than 1 aquifer present?  
<table>
<thead>
<tr>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Flow direction

- Horizontal hydraulic gradient (feet/foot):  
  __________  
  Unknown

- Vertical hydraulic gradient (feet/foot):  
  __________  
  Unknown

- K range (ft/day):  
  Measured using: Slug Test  Laboratory  Field data  
  low  |  |  |  
  high  |  |  |  

- Transmissivity (ft2/day):  
  Measured using: Slug Test  Laboratory  Field data  
  low  |  |  |  
  high  |  |  |  

- Comments:  

- Attachments: 

Thermal Treatment - Design

Thermal treatment: 

- Conductive
- Electrical Resistance

- 3 phase
- 6 phase
- AC power
- DC power

Steam

- Steam
- Steam + air
- Steam + O2

Other (describe)

Type of Test: 

- Pilot test
- Full-scale System

Geology of Treatment Zone: 

- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone: 

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 

Duration: 

Hydraulic Control: 

- Yes
- No

Treatment Cell Design:

Size of target zone (ft²): 

Thickness of target zone (ft): 

Depth to top of target zone (ft bgs): 

Thickness of target zone below water table (ft): 

Number of energy delivery points: 

Number of extraction points: 

Temperature Profile:

Initial formation temperature (deg C): 

Maximum representative formation temperature (deg C): 

Time to reach maximum representative temperature (days): 

Duration of treatment at representative temperature (days): 

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1: 

Duration of post-treatment monitoring (days): 

Mass of contaminant removed:

- Via liquid pumping: ____________ lb ____________ kg Unknown
- In vapor stream: ____________ lb ____________ kg Unknown
- Total: ____________ lb ____________ kg Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Facility ID#: 0690

### Performance

Remediation Goal:

- **In Groundwater:**
- **In Soil:**

Was the Remediation Goal Achieved:

- **In Groundwater**
- **In Soil**

General comments on the thermal application:

### Energy

Total Energy Used: ____________ kWh ____________ kWh/m³ ____________ kWh/yd³

- Total energy applied to treatment zone: ____________ kWh/m³ ____________ kWh/yd³
- Other energy: ____________ kWh/m³ ____________ kWh/yd³
  - Please note other energy: ________________________

### Cost

Total Project Cost: ________________________

- Consultant Cost: ________________________
- Thermal Vendor Cost: ________________________
- Energy Cost: ____________ m³ ____________ yd³
- Other Cost 1: ________________________
- Other Cost 2: ________________________
- Other Cost 3: ________________________
  - Please note other cost: ________________________
    - Other Cost 1: ________________________
    - Other Cost 2: ________________________
    - Other Cost 3: ________________________
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT PD ERH</th>
<th>Date:</th>
<th>9/13/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive Steam ERH Other:</td>
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<td></td>
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<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents Petroleum Hydrocarbons Pesticides Other:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test Full Scale System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start of Test:</td>
<td>5/7/1998</td>
<td>End of Test: Sep-98</td>
<td>120 days</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD DoD</td>
<td></td>
<td></td>
</tr>
</tbody>
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- **Facility Name:** Former Shell Bulk Fuel Terminal
- **Address:** 245 Jackson St.
- **City, State, Zip Code:** Eugene, OR
- **OU# or Site #:** State of Oregon LUST #20-94-4004; ECSI#1566

- **Primary point of contact:** Ralph Baker
  - **Organization:** TerraTherm
  - **Address:** 10 Stevens Road
  - **City, State, Zip Code:** Fitchburg, MA 01420
  - **Phone #:** 978-343-0300
  - **email:** rbaker@terratherm.com

- **Other contacts or vendors who worked on site:** None
  - **Point of contact:** Denis Conley
    - **Type:** Vendor, Consultant Vendor, Technical Applications Other
    - **Organization:** Haley and Aldrich
    - **Address:** 200 Town Centre Dr
    - **City, State, Zip Code:** Rochester, NY 14623
    - **Phone #:** 585-321-4245
    - **email:** dconley@haleyaldrich.com

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Hydraulic Conductivity information
  - Geologic cross-section
### General Site Assessment Data

**Facility ID:**

### Impacted Zone:
- **Length (parallel to flow direction)(ft.):** 125
- **Width (ft.):** 300
- **Thickness (ft.):** Unknown

- **Impacted zone as defined by documentation**
- **Alternative method for determining size of impacted zone (See source zone definition attachments)**
- **Map attachment**

### Monitor Wells:
- **Number of relevant monitoring wells with groundwater data:** None

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of wells relative to treatment zone:</td>
<td></td>
</tr>
<tr>
<td>Pre-treatment</td>
<td>In: 1/4</td>
</tr>
<tr>
<td>Post-treatment</td>
<td>In: 2</td>
</tr>
</tbody>
</table>

### Soil Borings:
- **Number of relevant soil borings with pre-treatment data:** 48
- **Number of relevant soil borings with post-treatment data:** 46

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Benzene</td>
<td>Other</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>0.1 mg/L</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>0.1 mg/L</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>MTBE</td>
<td></td>
<td>0.1 mg/L</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
<td>xylenes (total)</td>
<td></td>
<td>0.1 mg/L</td>
<td>10 mg/kg</td>
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### Types of Contaminants

- **Facility ID#:** 0700

### Comments:

- None

### Attachments:

- None
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<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td>☐</td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td>☐</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>☐</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td>☐</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td>☐</td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td>☐</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>☐</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- **Geology:**
  - **Vadose Zone:**
    - Relatively homogeneous and permeable unconsolidated sediments
    - Relatively homogeneous and impermeable unconsolidated sediments
    - Largely permeable sediments with inter-bedded lenses of lower permeability material
    - Largely impermeable sediments with inter-bedded layers of higher permeability material
    - Competent, but fractured bedrock (i.e. crystalline rock)
    - Weathered bedrock, limestone, sandstone

- **Saturated Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Facility ID#:** 0700

- **Ground surface elevation based on wells in or adjacent to treatment zone:** 417 ft amsl

- **Aquifer Characteristics:**
  - **Is more than 1 aquifer present?**
    - No
    - ☐ Yes (number): 2
  - **Depth to water:**
    - Low value (ft bgs): 2
    - High value (ft bgs): 10
    - Unknown: 18
  - **Flow direction:**
  - **Horizontal hydraulic gradient (feet/foot):**
  - **Vertical hydraulic gradient (feet/foot):**
  - **K range (ft/day):**
    - Measured using: Sprinkler Test
    - Low: 0.03
    - High: 0.001
  - **Transmissivity (ft²/day):**
    - Measured using: Sprinkler Test
    - Low: 14
    - High: 14

- **Comments:**
  - Permeability: 1 to 10 millidarcy
  - Second water bearing unit - 5000 md

- **Attachments:**
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  
  - Steam  
  - Steam + air  
  - Steam + O2  
  - Other (describe)  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded layers of lower permeability material  
- Largely impermeable sediments with inter-bedded lenses of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
5/7/1998  
Duration: 120 days  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  
Size of target zone (ft²):  
75000  
Unknown  
( ___ x ___ ft)  
Thick of target zone (ft):  
11.5  
Unknown  
Depth to top of target zone (ft bgs):  
0  
Unknown  
Thickness of target zone below water table (ft):  
0  
Unknown  
Number of energy delivery points:  
761  
Unknown  
Number of extraction points:  
277  
Unknown  

Temperature Profile:  
Initial formation temperature (deg C):  
x  
Unknown  
Maximum representative formation temperature (deg C):  
x  
Unknown  
Time to reach maximum representative temperature (days):  
x  
Unknown  
Duration of treatment at representative temperature (days):  
x  
Unknown  

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
Via liquid pumping:  
Unknown  
In vapor stream:  
Unknown  
Total:  
1.218 x 10^5  
Unknown  

Comments:  
dewatered zone during treatment and removed a total of 61,345 tons  
Spacing on 7.5 ft centers  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater:
  - DEQ Tier 1 risk-based concentrations for all groundwater exposure paths

- In Soil:
  - DEQ Tier 1 risk-based concentrations

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment: yes

- In Soil
  - Comment: yes

General comments on the thermal application:

_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

Lessons Learned

_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

Energy

Total Energy Used: ________________ kWhr ______________ kWhr/m$^3$ ______________ kWhr/yd$^3$

- Total energy applied to treatment zone: ________________ kWhr/m$^3$ ______________ kWhr/yd$^3$

- Other energy: ________________ kWhr/m$^3$ ______________ kWhr/yd$^3$
  - Please note other energy: ________________________________________________________________________

Cost

Total Project Cost: ________________

- Consultant Cost: ________________

- Thermal Vendor Cost: ________________

- Energy Cost: ________________ _ m$^3$ ______________ _ yd$^3$

- Other Cost 1: ________________

- Other Cost 2: ________________

- Other Cost 3: ________________
  - Please note other cost: ________________ Other Cost 1: ________________
    - Other Cost 2: ________________
    - Other Cost 3: ________________
<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td></td>
<td></td>
<td>Conductive</td>
<td>Steam</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td></td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
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<td></td>
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<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
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<td></td>
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<tr>
<td>Start of Test:</td>
<td>5/8/2000</td>
<td>End of Test: 11/14/2001</td>
<td>Duration:</td>
<td>17 months</td>
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<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
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<thead>
<tr>
<th>Facility Name:</th>
<th>ICN Pharmaceutical</th>
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<tr>
<td>City, State, Zip Code:</td>
<td>Portland, OR</td>
<td></td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Primary point of contact: | Chuck Esler | |
| Organization: | AMEC | |
| Address: | | |
| City, State, Zip Code: | | |
| Phone #: | 503-639-3400 | email: charles.esler@amec.com | |
| Other contacts or vendors who worked on site | None | |

| Other point of contact: | Jennifer Sutter | |
| Organization: | DEQ Northwest Region | |
| Address: | 2020 SW 4th Ave., Suite 400 | |
| City, State, Zip Code: | Portland, OR 97201 | |
| Phone #: | 503-229-6148 | email: sutter.jennifer@deq.state.or.us | |

**QA/QC**

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Good pre- and post-treatment groundwater data</td>
<td></td>
</tr>
<tr>
<td>Good pre- and post-treatment soil data</td>
<td></td>
</tr>
<tr>
<td>Good temperature profile vs. time information</td>
<td>Flux assessment</td>
</tr>
<tr>
<td>Groundwater elevations</td>
<td>Geologic cross-section</td>
</tr>
<tr>
<td>Hydraulic Conductivity information</td>
<td></td>
</tr>
</tbody>
</table>
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation: __________
- Alternative method for determining size of impacted zone (See source zone definition attachments): __________
- Map attachment: __________

Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Post-treatment: __________
- Number of wells relative to treatment zone:
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossgradient</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>None</td>
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<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
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<td>m/p-xylene</td>
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<td>1,2-xylene</td>
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<td>None</td>
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<td>Trifluoroethylene</td>
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<td>1,2-dichloroethane</td>
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<td>None</td>
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<tr>
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<td>1,1,1-trichloroethane</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Source zone is 120 ft by 80 ft down to 56 ft for a total of between 48,000 to 65,000 yd³

Attachments:

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________
### Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded layers of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded layers of lower permeability material</td>
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</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- **Geology:**
  - Wind: **X**
  - Relative humidity: **X**
  - Temperature: **X**

- **Ground surface elevation based on wells in or adjacent to treatment zone:**
  - **__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ 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Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 5/8/2000
- Duration: 17 months

Hydraulic Control  
- Yes
- No

Treatment Cell Design:  
- Size of target zone (ft²): 20000
- Thickness of target zone (ft): 38
- Depth to top of target zone (ft bgs): 20
- Thickness of target zone below water table (ft): 38
- Number of energy delivery points: 73
- Number of extraction points: 51

Temperature Profile:  
- Initial formation temperature (deg C): x Unknown
- Maximum representative formation temperature (deg C): x Unknown
- Time to reach maximum representative temperature (days): x Unknown
- Duration of treatment at representative temperature (days): x Unknown

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):

Mass of contaminant removed:  
- Via liquid pumping: 
  - lb: x Unknown
  - kg: x Unknown
- In vapor stream: 
  - lb: x Unknown
  - kg: x Unknown
- Total: 
  - lb: x Unknown
  - kg: x Unknown

Comments:  
17.5 ft well spacing and 15 ft vapor extraction well spacing for a total volume treated of 29,600 yd³.  
96 gallons of DNAPL removed.

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:
____ In Groundwater:

____ In Soil:

Lessons Learned

General comments on the thermal application:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Other energy:

Please note other energy:

Total energy applied to treatment zone:

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
**General Site Information**

- **File Analyzed By:** JT PD ERH
- **Type of treatment:** Conductive Steam ERH Other: __________
- **Type of Contaminant:** Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: coal tar
- **Treatment Status:** Active Post
- **Type of Test:** Pilot Test Full Scale System
- **Start of Test:** 11/9/1994 End of Test: 6/7/1996 Duration: 667 days
- **Type of Site:** Non-DOD DoD

**Facility Name:** Brodhead Creek Superfund Site

**City, State, Zip Code:** Stroudsburg, PA

**Primary point of contact:** SITE doc: EPA/540/R-00/500 March 2000

**Organization:**

**City, State, Zip Code:**

**Phone #:**

**email:**

**QA/QC**

**Characteristics of Interest**

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction) (ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________

- Pre-treatment: __________
- Post-treatment: __________

- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment: __________
  - Post-treatment: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: 9-Sep
- Number outside treatment zone: 4-Apr

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
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<td></td>
<td></td>
<td></td>
<td>Soil (mg/kg)</td>
<td>Soil (mg/kg)</td>
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<td>Pre-treatment</td>
<td>Post-treatment</td>
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<td></td>
<td>Groundwater</td>
<td>Soil</td>
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</tbody>
</table>

**Comments:**

- TRPH mg/kg: pre = 1830 post = 1670

**Attachments:**

- None
### Hydrogeologic Conceptual Model

**Geology:**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

**Ground surface elevation based on wells in or adjacent to treatment zone:** 376 ft amsl

**Aquifer Characteristics:**

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depth to water:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgsl):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgsl):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flow direction:** E

**Horizontal hydraulic gradient (feet/foot):** 0.005

**Vertical hydraulic gradient (feet/foot):**

**K range (ft/day):**

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Transmissivity (ft²/day):**

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
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</tbody>
</table>

**K range (ft/day):**

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
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</tr>
</tbody>
</table>

**Porosity:** n=0.3

**K range:** 100 to 150 Darcies

**Attachments:**

---

---
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  

Steam:  
- CROW  
- Steam  
- Steam + air  
- Steam + O2  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
- 11/9/1994  
- Duration: 567 d  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  

<table>
<thead>
<tr>
<th>Size of target zone (ft²)</th>
<th>1500</th>
<th>Unknown</th>
<th>40 x 80 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft)</td>
<td>Unknown</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs)</td>
<td>Unknown</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft)</td>
<td>Unknown</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points</td>
<td>6</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points</td>
<td>2</td>
<td>Unknown</td>
<td></td>
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</tbody>
</table>

Temperature Profile:  

| Initial formation temperature (deg C) | 20 | Unknown |
| Maximum representative formation temperature (deg C) | 70 | Unknown |
| Time to reach maximum representative temperature (days) | 461 | Unknown |
| Duration of treatment at representative temperature (days) | 1 | Unknown |

Attachment:  

<table>
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<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
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</table>

Mass of contaminant removed:  

<table>
<thead>
<tr>
<th>Via liquid pumping</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total</td>
<td>1504 gal</td>
</tr>
</tbody>
</table>

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.


Cost and Performance

Remediation Goal:

In Groundwater: ____________________________________________________________
In Soil: ________________________________________________________________

Was the Remediation Goal Achieved:

In Groundwater

Comment: ______________________________________________________________

In Soil

Comment: ______________________________________________________________

General comments on the thermal application:

Pore volumes flushed = 25.5 (at $85000/pore volume) the Pore volume size is 455,000 gallons

Lessons Learned

__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________
__________________________________________________________

Energy

Total Energy Used: _______ kWhr _______ kWhr/m^3 _______ kWhr/yd^3

Total energy applied to treatment zone: _______ kWhr/m^3 _______ kWhr/yd^3

Other energy: _______ kWhr/m^3 _______ kWhr/yd^3

Please note other energy:

Cost

Total Project Cost: 2168000

Consultant Cost: ____________________
Thermal Vendor Cost: ____________________

Energy Cost: 60000 m^3 _______ yd^3

Other Cost 1: ____________________
Other Cost 2: ____________________
Other Cost 3: ____________________

Please note other cost:

Other Cost 1: ____________________
Other Cost 2: ____________________
Other Cost 3: ____________________
General Site Information

File Analyzed By: JT PD  Date: 10/26/2006
Type of treatment: x Conductive  x Steam  ___ ERH  ___ Other: __________
Type of Contaminant: x Chlorinated Solvents  ___ Petroleum Hydrocarbons  ___ Pesticides
___ Wood Treating  ___ Other: __________
Treatment Status: ___ Active  ___ Post
Type of Test: x Pilot Test  ___ Full Scale System
Start of Test: __________  End of Test: __________  Duration: __________
Type of Site: ___ Non-DOD  x DoD

Facility Name: Naval Construction Battalion Center (Former NIKE)

City, State, Zip Code: North Kingston, RI
OU# or Site #: __________

Primary point of contact: Christine Williams
Organization: Navy
Address: __________
City, State, Zip Code: __________
Phone #: 617-918-1384  email: __________

Other contacts or vendors who worked on site  ___ None
Point of contact: Ian Osgerby
Type: x Vendor, Consultant  ___ Vendor, Technical Applications  ___ Other  __________
Organization: Navy
Address: __________
City, State, Zip Code: __________
Phone #: 978-318-8631  email: __________

QA/QC

Characteristics of Interest
___ Good pre- and post-treatment groundwater data  ___ Good pre- and post-treatment soil data
___ Good temperature profile vs. time information  ___ Flux assessment
___ Groundwater elevations  ___ Geologic cross-section
___ Hydraulic Conductivity information
## General Site Assessment Data

<table>
<thead>
<tr>
<th>Impact Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map attachment</td>
<td></td>
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</tbody>
</table>

Alternative method for determining size of impacted zone (See source zone definition attachments)

### Monitor Wells

<table>
<thead>
<tr>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>None</th>
</tr>
</thead>
</table>

Number of wells relative to treatment zone:

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>In:</th>
</tr>
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<tbody>
<tr>
<td>Upper gradient:</td>
<td></td>
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<td>Downgradient:</td>
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<tr>
<td>Crossgradient:</td>
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<thead>
<tr>
<th>Post-treatment</th>
<th>In:</th>
</tr>
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<tbody>
<tr>
<td>Upper gradient:</td>
<td></td>
</tr>
<tr>
<td>Downgradient:</td>
<td></td>
</tr>
<tr>
<td>Crossgradient:</td>
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### Soil Borings

<table>
<thead>
<tr>
<th>Number of relevant soil borings with pre-treatment data:</th>
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</table>

<table>
<thead>
<tr>
<th>Number of relevant soil borings with post-treatment data:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Number inside treatment zone:</th>
<th>Number outside treatment zone:</th>
</tr>
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</table>

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Chemical: Average Pre-treatment Concentration per Chemical:</th>
<th>Chemical: Average Post-treatment Concentration per Chemical:</th>
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</thead>
<tbody>
<tr>
<td>Tetrachloroethene</td>
<td>Trichloroethene</td>
<td>Bencene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Trichloroethene</td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>1,1-dichloroethene</td>
<td>Naphtalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
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<td>Toluene</td>
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<td>None</td>
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<tr>
<td>1,1-dichloroethene</td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
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<tr>
<td>1,2-dichloroethene</td>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
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<td>1,1,2-trichloroethane</td>
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<tr>
<td>Vinyl Chloride</td>
<td>Vinyl Chloride</td>
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<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>None</td>
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<table>
<thead>
<tr>
<th>Comments:</th>
<th></th>
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<table>
<thead>
<tr>
<th>Attachments:</th>
<th></th>
</tr>
</thead>
</table>
Hydrogeologic Conceptual Model

---

**Geology:**

**Zone**

**Vadose Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Ground surface elevation based on wells in or adjacent to treatment zone:**
- __________ ft amsl
- __________ Unknown

---

**Aquifer Characteristics:**

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): __________
  - Unknown (assuming single aquifer)

**Depth to water:**
- low value (ft bgs): __________ __________ __________
- high value (ft bgs): __________ __________ __________
- Unknown: __________ __________ __________

**Flow direction:**
- __________ __________ __________

**Horizontal hydraulic gradient (feet/foot):**
- __________ __________ __________ __________
- Unknown

**Vertical hydraulic gradient (feet/foot):**
- __________ __________ __________ __________
- Unknown

**K range (ft/day):**
- Measured using: Slug Test Laboratory Field data
  - low __________ __________ __________ __________
  - high __________ __________ __________ __________
  - Unknown

**Transmissivity (ft²/day):**
- Measured using: Slug Test Laboratory Field data
  - low __________ __________ __________ __________
  - high __________ __________ __________ __________
  - Unknown

---

**Comments:**

---

---

**Attachments:**

---
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>____ Conductive</th>
<th>____ Electrical Resistance</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>_________________________</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 phase</td>
</tr>
<tr>
<td>Steam</td>
<td></td>
<td>Steam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other (describe)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
<th>______ Relatively homogeneous and permeable unconsolidated sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>______ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>______ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>______ Largely permeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>______ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>______ Weathered bedrock, limestone, sandstone</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>______ Saturated only</th>
<th>______ Vadose only</th>
<th>______ Both (Saturated and Vadose zones)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>______ Duration:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Hydraulic Control:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>______</th>
<th>Unknown</th>
<th>( _____ x _____ ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>______</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>______</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>______</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>______</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>______</td>
<td>Unknown</td>
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<table>
<thead>
<tr>
<th>Temperature Profile:</th>
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</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>______</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>______</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>______</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>______</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

| Formation temperature immediately post-treatment: | ______ |
| Formation temperature post-treatment monitoring event 1: | ______ |
| Duration of post-treatment monitoring (days): | ______ |

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
<td>______</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td>______</td>
</tr>
<tr>
<td>Total:</td>
<td>______</td>
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</table>

<table>
<thead>
<tr>
<th>Comments:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachments:</td>
<td></td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

**Remediation Goal:**

- **In Groundwater:**
- **In Soil:**

**Was the Remediation Goal Achieved:**

- **In Groundwater:**
  - Comment:
- **In Soil:**
  - Comment:

**General comments on the thermal application:**

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

**Lessons Learned**

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

**Energy**

**Total Energy Used:**

- **Total energy applied to treatment zone:**
  - kWh
  - kWh/m³
  - kWh/ft³
- **Other energy:**
  - kWh
  - kWh/m³
  - kWh/ft³

Please note other energy:

_________________________________________________________________________________

**Cost**

**Total Project Cost:**

- **Consultant Cost:**
- **Thermal Vendor Cost:**
- **Energy Cost:**
- **Other Cost 1:**
- **Other Cost 2:**
- **Other Cost 3:**

Please note other cost:

- **Other Cost 1:**
- **Other Cost 2:**
- **Other Cost 3:**
General Site Information

File Analyzed By: JT PD Date: 11/6/2006
Type of treatment: Conductive Steam ERH Other: __________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Wood Treating Other: __________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 11/7/1993 End of Test: 12/2/1993 Duration: 25 d
Type of Site: Non-DOD DoD

Facility Name: Savannah River Site
Address: __________________________________________
City, State, Zip Code: Aiken, SC
OU# or Site #: Site 321 - Area M

Primary point of contact: Mark Amidon
Organization: Savannah River Site
Address: __________________________________________
Phone #: 803-952-7781 email: mark.amidon@srs.gov

Other contacts or vendors who worked on site None
Point of contact: Jim Kupar and Brian Looney
Type: Vendor, Consultant Vendor, Technical Applications Other __________
Organization: Savannah River Site Savannah River National Laboratory
Address: __________________________________________
City, State, Zip Code: __________________________________________
Phone #: 803-952-6525 / 803-725-3692 email: james.kupar@srs.gov / brian02.looney@srnl.doe.gov

QA/QC

Characteristics of Interest
Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
## General Site Assessment Data

- **Impacted Zone**: Length (parallel to flow direction)(ft.): **>25000**, Width (ft): **>16400**, Thickness (ft): ___
  - Length: 25000 ft, Width: 16400 ft, Thickness: ___
  - Unknown zone
- **Alternative method for determining size of impacted zone**: See source zone definition attachments
- **Map attachment**: ___

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>Crossgradient</td>
<td>None</td>
<td>0.01 mg/kg</td>
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<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>Jet Fuel</td>
<td>None</td>
<td>0.05 mg/kg</td>
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<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
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<td>Toluene</td>
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<td>None</td>
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<tr>
<td>1,1-dichloroethene</td>
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<td>None</td>
<td>Ethylbenzene</td>
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</tr>
<tr>
<td>1,2-dichloroethene</td>
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<td>m/p-xylene</td>
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<td>None</td>
<td>Crossgradient</td>
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<td>None</td>
<td>None</td>
<td>Jet Fuel</td>
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<td>Vinyl Chloride</td>
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<td>None</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Jet Fuel</td>
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<td>None</td>
<td>Benzene</td>
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<td>None</td>
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<td>Hexane</td>
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<td>None</td>
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<td>Chlorinated Solvents</td>
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<td></td>
<td>Other</td>
<td>Average Pre-treatment Concentration per Chemical</td>
<td>Average Post-treatment Concentration per Chemical</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
</tbody>
</table>

### Comments:

- Average post treatment soils concentrations for both constituents at 0.0001 mg/kg, from elevations 328 to 316.

### Attachments:

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ______
  - Upgradient: ____, Downgradient: ____, Crossgradient: ______

- Number inside treatment zone: ____, Number outside treatment zone: ___

- Number of relevant soil borings with pre-treatment data: ____
  - Upgradient: ____, Downgradient: ____
  - Crossgradient: ____

- Number of relevant soil borings with post-treatment data: ____
  - Upgradient: ____, Downgradient: ____
  - Crossgradient: ____

- Number of relevant monitoring wells with groundwater data: ___
  - Pre-treatment: ____, Post-treatment: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____

- Number of wells relative to treatment zone:
  - Pre-treatment: ____, Post-treatment: ____
  - Upgradient: ____, Downgradient: ____, Crossgradient: ____
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<tr>
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<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Ground surface elevation based on wells in or adjacent to treatment zone: | 355 ft amsl | Unknown |

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
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<thead>
<tr>
<th>Aquifer</th>
<th>Flow direction</th>
</tr>
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<tr>
<td></td>
<td>NE</td>
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</table>

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Horizontal hydraulic gradient (feet/foot):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vertical hydraulic gradient (feet/foot):</td>
</tr>
<tr>
<td></td>
<td>K range (ft/day)</td>
</tr>
<tr>
<td></td>
<td>Measured using: Slug Test Laboratory Field data</td>
</tr>
<tr>
<td></td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>high</td>
</tr>
<tr>
<td></td>
<td>Transmissivity (ft²/day):</td>
</tr>
<tr>
<td></td>
<td>Measured using: Slug Test Laboratory Field data</td>
</tr>
<tr>
<td></td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>high</td>
</tr>
</tbody>
</table>

Comments:

Downward gradient of 2 to 8 ft/yr. Radial flow outward at 15 to 100 ft/yr.

Attachments:
Thermal Treatment - Design

Thermal treatment: **X** Conductive  
**X** Electrical Resistance

Steam  **X** 6 phase  **X** AC power  **X** DC power

Steam  **X** Steam + air  **X** Steam + O2

Type of Test: **X** Pilot test  **X** Full-scale System

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone: **X** Saturated only  **X** Vadose only  **X** Both (Saturated and Vadose zones)

Start of Thermal Test: 11/7/1993  
Duration: 25 d

Hydraulic Control: **X** Yes  **X** No

Treatment Cell Design:

- Size of target zone (ft²): 710  **X** Unknown  **X** (30 x 30 ft)
- Thickness of target zone (ft): 24  **X** Unknown
- Depth to top of target zone (ft bgs): 23  **X** Unknown
- Thickness of target zone below water table (ft): 0  **X** Unknown
- Number of energy delivery points: 6  **X** Unknown
- Number of extraction points: 4  **X** Unknown

Temperature Profile:

- Initial formation temperature (deg C): 20  **X** Unknown
- Maximum representative formation temperature (deg C): 100  **X** Unknown
- Time to reach maximum representative temperature (days): 8  **X** Unknown
- Duration of treatment at representative temperature (days): 17  **X** Unknown

Formation temperature immediately post-treatment: 12/3/1993  100
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:

- Via liquid pumping:  **X** Unknown  **X** lb  **X** kg  **X** Unknown
- In vapor stream:  **X** Unknown  **X** lb  **X** kg  **X** Unknown
- Total:  **X** Unknown  **X** lb  **X** kg  **X** Unknown

Comments:

1430 yd³ of heated soil

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

Test to evaluate the enhanced removal of chlorinated VOCs from subsurface sediments using ohmic heating.

Was the Remediation Goal Achieved:

In Groundwater:

Comment:

In Soil:

Comment:

General comments on the thermal application:

Extraction well should be screened above and below clay lens.

Energy

Total Energy Used: 100,000 kWhr

kWhr kWhr/m³ kWhr/yd³

Total energy applied to treatment zone: 70 kWhr kWhr/m³ kWhr/yd³

Other energy: kWhr kWhr/m³ kWhr/yd³

Please note other energy:

Cost

Total Project Cost: 1,277,300

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
General Site Information

File Analyzed By: JT PD Date: 9/25/2007
Type of treatment: Conductive Steam ERH Other: ________________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: ________________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 6/15/2006 End of Test: _______ Duration: _______
Type of Site: Non-DOD DoD

Facility Name: Savannah River Site - C Reactor Area
Address: ____________________________________________
City, State, Zip Code: Aiken, SC
OU# or Site #: C Reactor

Primary point of contact: Joseph Amari
Organization: Washington Savannah River Company
Address: ____________________________________________
City, State, Zip Code: ____________________________________________
Phone #: ______________________ email: ______________________

Other contacts or vendors who worked on site: None
Point of contact: Robert F. Blundy
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: Washington Savannah River Company
Address: ____________________________________________
City, State, Zip Code: ____________________________________________
Phone #: ______________________ email: ______________________

QA/QC

Characteristics of Interest
- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
## Impacted Zone

<table>
<thead>
<tr>
<th>Length (parallel to flow direction)(ft.)</th>
<th>Width (ft.)</th>
<th>Thickness (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Map attachment**

**Alternative method for determining size of impacted zone (See source zone definition attachments)**

## Monitor Wells

- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment: _______
  - Post-treatment: _______

**Number of wells relative to treatment zone:**

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>Upgradient:</th>
<th>Downgradient:</th>
<th>Crossgradient:</th>
</tr>
</thead>
<tbody>
<tr>
<td>In:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uppgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Post-treatment</th>
<th>Upgradient:</th>
<th>Downgradient:</th>
<th>Crossgradient:</th>
</tr>
</thead>
<tbody>
<tr>
<td>In:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uppgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossgradient:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Soil Borings

- Number of relevant soil borings with pre-treatment data:
  - Pre-treatment: _______
  - Post-treatment: _______

**Number inside treatment zone:**

**Number outside treatment zone:**

### Types of Contaminants

**Chemicals of Concern**

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethylene</td>
<td>Hexane</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
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<tr>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
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<td>1,1-dichloroethane</td>
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<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
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<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>1,1,2-trichloroethane</td>
<td>i-p-xylene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>Chloroform</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

| Vinyl Chloride        |                        |       | None     | None              | None         | None                                          | None                                          |

### Comments:

- Additional comments... 
- Additional comments...

### Attachments:

- Attachment 1...
- Attachment 2...
### Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>X Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Largely permeable sediments with inter-bedded layers of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>X Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>X Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>X Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Largely permeable sediments with inter-bedded layers of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>X Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>X Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl    __________ Unknown

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>X</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
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<td></td>
</tr>
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Flow direction

Horizontal hydraulic gradient (feet/foot): __________ __________ __________ __________ Unknown

Vertical hydraulic gradient (feet/foot): __________ __________ __________ __________ Unknown

K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Transmissivity (ft²/day):

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
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</table>

Average K=0.4 ft/min

Comments:

Attachments:  

---
### Thermal Treatment - Design

**Facility ID:** 0742

<table>
<thead>
<tr>
<th><strong>Thermal treatment:</strong></th>
<th><strong>Conductive</strong></th>
<th><strong>Electrical Resistance</strong></th>
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</thead>
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<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th><strong>Steam</strong></th>
<th><strong>3 phase</strong></th>
<th><strong>6 phase</strong></th>
<th><strong>AC power</strong></th>
<th><strong>DC power</strong></th>
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</thead>
<tbody>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Other (describe)</strong></th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Type of Test:</strong></th>
<th><strong>Pilot test</strong></th>
<th><strong>Full-scale System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Geology of Treatment Zone:</strong></th>
<th><strong>Relatively homogeneous and permeable unconsolidated sediments</strong></th>
<th><strong>Relatively homogeneous and impermeable unconsolidated sediments</strong></th>
<th><strong>Largely permeable sediments with inter-bedded lenses of lower permeability material</strong></th>
<th><strong>Largely impermeable sediments with inter-bedded layers of higher permeability material</strong></th>
<th><strong>Competent, but fractured bedrock (i.e. crystalline rock)</strong></th>
<th><strong>Weathered bedrock, limestone, sandstone</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatment Target Zone:</strong></td>
<td><strong>Saturated only</strong></td>
<td><strong>Vadose only</strong></td>
<td><strong>Both (Saturated and Vadose zones)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>Start of Thermal Test:</strong></th>
<th><strong>6/15/2006</strong></th>
<th><strong>Duration:</strong></th>
<th><strong>Yes</strong></th>
<th><strong>No</strong></th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Treatment Cell Design:</strong></th>
<th><strong>Hydraulic Control</strong></th>
<th><strong>Unknown</strong></th>
<th><strong>Unknown</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Size of target zone (ft2):</strong></th>
<th><strong>Unknown</strong></th>
<th><strong>(  _  x  _  ft)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Thickness of target zone (ft):</strong></th>
<th><strong>Unknown</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Depth to top of target zone (ft bgs):</strong></th>
<th><strong>Unknown</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Thickens of target zone below water table (ft):</strong></th>
<th><strong>Unknown</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Number of energy delivery points:</strong></th>
<th><strong>Unknown</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Number of extraction points:</strong></th>
<th><strong>Unknown</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Temperature Profile:</strong></th>
<th><strong>Initial formation temperature (deg C):</strong></th>
<th><strong>18.3</strong></th>
<th><strong>Unknown</strong></th>
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</thead>
<tbody>
<tr>
<td></td>
<td><strong>Maximum representative formation temperature (deg C):</strong></td>
<td><strong>Unknown</strong></td>
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</tr>
<tr>
<td></td>
<td><strong>Time to reach maximum representative temperature (days):</strong></td>
<td><strong>Unknown</strong></td>
<td></td>
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<tr>
<td></td>
<td><strong>Duration of treatment at representative temperature (days):</strong></td>
<td><strong>Unknown</strong></td>
<td></td>
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<tr>
<td></td>
<td><strong>Formation temperature immediately post-treatment:</strong></td>
<td><strong>Unknown</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Formation temperature post-treatment monitoring event 1:</strong></td>
<td><strong>Unknown</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Duration of post-treatment monitoring (days):</strong></td>
<td><strong>Unknown</strong></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Mass of contaminant removed:</strong></th>
<th><strong>Via liquid pumping:</strong></th>
<th><strong>lb</strong></th>
<th><strong>kg</strong></th>
<th><strong>Unknown</strong></th>
</tr>
</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th><strong>In vapor stream:</strong></th>
<th><strong>lb</strong></th>
<th><strong>kg</strong></th>
<th><strong>Unknown</strong></th>
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<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th><strong>Total:</strong></th>
<th><strong>lb</strong></th>
<th><strong>kg</strong></th>
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<tbody>
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<table>
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<th><strong>Comments:</strong></th>
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<table>
<thead>
<tr>
<th><strong>Attachments:</strong></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached. |
Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: _______ kWhr _______ kWhr/m³ _______ kWhr/yd³

Total energy applied to treatment zone: _______ kWhr/m³ _______ kWhr/yd³

Other energy: _______ kWhr/m³ _______ kWhr/yd³

Please note other energy:

Cost

Total Project Cost:

Consultant Cost: _______ m³ _______ yd³

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
<table>
<thead>
<tr>
<th><strong>General Site Information</strong></th>
<th><strong>Facility ID#: 0750</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>File Analyzed By:</strong> JT PD</td>
<td><strong>Date:</strong> 5/4/2005</td>
</tr>
<tr>
<td><strong>Type of treatment:</strong></td>
<td><strong>Type of Contaminant:</strong></td>
</tr>
<tr>
<td>Conductive, Steam, ERH, Other:</td>
<td>Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides, Wood Treating, Other:</td>
</tr>
<tr>
<td><strong>Treatment Status:</strong></td>
<td><strong>Type of Test:</strong> Pilot Test, Full Scale System</td>
</tr>
<tr>
<td>Active, Post</td>
<td><strong>Start of Test:</strong> 9/10/2000, <strong>End of Test:</strong> 9/28/2001</td>
</tr>
<tr>
<td><strong>Type of Site:</strong></td>
<td><strong>Duration:</strong> 365 d</td>
</tr>
<tr>
<td>Non-DOD, DoD</td>
<td><strong>Facility Name:</strong> Savannah River Site</td>
</tr>
<tr>
<td><strong>Address:</strong></td>
<td><strong>City, State, Zip Code:</strong> Aiken, SC 29808</td>
</tr>
<tr>
<td><strong>OU# or Site #:</strong> 321-M Solvent Storage Area</td>
<td></td>
</tr>
<tr>
<td><strong>Primary point of contact:</strong> Jim Kupar</td>
<td><strong>Organization:</strong> Bechtel Savannah River, Inc.</td>
</tr>
<tr>
<td><strong>Address:</strong> Bldg. 730-4B, Rm 3029</td>
<td><strong>City, State, Zip Code:</strong> Aiken, SC 29808</td>
</tr>
<tr>
<td><strong>Phone #:</strong> 803-952-6525, email: <a href="mailto:james.kupar@srs.gov">james.kupar@srs.gov</a></td>
<td></td>
</tr>
<tr>
<td><strong>Other contacts or vendors who worked on site:</strong> None</td>
<td></td>
</tr>
<tr>
<td><strong>Point of contact:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type:</strong> Vendor, Consultant, Vendor, Technical Applications, Other, Other</td>
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<tr>
<td><strong>Organization:</strong></td>
<td></td>
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<tr>
<td><strong>Address:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>City, State, Zip Code:</strong></td>
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</tr>
<tr>
<td><strong>Phone #:</strong> email:</td>
<td></td>
</tr>
</tbody>
</table>

**QA/QC**

**Characteristics of Interest**

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0750

#### Impacted Zone:
- **Length (parallel to flow direction)(ft.):** >25000
- **Width (ft):** >16400
- **Thickness (ft):** 16
- **Unknown**

- **Impacted zone as defined by documentation**
- **Alternative method for determining size of impacted zone (See source zone definition attachments)**

- **Map attachment**

#### Monitor Wells:
- **Number of relevant monitoring wells with groundwater data:**
  - **Pre-treatment:**
  - **Post-treatment:** None

- **Number of wells relative to treatment zone:**
  - **Pre-treatment In:**
  - **Upgradient:**
  - **Downgradient:**
  - **Crossgradient:**

- **Post-treatment In:**
  - **Upgradient:**
  - **Downgradient:**
  - **Crossgradient:**

#### Soil Borings:
- **Number of relevant soil borings with pre-treatment data:**
- **Number of relevant soil borings with post-treatment data:**

- **Number inside treatment zone:**
- **Number outside treatment zone:**

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>BTEX</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
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<td>None</td>
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<tr>
<td>1,1-dichloroethane</td>
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<td>1,2-dichloroethane</td>
<td>m+p-xylene</td>
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<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
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<td>None</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Attachments:
### Hydrogeologic Conceptual Model

#### Geology:

- **Zone**
  - **Vadose Zone:**
    - [X] Largely permeable sediments with inter-bedded lenses of lower permeability material
  - **Saturated Zone:**
    - [X] Largely permeable sediments with inter-bedded layers of higher permeability material
    - [X] Competent, but fractured bedrock (i.e. crystalline rock)
    - [X] Weathered bedrock, limestone, sandstone

#### Ground surface elevation based on wells in or adjacent to treatment zone:
- **ft amsl:**
- **Unknown:**

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - [X] Yes (number): 3
  - Unknown (assume single aquifer)

#### Depth to water:
- **Aquifer 1**
  - Low value (ft bgs): 135
  - High value (ft bgs): 145
- **Aquifer 2**
  - Unknown:
- **Aquifer 3**
  - Unknown:

#### Flow direction

#### Horizontal hydraulic gradient (feet/foot):
- Unknown:

#### Vertical hydraulic gradient (feet/foot):
- Unknown:

#### K range (ft/day):

<table>
<thead>
<tr>
<th>Measured using</th>
<th>Low</th>
<th>High</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slug Test</td>
<td>576</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft²/day):

<table>
<thead>
<tr>
<th>Measured using</th>
<th>Low</th>
<th>High</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slug Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

- Average $K=0.4$ ft/min

#### Attachments:
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
- 3 phase
- 6 phase
- AC power
- DC power

Steam
- Steam
- Steam + air
- Steam + O2

Other (describe)

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 9/10/2000
- Duration: 365 d

Hydraulic Control
- Yes
- No

Treatment Cell Design:

Size of target zone (ft²):  
- 10,000
- Unknown

Thickness of target zone (ft):  
- 140
- Unknown

Depth to top of target zone (ft bgs):  
- 20
- Unknown

Thickness of target zone below water table (ft):  
- 15
- Unknown

Number of extraction points:  
- 9
- Unknown

Number of energy delivery points:  
- 4
- Unknown

Temperature Profile:

Initial formation temperature (deg C):  
- 20
- Unknown

Maximum representative formation temperature (deg C):  
- 100
- Unknown

Time to reach maximum representative temperature (days):  
- 180
- Unknown

Duration of treatment at representative temperature (days):  
- 185
- Unknown

Date  
Formation temperature immediately post-treatment:  
- 10/1/2001
- 99

Formation temperature post-treatment monitoring event 1:  
- 11/2/2001
- 90

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

- Via liquid pumping:  
  - lb
  - kg
  - Unknown

- In vapor stream:  
  - lb
  - kg
  - Unknown

- Total:  
  - 31,000
  - lb
  - x kg
  - Unknown

Comments:

Treated 52,000 cubic yards  
Three clusters of wells with steam injection wells in each cluster with injection intervals of 50ft-70 ft bgs and 150ft-160 ft bgs

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Steam injected - 4.5x10E10) BTUs (13188198.2 kw-hr). Objectives: 1) contaminants removed from target source area; 2) target zone must be heated to applied boiling point; 3) Air to support HPO must be injected into treatment zone.

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: _______ kWhr ______ kWhr/m^3 ______ kWhr/yd^3

Total energy applied to treatment zone: _______ kWhr ______ kWhr/m^3 ______ kWhr/yd^3

Other energy: _______ kWhr ______ kWhr/m^3 ______ kWhr/yd^3

Please note other energy: __________________________________________________________

Cost

Total Project Cost: $29 / yd^3

Consultant Cost: __________________________

Thermal Vendor Cost: __________________________

Energy Cost: _______ m^3 ______ yd^3

Other Cost 1: __________________________

Other Cost 2: __________________________

Other Cost 3: __________________________

Please note other cost: __________

Other Cost 1: __________________________

Other Cost 2: __________________________

Other Cost 3: __________________________
<table>
<thead>
<tr>
<th></th>
<th>File Analyzed By: JT PD</th>
<th>Date: 10/11/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive Steam ERH Other: RFH</td>
<td></td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
<td></td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active Post</td>
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<tr>
<td>Type of Test:</td>
<td>Pilot Test Full Scale System</td>
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<tr>
<td>Start of Test:</td>
<td>3/25/1993</td>
<td></td>
</tr>
<tr>
<td>End of Test:</td>
<td>4/26/1993</td>
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</tr>
<tr>
<td>Duration:</td>
<td>27 d</td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD DoD</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Facility Name: Savannah River Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Aiken, SC 29801</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td>Site 321 M-Area Seepage Basin</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Primary point of contact: <a href="http://www.osti.gov/bridge">www.osti.gov/bridge</a> doc no.: WSRC-TR-93-673</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td></td>
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<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<td></td>
</tr>
<tr>
<td>email:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Other contacts or vendors who worked on site: None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point of contact:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td>Vendor, Consultant Vendor, Technical Applications Other</td>
</tr>
<tr>
<td>Organization:</td>
<td></td>
</tr>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<td></td>
</tr>
<tr>
<td>email:</td>
<td></td>
</tr>
</tbody>
</table>

**QA/QC**

<table>
<thead>
<tr>
<th></th>
<th>Characteristics of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good pre- and post-treatment groundwater data</td>
</tr>
<tr>
<td></td>
<td>Good pre- and post-treatment soil data</td>
</tr>
<tr>
<td></td>
<td>Good temperature profile vs. time information</td>
</tr>
<tr>
<td></td>
<td>Flux assessment</td>
</tr>
<tr>
<td></td>
<td>Groundwater elevations</td>
</tr>
<tr>
<td></td>
<td>Geologic cross-section</td>
</tr>
<tr>
<td></td>
<td>Hydraulic Conductivity information</td>
</tr>
</tbody>
</table>
## Impacted Zone
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

## General Site Assessment Data

### Monitor Wells
- Number of relevant monitoring wells with groundwater data: _None_
- Pre-treatment: __________
- Post-treatment: __________

<table>
<thead>
<tr>
<th>Location</th>
<th>Pre-treatment</th>
<th>Upgradient</th>
<th>Downgradient</th>
<th>Crossgradient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>__________</td>
<td>__________</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td></td>
<td>__________</td>
<td>__________</td>
<td>__________</td>
<td>__________</td>
</tr>
</tbody>
</table>

### Soil Borings
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________

<table>
<thead>
<tr>
<th>Location</th>
<th>Pre-treatment</th>
<th>Upgradient</th>
<th>Downgradient</th>
<th>Crossgradient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>__________</td>
<td>__________</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td></td>
<td>__________</td>
<td>__________</td>
<td>__________</td>
<td>__________</td>
</tr>
</tbody>
</table>

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdir</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>Ethylbenzene</td>
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<td>m+p-xylene</td>
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<td>None</td>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td></td>
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<td></td>
<td>None</td>
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### Comments

- None

### Attachments

- None
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
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<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
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</tbody>
</table>

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td>low (ft bgs):</td>
<td>high (ft bgs):</td>
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<tr>
<td>Flow direction</td>
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#### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td>x Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td>x Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone:

- 360 ft amsl
- Unknown:

#### Comments:

- Blank line

#### Attachments:

- Blank line
### Thermal Treatment - Design

**Facility ID:** 0760

- **Thermal Treatment:**
  - Conductive
  - Electrical Resistance
    - 3 phase
    - 6 phase
    - AC power
    - DC power
  - Steam
    - Steam + air
    - Steam + O2
- **Type of Test:** Pilot test
- **Full-scale System**
- **Other (describe):** RFH
- **Geology of Treatment Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded layers of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone
- **Treatment Target Zone:**
  - Saturated only
  - Vadose only
  - Both (Saturated and Vadose zones)
- **Start of Thermal Test:** 3/25/1993
- **Duration:** 27 d
- **Hydraulic Control**: Yes
- **No**

#### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²)</th>
<th>1000</th>
<th>Unknown</th>
<th>(30 x 10 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft)</td>
<td>10</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs)</td>
<td>15</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft)</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points</td>
<td>1</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points</td>
<td>1</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

#### Temperature Profile:

| Initial formation temperature (deg C) | 20 | Unknown |
| Maximum representative formation temperature (deg C) | 65 | Unknown |
| Time to reach maximum representative temperature (days) | 27 | Unknown |
| Duration of treatment at representative temperature (days) | 1 | Unknown |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
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</table>

**Formation temperature immediately post-treatment:**

**Formation temperature post-treatment monitoring event 1:**

**Duration of post-treatment monitoring (days):**

#### Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Via liquid pumping</th>
<th>Unknown</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total</td>
<td>171.5</td>
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</table>

**Comments:**

- Shut down for 7 days

**Attachments:**

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: 
- In Soil: 

Was the Remediation Goal Achieved:

- In Groundwater: 
  Comment: 
- In Soil: 
  Comment: 

General comments on the thermal application:

Of the 21,200 kWhr used, only 65% was converted to FR power in which only 85% went into the formation.

Objectives: 1) Simple installation, start up, and trouble free operation 2) accelerated TCE and PCE volatilization 3) reduced cost over comparable technologies and 4) conformance of field performance with treatability studies and computer predictive modeling.

Lessons Learned:

- 
- 
- 
- 
- 
- 

Energy

Total Energy Used: 21200 kWhr

- Total energy applied to treatment zone: 11675 kWhr

Other energy: Please note other energy:

Cost

Total Project Cost: 853994

- Consultant Cost: 
- Thermal Vendor Cost: 
- Energy Cost: 11020 kWhr/m³ kWhr/yd³ 
- Other Cost 1: 245867 m³ yd³ 
- Other Cost 2: 241390 
- Other Cost 3: 366757 

Please note other cost:

- Other Cost 1: Rf delivery 
- Other Cost 2: field support 
- Other Cost 3: off-gas treatment/well prep and monitoring/analytical
**General Site Information**

- **File Analyzed By:** JT
- **PD:**
- **Date:** 8/20/2007
- **Type of treatment:**
  - [X] Conductive
  - [X] Steam
  - [X] ERH
  - [X] Other: ______________
- **Type of Contaminant:**
  - [X] Chlorinated Solvents
  - [X] Petroleum Hydrocarbons
  - [X] Pesticides
  - [X] Wood Treating
  - [X] Other: ______________
- **Treatment Status:**
  - [X] Active
  - [X] Post
- **Type of Test:**
  - [X] Pilot Test
  - [X] Full Scale System
- **Start of Test:** 1/29/2007
- **End of Test:** 6/20/2007
- **Duration:** 142
- **Type of Site:**
  - [X] Non-DOD
  - [X] DoD

- **Facility Name:** South Eastern US
- **Address:**
- **City, State, Zip Code:** South Eastern US
- **OU# or Site #:** ______________

- **Primary point of contact:** Ralph Baker
- **Organization:** TerraTherm, Inc.
- **Address:** 10 Stevens Road
- **City, State, Zip Code:** Fitchburg, MA 01420
- **Phone #:** 978-343-0300
- **email:** rbaker@terratherm.com

- **Other contacts or vendors who worked on site:** None

- **Point of contact:**
  - **Type:** __________ Vendor, Consultant
  - __________ Vendor, Technical Applications
  - __________ Other
  - __________

- **Organization:** ______________
- **Address:** ______________
- **City, State, Zip Code:** ______________
- **Phone #:** ______________
- **email:** ______________

**QA/QC**

- **Characteristics of Interest**
  - [X] Good pre- and post-treatment groundwater data
  - [X] Good pre- and post-treatment soil data
  - [X] Good temperature profile vs. time information
  - [X] Flux assessment
  - [X] Groundwater elevations
  - [X] Geologic cross-section
  - [X] Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0765

<table>
<thead>
<tr>
<th><strong>Impacted Zone:</strong></th>
<th><strong>Length (parallel to flow direction)(ft.):</strong></th>
<th><strong>Width (ft):</strong></th>
<th><strong>Thickness (ft):</strong></th>
<th><strong>Unknown</strong></th>
<th><strong>Impacted zone as defined by documentation</strong></th>
<th><strong>Alternative method for determining size of impacted zone (See source zone definition attachments)</strong></th>
<th><strong>Map attachment</strong></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Monitor Wells:</strong></th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Soil Borings:</strong></th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>Number of relevant soil borings with post-treatment data:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>11</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Types of Contaminants</strong></th>
<th><strong>Chemicals of Concern</strong></th>
<th><strong>Average Pre-treatment Concentration per Chemical:</strong></th>
<th><strong>Average Post-treatment Concentration per Chemical:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Groundwater (mg/L)</strong></td>
<td><strong>Soil (mg/kg)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groundwater</td>
<td>Soil</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross gradient</td>
<td>1,000 mg/L</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
</tr>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethylene</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

**Attachments:**
**Ground surface elevation based on wells in or adjacent to treatment zone:** 897 ft amsl  Unknown

### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>X Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>X Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>X Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>X Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow direction</th>
<th>SW</th>
</tr>
</thead>
</table>

| Horizontal hydraulic gradient (feet/foot): | 0.03 | | Unknown |
| Vertical hydraulic gradient (feet/foot): | 0.04 | | Unknown |

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>0.028</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td>0.24</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmissivity (ft2/day):</th>
<th>Measured using</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**A groundwater extraction system was installed within the treatment zone to ensure capture and to enhance natural upward gradients to minimize the potential for vertical mobilization of DNAPL into the bedrock during heating.**

**Comments:**

---

**Attachments:**

---
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>x</th>
<th>Thermal treatment:</th>
<th>x</th>
<th>Conductive</th>
<th>In Situ Thermal Desorption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Steam</td>
<td>Steam</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other (describe)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Type of Test:</th>
<th>x</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
</table>

| x | Geology of Treatment Zone: | x | Relatively homogeneous and permeable unconsolidated sediments |
|   |                             |   | Largely permeable sediments with inter-beded lenses of lower permeability material |
|   |                             |   | Relatively homogeneous and impermeable unconsolidated sediments |
|   |                             |   | Largely impermeable sediments with inter-beded layers of higher permeability material |
|   |                             |   | Competent, but fractured bedrock (i.e. crystalline rock) |
|   |                             |   | Weathered bedrock, limestone, sandstone |

<table>
<thead>
<tr>
<th>x</th>
<th>Treatment Target Zone:</th>
<th>x</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Start of Thermal Test:</th>
<th>1/29/2007</th>
<th>Duration:</th>
<th>142</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Hydraulic Control</th>
<th>x</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Treatment Cell Design:</th>
<th>2554</th>
<th>Unknown</th>
<th>(33 x 76 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size of target zone (ft2):</td>
<td>2554</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thickness of target zone (ft):</td>
<td>35</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depth to top of target zone (ft bgs):</td>
<td>0</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thickness of target zone below water table (ft):</td>
<td>15</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of extraction delivery points:</td>
<td>10</td>
<td>Unknown</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Temperature Profile:</th>
<th>20</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial formation temperature (deg C):</td>
<td>20</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Maximum representative formation temperature (deg C):</td>
<td>101</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Time to reach maximum representative temperature (days):</td>
<td>75</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Duration of treatment at representative temperature (days):</td>
<td>65</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/18/2007</td>
<td>100</td>
</tr>
<tr>
<td>7/15/2007</td>
<td>90</td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td>165</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
</tr>
<tr>
<td>In vapor stream:</td>
</tr>
<tr>
<td>Total:</td>
</tr>
</tbody>
</table>

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

____ In Groundwater: ____________________________________________________________

X In Soil: 95% UCL of mean TCE concentration must be <0.060 mg/kg

Was the Remediation Goal Achieved:

____ In Groundwater: ____________________________________________________________

Comment: ____________________________________________________________________

X In Soil: 95% UCL of mean TCE concentration = 0.017 mg/kg

Comment: ____________________________________________________________________

General comments on the thermal application:

______________________________________________________________________________

__________________________________________

Lessons Learned:

______________________________________________________________________________

__________________________________________

Total Energy Used: 1860600 kWhr kWhr/m³ kWhr/yd³

X Total energy applied to treatment zone: 1776600 kWhr/m³ kWhr/yd³

____ Other energy: 84000 kWhr/m³ kWhr/yd³

____ Please note other energy: misc. motors, pumps

Total Project Cost: $disclose the cost of the

____ Consultant Cost: ____________________________________________________________

____ Thermal Vendor Cost: ______________________________________________________$

____ Energy Cost: __________________________ m³ __________ yd³

____ Other Cost 1: _____________________________________________________________

____ Other Cost 2: _____________________________________________________________

____ Other Cost 3: _____________________________________________________________

____ Please note other cost: __________ Other Cost 1: _______________________________

____ Other Cost 2: _____________________________________________________________

____ Other Cost 3: _____________________________________________________________
General Site Information

File Analyzed By: JT PD  
Date: 10/11/2006
Type of treatment: Conductive Steam ERH Other: 
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 
Treatment Status: Active Post 
Type of Test: Pilot Test Full Scale System
Type of Site: Non-DOD DoD

Facility Name: Oak Ridge Reservation
Address: 
City, State, Zip Code: Oak Ridge, TN
OU# or Site #: Site K-25

Primary point of contact: OSTI.gov/bridge document #: DOE/OR/22160-T22 vol 1 & 2
Organization: 
Address: 
City, State, Zip Code: 
Phone #: email: 

Other contacts or vendors who worked on site: None
Point of contact: 
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: 
Address: 
City, State, Zip Code: 
Phone #: email: 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data 
Good pre- and post-treatment soil data 
Good temperature profile vs. time information 
Flux assessment 
Groundwater elevations 
Geologic cross-section 
Hydraulic Conductivity information
General Site Assessment Data

Facility ID: 0768

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): ________
- Width (ft.): ________
- Thickness (ft.): ________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: ________
- Pre-treatment: ________
- Post-treatment: ________
- None

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: ________
- Number of relevant soil borings with post-treatment data: ________
- Number inside treatment zone: ________
- Number outside treatment zone: ________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossit</td>
<td></td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzenedicloride</td>
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<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>None</td>
<td>None</td>
</tr>
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<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
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<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>p-xylene</td>
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<td>None</td>
<td>0.01 mg/kg</td>
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<tr>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- 

**Attachments:**

- 

- 

- 

- 

- 

- 

- 

- 

- 

- 

### Unconsolidated Sediments

**Vadose Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Aquifer Characteristics:

**Is more than 1 aquifer present?**
- No
- Yes (number): _____________
  - Aquifer 1
  - Aquifer 2
  - Aquifer 3
- Unknown (assume single aquifer)

**Depth to water:**
- Low value (ft bgs): _____________
- High value (ft bgs): _____________
- Unknown: _____________

**Flow direction:**
- _____________

**Horizontal hydraulic gradient (feet/foot):**
- _____________
- Unknown

**Vertical hydraulic gradient (feet/foot):**
- _____________
- Unknown

**K range (ft/day):**
- Measured using: Slug Test Laboratory Field data
  - Low: _____________
  - High: _____________
  - Unknown

**Transmissivity (ft²/day):**
- Measured using: Slug Test Laboratory Field data
  - Low: _____________
  - High: _____________
  - Unknown

### Comments:
- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________

### Attachments:
- __________________________________________________________________________
- __________________________________________________________________________
### Thermal Treatment - Design

#### Facility ID:
0768

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

#### Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

#### Start of Thermal Test:
- 6/13/1995
- Duration: 26 d

#### Hydraulic Control
- Yes
- No

#### Treatment Cell Design:
- Size of target zone (ft^2): 400
- Thickness of target zone (ft): 70
- Depth to top of target zone (ft bgs): 0
- Thickness of target zone below water table (ft): 0
- Number of energy delivery points: 11
- Number of extraction points: 4
- Date
- Temperature (deg C)

#### Temperature Profile:
- Initial formation temperature (deg C): 18
- Maximum representative formation temperature (deg C): 75
- Time to reach maximum representative temperature (days): 25
- Duration of treatment at representative temperature (days): 1

#### Mass of contaminant removed:
- Via liquid pumping: Unknown
- In vapor stream: Unknown
- Total: Unknown

#### Comments:

#### Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
General comments on the thermal application:

Cost was $144/ton

Lessons Learned

Cost

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost: ____________ kWhr ____________ kWhr/yd³

Other Cost 1: ____________

Other Cost 2: ____________

Other Cost 3: ____________

Please note other cost: ____________

Energy

Total Energy Used: 25900 kWhr ____________ kWhr/m³ ____________ kWhr/yd³

Total energy applied to treatment zone: ____________ kWhr/m³ ____________ kWhr/yd³

Other energy: ____________ kWhr/m³ ____________ kWhr/yd³

Please note other energy: ____________

Energy

Remediation Goal:

In Soil:

1) Heat to 85 to 95 C  2) measure extracted gas flowrate  3) collect and condense extracted gas samples  4) measure energy  5) measure temperature distribution with time and energy

Was the Remediation Goal Achieved:

In Groundwater: ____________

Comment: ____________

In Soil: ____________

Comment: ____________
<table>
<thead>
<tr>
<th>General Site Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Analyzed By: JT PD</td>
</tr>
<tr>
<td>Date: 11/14/2006</td>
</tr>
<tr>
<td>Type of treatment: Conductive Steam ERH Other:</td>
</tr>
<tr>
<td>Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
</tr>
<tr>
<td>Treatment Status: Active Post</td>
</tr>
<tr>
<td>Type of Test: Pilot Test Full Scale System</td>
</tr>
<tr>
<td>Start of Test: 8/7/2000 End of Test: 11/5/2000 Duration: 88d</td>
</tr>
<tr>
<td>Type of Site: Non-DOD DoD</td>
</tr>
</tbody>
</table>

| Facility Name: Air Force Plant 4 |
| Address: |
| City, State, Zip Code: Ft. Worth, TX |
| OU# or Site #: Building 181 |

| Primary point of contact: George Walters |
| Organization: Air Force |
| Address: ASC/ENVR 1801 Tenth St., Suite 2 |
| City, State, Zip Code: Wright-Patterson AFB, OH 45433-7626 |
| Phone #: 937-255-1988 email: george.walters@wpafb.af.mil |

| Other contacts or vendors who worked on site: None |
| Point of contact: Craig Holloway |
| Type: Vendor, Consultant Vendor, Technical Applications Other |
| Organization: URS |
| Address: 9400 Amberglen Boulevard |
| City, State, Zip Code: Austin, TX 78729 |
| Phone #: 512-454-4797 email: craig_holloway@urscorp.com |

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
## General Site Assessment Data

**Facility ID:** 0770

### Impacted Zone

- **Length (parallel to flow direction)(ft.):** 1270
- **Width (ft):** 700
- **Thickness (ft):** 10

**Notes:**
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells

- **Number of relevant monitoring wells with groundwater data:**
  - Pre-treatment: 6
  - Post-treatment: 1

**Notes:**

### Soil Borings

- **Number of relevant soil borings with pre-treatment data:** 1
- **Number of relevant soil borings with post-treatment data:** 1

- **Number inside treatment zone:** 1
- **Number outside treatment zone:** 1

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Crosscap</td>
<td></td>
<td>50 mg/L</td>
<td>10 mg/kg</td>
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<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>Crosscap</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td>Crosscap</td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td>cis-1,2-dichloroethylene</td>
<td>Benzene</td>
<td>Crosscap</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethylene</td>
<td>Toluene</td>
<td>Crosscap</td>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<tr>
<td>1,2-dichloroethane</td>
<td>m+p-xylene</td>
<td>Crosscap</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>Crosscap</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>m+p-xyylene</td>
<td>Crosscap</td>
<td></td>
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<tr>
<td>1,1,2,2-tetrachloroethane</td>
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<td>Crosscap</td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td>vinyl chloride</td>
<td></td>
<td>Crosscap</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- Additional comments and notes

### Attachments:

- Map attachment
- Other supporting documents
Hydrogeologic Conceptual Model

Geology:  

Zone | Unconsolidated Sediments  
--- | --------------------------  
Vadose Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  
Saturated Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Ground surface elevation based on wells in or adjacent to treatment zone:  

f amsl  

Is more than 1 aquifer present?  

- Yes (number):  

Aquifer 1  
- Aquifer 2  
- Aquifer 3  

Depth to water:  
- low value (ft bgs):  
  - 27  
- high value (ft bgs):  
  - 30  
- Unknown:  

Flow direction:  

- NE  

Horizontal hydraulic gradient (feet/foot):  
- Vertical hydraulic gradient (feet/foot):  

K range (ft/day):  

Measured using:  
- Slug Test  
- Laboratory  
- Field data  

Low  
- High  

Transmissivity (ft2/day):  

Measured using:  
- Slug Test  
- Laboratory  
- Field data  

Low  
- High  

Comments:  

Other - Terrace aluvium aquifer  
K=0.05 ft/day to 4.51 ft/day  
Horizontal hydraulic gradient - 0.004  

Attachments:
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone
- Other (describe)

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 8/7/2000
- Duration: 84d

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:
- Size of target zone (ft²): 1120
- Thickness of target zone (ft): 17
- Depth to top of target zone (ft bgs): 2.5
- Thickness of target zone below water table (ft): 2
- Number of energy delivery points: 7
- Number of extraction points: 15

Temperature Profile:
- Initial formation temperature (deg C): 22
- Maximum representative formation temperature (deg C): 110
- Time to reach maximum representative temperature (days): 40
- Duration of treatment at representative temperature (days): 20

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Mass of contaminant removed:
- Via liquid pumping: 2.45 lb
- In vapor stream: 150 lb
- Total: 150 lb

Volume treated - 3930 cubic yds

Notes: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance Facility ID#: 0770

Remediation Goal:
- In Groundwater: TCE less than 10 mg/L
- In Soil: TCE less than 11.5 mg/kg

Was the Remediation Goal Achieved:
- In Groundwater
  Comment: Yes, except for WJETA062 at 10.7 mg/L
- In Soil
  Comment: Yes

General comments on the thermal application:

Objective: Reach the boiling point of TCE at depth

Lessons Learned

Energy

Total Energy Used:
- ___________ kWh
- ___________ kWh/m³
- ___________ kWh/yard³
- ___________ Total energy applied to treatment zone:
- ___________ kWh/m³
- ___________ kWh/yard³
- ___________ Other energy:
- ___________ kWh/m³
- ___________ kWh/yard³
- Please note other energy: ________________

Cost

Total Project Cost: 548306
- Consultant Cost: ________________
- Thermal Vendor Cost: ________________
- Energy Cost: 28588
  ___________ m³ ___________ yard³
- Other Cost 1: 286718
- Other Cost 2: 188515
- Other Cost 3: 44485
- Please note other cost: ________________
  - Other Cost 1: capital cost
  - Other Cost 2: operation and maintenance
  - Other Cost 3: other technology specific cost
General Site Information

File Analyzed By: JT PD Date: 4/7/2005
Type of treatment:  ____ Conductive  ____ Steam  x ERH  ____ Other: _______________
Type of Contaminant:  x Chlorinated Solvents  ____ Petroleum Hydrocarbons  ____ Pesticides
 ____ Wood Treating  ____ Other: ____________________________
Treatment Status:  ____ Active  x Post
Type of Test:  ____ Pilot Test  x Full Scale System
Start of Test: 5/13/2002  End of Test: 2/19/2002  Duration: 221 d
Type of Site:  ____ Non-DOD  x DoD

Facility Name: Air Force Plant 4
Address: __________________________________________
City, State, Zip Code: Ft. Worth, TX
OU# or Site #: Building 181

Primary point of contact: George Walters
Organization: Air Force
Address: ASC/ENVR 1801 Tenth St., suite 2
City, State, Zip Code: Wright-Patterson AFB OH 45433-7626
Phone #: 937-255-1988  email: george.walters@wpafb.af.mil

Other contacts or vendors who worked on site  ____ None
Point of contact: Craig Holloway
Type:  x Vendor, Consultant  ____ Vendor, Technical Applications  ____ Other  _______________
Organization: URS
Address: 9400 Amberglen Boulevard
City, State, Zip Code: Austin, TX 78729
Phone #: 512-454-4797  email: craig_holloway@urscorp.com

QA/QC

____ Characteristics of Interest
 ____ Good pre- and post-treatment groundwater data  ____ Good pre- and post-treatment soil data
 ____ Good temperature profile vs. time information  ____ Flux assessment
 ____ Groundwater elevations  ____ Geologic cross-section
 ____ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0780

#### Impacted Zone:
- **Length (parallel to flow direction)(ft.):** 1370
- **Width (ft):** 700
- **Thickness (ft):** Unknown
- **Impacted zone as defined by documentation**
- **Alternative method for determining size of impacted zone (See source zone definition attachments)**
- **Map attachment**

#### Monitor Wells:
- **Number of relevant monitoring wells with groundwater data:**
  - Pre-treatment: 10
  - Post-treatment: 10
- **Number of wells relative to treatment zone:**
  - Pre-treatment: In: 1 Upgradient: 1 Downgradient: 1 Crossgradient: 1
  - Post-treatment: In: 1 Upgradient: 1 Downgradient: 1 Crossgradient: 1
- **Comments:**

#### Soil Borings:
- **Number of relevant soil borings with pre-treatment data:** 10
- **Number of relevant soil borings with post-treatment data:** 10
- **Number inside treatment zone:** 10
- **Number outside treatment zone:** 10

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Toluene</td>
<td>Jet Fuel</td>
<td>Crossdr</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
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<td>None</td>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td></td>
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<td>None</td>
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<td>Benzene</td>
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<td>None</td>
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<td>Vinyl Chloride</td>
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#### Comments:

- None

#### Attachments:

- None
<table>
<thead>
<tr>
<th>Geology: Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: 650 ft amsl

Is more than 1 aquifer present? Yes (number): 2

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction: NE

Horizontal hydraulic gradient (feet/foot): 0.008
Vertical hydraulic gradient (feet/foot):

K range (ft/day) Measured using: Slug Test Laboratory Field data
low 13 | | | Unknown |
high 132 | | | |
Transmissivity (ft2/day) Measured using: Slug Test Laboratory Field data
low 0.067 | | | Unknown |
high 0.88 | | | |

Comments:
Other - Terrace aluvium aquifer K=0.05 ft/day to 4.51 ft/day
Horizontal hydraulic gradient - 0.004

Attachments:
### Thermal Treatment - Design

**Facility ID:** 0780

#### Thermal treatment:
- Conductive
- Electrical Resistance
- Steam
  - 3 phase
  - 6 phase
  - AC power
  - DC power
  - Steam
  - Steam + air
  - Steam + O2
  - Other (describe)

#### Type of Test:
- Pilot test
- Full-scale System

#### Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

#### Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

#### Start of Thermal Test:
- 5/13/2002
- Duration: 271 d

#### Hydraulic Control
- Yes
- No

#### Treatment Cell Design:
- Size of target zone (ft²): 21,780
- Thickness of target zone (ft): 77
- Depth to top of target zone (ft bgs): 0
- Thickness of target zone below water table (ft): 4
- Number of energy delivery points: 73
- Number of extraction points: 10
- Unknown
- Unknown
- Unknown
- Unknown
- Unknown

#### Temperature Profile:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

- Initial formation temperature (deg C): 23.4
- Maximum representative formation temperature (deg C): 90
- Time to reach maximum representative temperature (days): 100
- Duration of treatment at representative temperature (days): 121

- Formation temperature immediately post-treatment:
- Formation temperature post-treatment monitoring event 1:
- Duration of post-treatment monitoring (days):

#### Mass of contaminant removed:

- Via liquid pumping: 0.227 lb x kg
- In vapor stream: 640.9 lb x kg
- Total: 641.15 lb x kg

#### Comments:

#### Attachments:

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Cost and Performance

#### Facility ID:
0780

**Performance**

**Remediation Goal:**

- **In Groundwater:** TCE less than 10 mg/L
- **In Soil:** TCE less than 11.5 mg/kg

**Was the Remediation Goal Achieved:**

- **In Groundwater**
  - Comment: Yes, except for WJETA062 at 10.7 mg/L
- **In Soil**
  - Comment: Yes

**General comments on the thermal application:**

<table>
<thead>
<tr>
<th>Energy</th>
<th>Total Energy Used:</th>
<th>1899000</th>
<th>kWhr</th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total energy applied to treatment zone:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Other energy:</td>
<td></td>
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<tr>
<td></td>
<td>Please note other energy:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lessons Learned**

Area near tank did not allow electrodes, and thus area is still above target goal and continues to rise in groundwater, as of 10/2006 well was at 37,000 ppb.

**Cost**

<table>
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<tr>
<td></td>
<td>Energy Cost:</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Other Cost 2: operation and maintenance for technology</td>
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<tr>
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<td>Other Cost 3: other technology specific cost</td>
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### General Site Information

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<tr>
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<td></td>
<td>Type of Contaminant:</td>
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<tr>
<td></td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
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<tr>
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<td>Treatment Status:</td>
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<td></td>
<td>Type of Test:</td>
<td></td>
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<td>Pilot Test Full Scale System</td>
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<td></td>
<td>Type of Site:</td>
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<td></td>
<td>Non-DOD DoD</td>
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<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>Address: San Antonio, TX</td>
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<tr>
<td></td>
<td>OU# or Site #: S-1</td>
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|   | Primary point of contact:       |
|   | Organization:                   |
|   | Address:                        |
|   | City, State, Zip Code:          |
|   | Phone #:                        |
|   | email:                          |

|   | Other contacts or vendors who worked on site None |
|   | Point of contact:               |
|   | Type: Vendor, Consultant Vendor, Technical Applications Other |
|   | Organization:                   |
|   | Address:                        |
|   | City, State, Zip Code:          |
|   | Phone #:                        |
|   | email:                          |

### QA/QC

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</tr>
<tr>
<td></td>
<td>Good pre- and post-treatment soil data</td>
</tr>
<tr>
<td></td>
<td>Good temperature profile vs. time information</td>
</tr>
<tr>
<td></td>
<td>Flux assessment</td>
</tr>
<tr>
<td></td>
<td>Groundwater elevations</td>
</tr>
<tr>
<td></td>
<td>Geologic cross-section</td>
</tr>
<tr>
<td></td>
<td>Hydraulic Conductivity information</td>
</tr>
</tbody>
</table>
General Site Assessment Data

Impact Zone:
- Length (parallel to flow direction)(ft.): __________  Width (ft): __________  Thickness (ft): __________  [Unknown]
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________________
  - Pre-treatment: __________  Post-treatment: __________  [None]
  - Number of relevant monitoring wells with groundwater data:
    - Pre-treatment: __________  Upgradient: __________  Downgradient: __________  Crossgradient: __________
    - Post-treatment: __________  Upgradient: __________  Downgradient: __________  Crossgradient: __________

Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________  Number of relevant soil borings with post-treatment data: __________
  - Number inside treatment zone: __________  Number outside treatment zone: __________
  - Number of wells relative to treatment zone:
    - Pre-treatment: __________  In: __________  Upgradient: __________  Downgradient: __________  Crossgradient: __________
    - Post-treatment: __________  In: __________  Upgradient: __________  Downgradient: __________  Crossgradient: __________

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemical of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
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<td>None</td>
</tr>
<tr>
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<td>None</td>
</tr>
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<td>Ethylene</td>
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<tr>
<td>1,1,2-trichloroethene</td>
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</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
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<td>None</td>
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</tr>
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Comments:

Attachments:
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: 690 ft amsl

Is more than 1 aquifer present?  No  Yes (number):  x  Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
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<tbody>
<tr>
<td></td>
<td>low value (ft bgs): 74</td>
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<td></td>
<td>high value (ft bgs): 73</td>
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<td></td>
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Flow direction

Horizontal hydraulic gradient (feet/foot):  

Vertical hydraulic gradient (feet/foot):  

K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>15.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
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</table>

Transmissivity (ft2/day):  

<table>
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<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Attachments:
Thermal Treatment - Design

**Thermal treatment:**
- **Conductive**
- **Electrical Resistance**
  - 3 phase
  - 6 phase
  - AC power
  - DC power
- **Steam**
  - Steam
  - Steam + air
  - Steam + O2
- **Other (describe)**: RFH (IITRI)

**Type of Test:**
- Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:** 4/3/1993
**Duration:** 61 d

**Treatment Cell Design:**
- **Hydraulic Control**
- **Yes**
- **No**

**Size of target zone (ft2):** 141
**Thickness of target zone (ft):** 23.3
**Depth to top of target zone (ft bgs):** 0
**Thickness of target zone below water table (ft):** 0
**Number of energy delivery points:** 4
**Number of extraction points:** 16

**Temperature Profile:**
- **Initial formation temperature (deg C):** 20
- **Maximum representative formation temperature (deg C):** 110
- **Time to reach maximum representative temperature (days):** 56
- **Duration of treatment at representative temperature (days):** 4

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Formation temperature immediately post-treatment:**

**Formation temperature post-treatment monitoring event 1:**

**Duration of post-treatment monitoring (days):**

**Mass of contaminant removed:**
- Via liquid pumping: ___________________________ lb _____ kg _____ Unknown
- In vapor stream: ___________________________ lb _____ kg _____ Unknown
- Total: ___________________________ lb _____ kg _____ Unknown

**Comments:**

**Attachments:**

---

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater:

Comment:

In Soil:

Comment:

General comments on the thermal application:

Lessons Learned

Total Energy Used:

Total energy applied to treatment zone:

Other energy:

Please note other energy:

Energy Cost:

Consultant Cost:

Thermal Vendor Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Cost

Total Project Cost: 2536093

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
General Site Information

File Analyzed By: JT PD
Type of treatment: Conductive Steam ERH Other: RFH
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: ____________________________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 4/26/1994
End of Test: 6/14/1994
Duration: 50 d
Type of Site: Non-DOD DoD

Facility Name: Kelly AFB (KAI)
Address: __________________________________________
City, State, Zip Code: San Antonio, TX
OU# or Site #: S-1
Primary point of contact:
Organization: ______________________________________
Address: __________________________________________
City, State, Zip Code: _________________________________
Phone #: ______________________________ email: ____________________________

Other contacts or vendors who worked on site:
Point of contact:
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: __________________________________________
Address: __________________________________________
City, State, Zip Code: _________________________________
Phone #: ______________________________ email: ____________________________

QA/QC

Characteristics of Interest
____ Good pre- and post-treatment groundwater data
____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information
____ Flux assessment
____ Groundwater elevations
____ Geologic cross-section
____ Hydraulic Conductivity information
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
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<td>None</td>
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<td>None</td>
<td>None</td>
</tr>
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<td>Vinyl Chloride</td>
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</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- Additional details or notes related to the assessment data.

### Attachments:

- Any supplementary documents or data related to the site assessment.
## Hydrogeologic Conceptual Model

### Geology:

**Zone** | **Unconsolidated Sediments** |  
--- | --- |  
Vadose Zone: |  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Saturated Zone: |  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

### Ground surface elevation based on wells in or adjacent to treatment zone:

- 690 ft amsl  
- Unknown

### Aquifer Characteristics:

- Is more than 1 aquifer present?  
  - No  
  - Yes (number):  
  - Unknown (assume single aquifer)  

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
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</tr>
</tbody>
</table>

- Flow direction ::

### Horizontal hydraulic gradient (feet/foot):

- Unknown

### Vertical hydraulic gradient (feet/foot):

- Unknown

### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>15.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
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</tr>
</tbody>
</table>

### Transmissivity (ft²/day):

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<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

-  

### Attachments:

-  

---

Facility ID#: 0001
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power
Steam
  - Steam
  - Steam + air
  - Steam + O2

Other (describe)  RFH (KAI)

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 4/26/1994
- Duration: 50 d

Hydraulic Control  
- Yes
- No

10. Treatment Cell Design:

Size of target zone (ft2): 141
Thickness of target zone (ft): 33.3
Depth to top of target zone (ft bgs): 0
Thickness of target zone below water table (ft): 0
Number of energy delivery points: 4
Number of extraction points: 16

4. Temperature Profile:

Initial formation temperature (deg C): Unknown
Maximum representative formation temperature (deg C): Unknown
Time to reach maximum representative temperature (days): Unknown
Duration of treatment at representative temperature (days): Unknown

Date           Temperature (deg C)

Formation temperature immediately post-treatment: Unknown
Formation temperature post-treatment monitoring event 1: Unknown
Duration of post-treatment monitoring (days): Unknown

0. Mass of contaminant removed:

Via liquid pumping: Unknown
In vapor stream: Unknown
Total: Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

- In Groundwater: ____________________________________________________________________________
- In Soil: ________________________________________________________________________________

Was the Remediation Goal Achieved:

- In Groundwater: __________________________________________________________________________
  Comment: ________________________________________________________________________________
- In Soil: ________________________________________________________________________________
  Comment: ________________________________________________________________________________

General comments on the thermal application:

__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

Lessons Learned

__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

Energy

Total Energy Used: _________________________________________________________________________
  __kWhr __kWhr/m³ __kWhr/yd³
  __Total energy applied to treatment zone: _________________________________________________________________________
  __Other energy: _________________________________________________________________________
  __Please note other energy: _________________________________________________________________________

Cost

Total Project Cost: 2477216

- Consultant Cost: _________________________________________________________________________
- Thermal Vendor Cost: _______________________________________________________________________
- Energy Cost: _____________________________________________________________________________
  __m³ __yd³
- Other Cost 1: _____________________________________________________________________________
- Other Cost 2: _____________________________________________________________________________
- Other Cost 3: _____________________________________________________________________________
- Please note other cost: _______________________________________________________________________
  __Other Cost 1: _____________________________________________________________________________
  __Other Cost 2: _____________________________________________________________________________
  __Other Cost 3: _____________________________________________________________________________
General Site Information

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<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th>9/27/2006</th>
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<tr>
<td>Type of treatment:</td>
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<td>ERH</td>
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<td>Type of Contaminant:</td>
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<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
<td>Other:</td>
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<td>Treatment Status:</td>
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<td>Post</td>
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<td></td>
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<td>Type of Test:</td>
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<td>Full Scale System</td>
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<td>Start of Test:</td>
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<td>End of Test: 2003</td>
<td>Duration: varied</td>
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<td>Type of Site:</td>
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<td>DoD</td>
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Facility Name: Petro-Chemical System (AKA Turtle Bayou)

Address: __________________________
City, State, Zip Code: Liberty, TX
OU# or Site #: __________________________

Primary point of contact: Chris Villarreal

Organization: US EPA

Address: __________________________
City, State, Zip Code: __________________________
Phone #: 214-665-6758 email: chris.villarreal@epamail.epa.gov

Other contacts or vendors who worked on site: None

Point of contact: __________________________
Type: Vendor, Consultant Vendor, Technical Applications Other

Organization: __________________________
Address: __________________________
City, State, Zip Code: __________________________
Phone #: __________________________ email: __________________________

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
**General Site Assessment Data**

### Impacted Zone
- Length (parallel to flow direction)(ft.):  
- Width (ft.):  
- Thickness (ft.):  

- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells
- Number of relevant monitoring wells with groundwater data:
  - Pre-treatment:  
  - Post-treatment:  

- Number of wells relative to treatment zone:
  - Pre-treatment: In:  
  - Upgradient:  
  - Downgradient:  
  - Crossgradient:  
  - Post-treatment: In:  
  - Upgradient:  
  - Downgradient:  
  - Crossgradient:

### Soil Borings
- Number of relevant soil borings with pre-treatment data: 1, 3, 1, 1, 2
- Number of relevant soil borings with post-treatment data:
  - Number inside treatment zone: 1, 2, 1, 1, 2
  - Number outside treatment zone:  

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Trihalomethanes</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<td>Tetrahalomethanes</td>
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<td>cis-1,2-dichloroethene</td>
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<td>Vinyl Chloride</td>
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<td>12-DCE</td>
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<td>Other</td>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
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<td></td>
<td></td>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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</tbody>
</table>

**Comments:**

# of borings per cell for example: 1, 2, 3, and 4

**Attachments:**
Hydrogeologic Conceptual Model

Geology:

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-beded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-beded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: _______ ft amsl _______ Unknown

Aquifer Characteristics:

Is more than 1 aquifer present? __ No __ x Yes (number): _____________ _____________ Unknown (assume single aquifer)

Depth to water:
- low value (ft bgs): 12
- high value (ft bgs): 22
- Unknown:

Flow direction: S to SW

Horizontal hydraulic gradient (feet/foot):
- _______ _______ _______ _______ _______ Unknown

Vertical hydraulic gradient (feet/foot):
- _______ _______ _______ _______ _______ Unknown

K range (ft/day)
- Measured using: Slug Test Laboratory Field data
- low below: _______ _______ _______ Unknown
- high _______ _______ _______ _______ _______ _______ _______

Transmissivity (ft²/day):
- Measured using: Slug Test Laboratory Field data
- low below: _______ _______ _______ Unknown
- high _______ _______ _______ _______ _______ _______ _______

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<th>K(ft/day)</th>
<th>T (ft²/day)</th>
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<td>C1</td>
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<td>0.0036</td>
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<td>0.09</td>
<td>S1</td>
<td>5</td>
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Comments:

Attachments: ________________________________

______________________________

______________________________
Thermal Treatment - Design

Facility ID#: 0810

Thermal treatment:  

- [x] Conductive
- [ ] Electrical Resistance

Main Waste area:

- [x] Steam
- [ ] Steam + air
- [ ] Steam + O2
- [ ] Other (describe)

Type of Test:  

- [x] Pilot test
- [ ] Full-scale System

Geology of Treatment Zone:

- [x] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded layers of higher permeability material
- [ ] Largely impermeable sediments with inter-bedded lenses of lower permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

Treatment Target Zone:

- [x] Saturated only
- [ ] Vadose only
- [x] Both (Saturated and Vadose zones)

Start of Thermal Test:  

- [x] Dec-01

Duration:  

- [x] 27 months

Hydraulic Control:

- [x] Yes
- [ ] No

Treatment Cell Design:

Size of target zone (ft²):  

- [ ] Unknown  

(  ____ x  ____ ft)

Thickness of target zone (ft):  

- [ ] Unknown  

22

Depth to top of target zone (ft bgs):  

- [ ] Unknown  

2

Thickness of target zone below water table (ft):  

- [ ] Unknown  

12

Number of energy delivery points:  

- [ ] Unknown  

1

Number of extraction points:  

- [ ] Unknown  

20

Temperature Profile:

Initial formation temperature (deg C):  

- [ ] Unknown  

x

Maximum representative formation temperature (deg C):  

- [ ] Unknown  

x

Time to reach maximum representative temperature (days):  

- [ ] Unknown  

x

Duration of treatment at representative temperature (days):  

- [ ] Unknown  

x

Formation temperature immediately post-treatment:  

- [ ] Unknown  

x

Formation temperature post-treatment monitoring event 1:  

- [ ] Unknown  

x

Duration of post-treatment monitoring (days):  

- [ ] Unknown  

x

Mass of contaminant removed:

Via liquid pumping:  

- [ ] Unknown  

x

In vapor stream:  

- [ ] Unknown  

x

Total:  

- [ ] Unknown  

x

Date

Temperature (deg C)

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
- West waste area  
- 3 phase  
- 6 phase  
- AC power  
- DC power

Steam  
- Steam  
- Steam + air  
- Steam + O2

Other (describe)

Type of Test:  
- Pilot test  
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
- Oct-98  
- Duration: 43 months

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

Size of target zone (ft2):  

Thickness of target zone (ft):  
- 28  
- Unknown

Depth to top of target zone (ft bgs):  
- 9  
- Unknown

Thickness of target zone below water table (ft):  
- 16  
- Unknown

Number of energy delivery points:  
- 12  
- Unknown

Number of extraction points:  
- 16  
- Unknown

Temperature Profile:

Initial formation temperature (deg C):  
- Unknown

Maximum representative formation temperature (deg C):  
- Unknown

Time to reach maximum representative temperature (days):  
- Unknown

Duration of treatment at representative temperature (days):  
- Unknown

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:

Via liquid pumping:  
- Unknown

In vapor stream:  
- Unknown

Total:  
- Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Thermal Treatment - Design

**Facility ID:** 0810

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Office trailer area</th>
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<tbody>
<tr>
<td>Electrical Resistance</td>
<td>3 phase</td>
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<tr>
<td>Steam</td>
<td>AC power</td>
<td>DC power</td>
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<table>
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<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
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<tbody>
<tr>
<td>Geology of Treatment Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded layers of lower permeability material</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>Weathered bedrock, limestone, sandstone</td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
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<tbody>
<tr>
<td>Start of Thermal Test:</td>
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| Hydraulic Control | Yes | No |

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<th>Treatment Cell Design:</th>
<th><strong>Date</strong></th>
<th><strong>Temperature (deg C)</strong></th>
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</thead>
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<tr>
<td>Size of target zone (ft²):</td>
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<td>Thickness of target zone (ft):</td>
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<tr>
<td>Depth to top of target zone (ft bgs):</td>
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<tr>
<td>Thickness of target zone below water table (ft):</td>
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<tr>
<td>Number of energy delivery points:</td>
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<tr>
<td>Number of extraction points:</td>
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<tr>
<th>Temperature Profile:</th>
<th><strong>Date</strong></th>
<th><strong>Temperature (deg C)</strong></th>
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</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
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</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
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<td></td>
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<tr>
<td>Time to reach maximum representative temperature (days):</td>
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<tr>
<td>Duration of treatment at representative temperature (days):</td>
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<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
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<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
<th><strong>lb</strong></th>
<th><strong>kg</strong></th>
<th><strong>Date</strong></th>
<th><strong>Temperature (deg C)</strong></th>
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<tbody>
<tr>
<td>Via liquid pumping:</td>
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</tr>
<tr>
<td>In vapor stream:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total:</td>
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<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
**Thermal Treatment - Design**

**Thermal treatment:**
- Conductive

**Type of Test:**
- Pilot test

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Large permeable sediments with inter-bedded lenses of lower permeability material

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- Oct-98

**Duration:**
- 39 months

**Hydraulic Control:**
- Yes
- No

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft^2):</th>
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<tr>
<td>Thickness of target zone (ft):</td>
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<td>Depth to top of target zone (ft bgs):</td>
<td>2</td>
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<td>Thickness of target zone below water table (ft):</td>
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<td>Number of energy delivery points:</td>
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<td>Number of extraction points:</td>
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**Thermal Treatment:**

<table>
<thead>
<tr>
<th>Steam + air</th>
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</thead>
<tbody>
<tr>
<td>Steam + O2</td>
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</table>

**Facility ID #:**
- 0810

**Mass of contaminant removed:**

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<thead>
<tr>
<th>Via liquid pumping:</th>
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<tbody>
<tr>
<td>In vapor stream:</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Temperature Profile:**

| Initial formation temperature (deg C): | Unknown |
| Maximum representative formation temperature (deg C): | Unknown |
| Time to reach maximum representative temperature (days): | Unknown |
| Duration of treatment at representative temperature (days): | Unknown |

**Duration of post-treatment monitoring (days):**
- Date
- Temperature (deg C)

**Notes:**
- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment:  

- Conductive  
- Electrical Resistance  
- Easement South  
- 3 phase  
- 6 phase  
- AC power  
- DC power  
- Steam  
- Steam + air  
- Steam + O2

Type of Test: 
- Pilot test  
- Full-scale System

Geology of Treatment Zone: 
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded layers of lower permeability material  
- Largely impermeable sediments with inter-bedded lenses of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone: 
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test: 
- Oct-98  
- Duration: 39 months

Hydraulic Control: 
- Yes  
- No

Treatment Cell Design:
- Size of target zone (ft²):  
- Thickness of target zone (ft):  
- Depth to top of target zone (ft bgs):  
- Thickness of target zone below water table (ft):  
- Number of energy delivery points:  
- Number of extraction points:  

Temperature Profile:
- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C):  
- Time to reach maximum representative temperature (days):  
- Duration of treatment at representative temperature (days):  

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<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
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Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:
- Via liquid pumping:  
- In vapor stream:  
- Total:  

<table>
<thead>
<tr>
<th></th>
<th>lb</th>
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Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance  
Facility ID#: 0810

**Remediation Goal:**
*In Groundwater*
*In Soil*

**Was the Remediation Goal Achieved:**
*In Groundwater*
Comment: 

*In Soil*
Comment: 

**General comments on the thermal application:**

**Lessons Learned**

**Energy**

Total Energy Used:  

Total energy applied to treatment zone:  

Other energy:  

Please note other energy:  

**Cost**

Total Project Cost:  

Consultant Cost:  

Thermal Vendor Cost:  

Energy Cost:  

Other Cost 1:  

Other Cost 2:  

Other Cost 3:  

Please note other cost:  

Other Cost 1:  

Other Cost 2:  

Other Cost 3:  

**Comment:**

**General comments on the thermal application:**

In Soil:

In Groundwater:

**Was the Remediation Goal Achieved:**

In Groundwater:  

Comment:  

In Soil:  

Comment:  

**Lessons Learned**  

**Energy**

Total Energy Used:  

Total energy applied to treatment zone:  

Other energy:  

Please note other energy:  

**Cost**

Total Project Cost:  

Consultant Cost:  

Thermal Vendor Cost:  

Energy Cost:  

Other Cost 1:  

Other Cost 2:  

Other Cost 3:  

Please note other cost:  

Other Cost 1:  

Other Cost 2:  

Other Cost 3:  

**Comment:**

**General comments on the thermal application:**

In Soil:

In Groundwater:

**Was the Remediation Goal Achieved:**

In Groundwater:  

Comment:  

In Soil:  

Comment:  

**Lessons Learned**
General Site Information

File Analyzed By: JT PD

Type of treatment: Conductive Steam ERH Other:

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System

Start of Test: ___________________________ End of Test: ___________________________ Duration: ____________

Type of Site: Non-DOD DoD

Facility Name: Shell's Gasmer Rd, R&D Facility

City, State, Zip Code: TX

OU# or Site #:

Primary point of contact: Denis Conley

Organization: Haley & Aldrich

Address: 200 Town Centre Dr.

City, State, Zip Code: Rochester, NY 14623

Phone #: 585-321-4246 email: dconley@haleyaldrich.com

Other contacts or vendors who worked on site None

Point of contact:

Type: Vendor, Consultant Vendor, Technical Applications Other

Organization:

Address:

City, State, Zip Code:

Phone #: email:

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data

Good temperature profile vs. time information Flux assessment

Groundwater elevations Geologic cross-section

Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:** Length (parallel to flow direction)(ft.):  
Width (ft.):  
Thickness (ft.):  
Unknown

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: None
- Number of wells relative to treatment zone:
  - Pre-treatment: In:  
    Upgradient:  
    Downgradient:  
    Crossgradient:  
  - Post-treatment: In:  
    Upgradient:  
    Downgradient:  
    Crossgradient:  

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data:  
- Number of relevant soil borings with post-treatment data:  
- Number inside treatment zone:  
- Number outside treatment zone:  

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
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<td>None</td>
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<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>trans-1,2-dichloroethene</td>
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<td>1,1,2,2-tetrachloroethane</td>
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<td>Vinyl Chloride</td>
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**Comments:**

- None

**Attachments:**

- None

---

**Facility ID:** 0815
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>___ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>___ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>___ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>___ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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</tr>
<tr>
<td></td>
<td>___ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): ___________</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Flow direction

___

#### Horizontal hydraulic gradient (feet/foot):

___

#### Vertical hydraulic gradient (feet/foot):

___

#### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>K range (ft/day)</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft²/day):

<table>
<thead>
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<th>Laboratory</th>
<th>Field data</th>
<th>Transmissivity (ft²/day)</th>
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</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
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<td></td>
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</table>

#### Facility ID#:

0815

---

### Additional Comments:

---

### Attachments:

---
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>% 3 phase 6 phase AC power DC power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam Steam Steam + air Steam + O2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other (describe)</td>
</tr>
</tbody>
</table>

Type of Test: Pilot test Full-scale System

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: Date

Hydraulic Control: Yes No

Treatment Cell Design:
- Size of target zone (ft²): Unknown
- Thickness of target zone (ft): Unknown
- Depth to top of target zone (ft bgs): Unknown
- Thickness of target zone below water table (ft): Unknown
- Number of energy delivery points: Unknown
- Number of extraction points: Unknown

Temperature Profile:
- Initial formation temperature (deg C): Unknown
- Maximum representative formation temperature (deg C): Unknown
- Time to reach maximum representative temperature (days): Unknown
- Duration of treatment at representative temperature (days): Unknown

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature immediately post-treatment: Unknown
Formation temperature post-treatment monitoring event 1: Unknown
Duration of post-treatment monitoring (days): Unknown

Mass of contaminant removed:
- Via liquid pumping: lb kg Unknown
- In vapor stream: lb kg Unknown
- Total: lb kg Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Facility ID#: 0815

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:

___ In Soil

Comment:

General comments on the thermal application:

Lessons Learned

___ Energy

Total Energy Used: ___ kWhr ___ kWhr/m^3 ___ kWhr/yd^3

___ Total energy applied to treatment zone: ___ kWhr/m^3 ___ kWhr/yd^3

___ Other energy: ___ kWhr/m^3 ___ kWhr/yd^3

___ Please note other energy:

___ Cost

Total Project Cost:

___ Consultant Cost:

___ Thermal Vendor Cost:

___ Energy Cost: ___ m^3 ___ yd^3

___ Other Cost 1:

___ Other Cost 2:

___ Other Cost 3:

___ Please note other cost:

___ Other Cost 1:

___ Other Cost 2:

___ Other Cost 3:
General Site Information

File Analyzed By: JT PD Date: 1/25/2007
Type of treatment: Conductive Steam ERH Other: __________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Other: __________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 1997 End of Test: 1997 Duration: varied
Type of Site: Non-DOD DoD

Facility Name: Ft. Hood / Robert Gray Army Field
Address: __________________________
City, State, Zip Code: Killian, TX
OU# or Site #: ______________________

Primary point of contact: Book: Steam and Electroheating Remediation of Tight Soils
Organization: copyright 2000 by CRC Press, LLC
Address: __________________________
City, State, Zip Code: ______________________
Phone #: __________________________ email: __________________________

Other contacts or vendors who worked on site: None
Point of contact: Dr. C. Herb Ward
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: Rice University
Address: __________________________
City, State, Zip Code: ______________________
Phone #: 713-348-4086 email: wardch@rice.edu

QA/QC

Characteristics of Interest

________ Good pre- and post-treatment groundwater data _______ Good pre- and post-treatment soil data
________ Good temperature profile vs. time information _______ Flux assessment
________ Groundwater elevations _______ Geologic cross-section
________ Hydraulic Conductivity information
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Cross-section on page 9-12**
- **Pre-treatment mass estimate of 199,199.58 pounds**

### Comments:

- None

### Attachments:

- None
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>None</td>
<td>None</td>
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<tr>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
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</tr>
<tr>
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<td>Vinyl Chloride</td>
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<td>None</td>
</tr>
</tbody>
</table>

### Comments:

Cross-section on pag 9-12

Pre-treatment mass estimate of 8984.92 pounds
## General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>In:</td>
<td>Upgradient:</td>
</tr>
<tr>
<td>__________</td>
<td>__________</td>
</tr>
</tbody>
</table>

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________

<table>
<thead>
<tr>
<th>Number inside treatment zone:</th>
<th>Number outside treatment zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td>__________ / __________</td>
<td>__________ / __________</td>
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</table>

## Types of Contaminants

### Chemicals of Concern

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
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<td>None</td>
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</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
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<td>1,1-dichloroethene</td>
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### Comments:

Cross-section on page 9-12

Pre-treatment mass estimate

of 3234.38 pounds

Attachments:

- Cross-section on pag 9-12
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Vadose Zone:</th>
<th>Saturated Zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-beded lenses of lower permeability material</td>
<td>Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-beded layers of higher permeability material</td>
<td>Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Ground surface elevation based on wells in or adjacent to treatment zone: | __________ ft amsl | __ Unknown |

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth to water:</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low value (ft bgs):</td>
<td>9.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Flow direction | East |

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
<td>Aquifer 1</td>
<td>Aquifer 2</td>
<td>Aquifer 3</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>9.45E-06</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>9.30E-05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmissivity (ft²/day):</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
<th>K = 1e-4 cm/sec for weathered shale/limestone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K = 3.3e-8 to 2.1e-9 cm/sec for slug tests.</td>
</tr>
</tbody>
</table>

| Attachments: | |
|--------------||
|              ||
|              ||
Thermal Treatment - Design

Thermal treatment: X Conductive

Electrical Resistance: Cell A

3 phase X 6 phase AC power DC power

Steam

Steam X Steam + air X Steam + O2

Other (describe)

Type of Test: X Pilot test

Relative homogenous and permeable unconsolidated sediments

Relatively homogenous and impermeable unconsolidated sediments

Largely permeable sediments with inter-bedded lenses of lower permeability material

Largely impermeable sediments with inter-bedded layers of higher permeability material

Competent, but fractured bedrock (i.e. crystalline rock)

Weathered bedrock, limestone, sandstone

Treatment Target Zone: X Saturated only X Vadose only X Both (Saturated and Vadose zones)

Start of Thermal Test: 3-1997 (ended 9-5-97) Duration: 6 months

Hydraulic Control X Yes X No

Size of target zone (ft2): 900

Thickness of target zone (ft): 24

Depth to top of target zone (ft bgs): Unknown

Thickness of target zone below water table (ft): Unknown

Number of energy delivery points: 6

Number of extraction points: 4

Initial formation temperature (deg C): 20.5

Maximum representative formation temperature (deg C): 54.4

Time to reach maximum representative temperature (days): Unknown

Duration of treatment at representative temperature (days): Unknown

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping: lb kg Unknown

In vapor stream: lb kg Unknown

Total: 15150 lb kg Unknown

Comments: Hydraulic Fractures at 12, 15, 18, and 21 ft. GW recovery well was upgradient (GW-A) Post mass of 4770.18 pounds

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
## Thermal Treatment - Design

### Facility ID: 0920

**Thermal treatment:**
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power

**Steam Cell B**
- Steam
- Steam + air
- Steam + O2

**Other (describe)**

**Type of Test:**
- Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- Apr-97

**Duration:**
- Unknown

**Hydraulic Control**
- Yes
- No

### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft2):</th>
<th>570</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>22</td>
<td>Unknown</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>4</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>4</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### Temperature Profile:

| Initial formation temperature (deg C): | 21 | Unknown |
| Maximum representative formation temperature (deg C): | Unknown |
| Time to reach maximum representative temperature (days): | Unknown |
| Duration of treatment at representative temperature (days): | Unknown |

**Formation temperature immediately post-treatment:**
- Unknown

**Formation temperature post-treatment monitoring event 1:**
- Unknown

**Duration of post-treatment monitoring (days):**
- Unknown

### Mass of contaminant removed:

- Via liquid pumping: Unknown
- In vapor stream: Unknown
- Total: 7820 lb

**Notes:**

- Hydraulic Fractures at 12, 15, 18, and 21 ft
- the steam injection well (SIM) was completed at 16 ft
- GW recovery well was upgradient (GW-A)
- Post mass of 1165.37

### Attachments:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
</table>

**Comments:**

- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Thermal Treatment - Design

**Facility ID#: 0820**

- **Thermal treatment:**
  - **Conductive**
  - **Electrical Resistance**
    - 3 phase
    - 6 phase
    - AC power
    - DC power

- **Steam**: Cell C
  - Steam
  - Steam + air
  - Steam + O2

- **Other (describe)**

- **Type of Test**: Pilot test
  - Full-scale System

- **Geology of Treatment Zone**: Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Treatment Target Zone**: Saturated only
  - Vadose only
  - Both (Saturated and Vadose zones)

- **Start of Thermal Test**: 7/1/1997 (ended 9/5/97)
  - Duration: 67 days

- **Hydraulic Control**: Yes
  - No

- **Treatment Cell Design**:
  - Size of target zone (ft²): 580
  - Thickness of target zone (ft): 22
  - Depth to top of target zone (ft bgs): Unknown
  - Thickness of target zone below water table (ft): Unknown
  - Number of energy delivery points: 11
  - Number of extraction points: 5

- **Temperature Profile**:
  - Initial formation temperature (deg C): 20.5
  - Maximum representative formation temperature (deg C): 93.3
  - Time to reach maximum representative temperature (days): Unknown
  - Duration of treatment at representative temperature (days): Unknown

- **Formation temperature immediately post-treatment**: Unknown
- **Formation temperature post-treatment monitoring event 1**: Unknown
- **Duration of post-treatment monitoring (days)**: Unknown

- **Mass of contaminant removed**:
  - Via liquid pumping: Unknown
  - In vapor stream: Unknown
  - Total: 2766 lb

- **Comments**: The steam injection well (SIM) was completed at 15 and 18 ft and at 12 ft GW recovery well was upgradient (GW-A)
  - Post mass of 468.30

- **Attachments**: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Facility ID#: 0820

### Performance

Remediation Goal:

- **In Groundwater:**
  - Comment:

- **In Soil:**
  - Comment:

Was the Remediation Goal Achieved:

- **In Groundwater**
  - Comment:

- **In Soil**
  - Comment:

General comments on the thermal application:

- Cells A and B were spaced 41.5 ft apart (center to center) and cells B and C were spaced 31 ft apart (center to center).
- Demonstrate the viability of newly developed remediation methods and to promote more widespread use of effective innovative technologies.
- Objectives: 1) reduce TRPH to 1000 mg/kg or less 2) measure extent of treatment zone 3) id design characteristics important for site selection and scale-up and 4) determine operating costs under normal conditions.

**Lessons Learned**

Measures of success (technical): 1) determine recovery rates of vapor and liquid 2) determine distribution of extracted volatiles and SVOCs by means of vapor-phase chromatographic boil point analysis and 3) determine if heating (soil) front could be monitored by measurements of soil temperature.

### Energy

Total Energy Used: 17612 kWhr

- Total energy applied to treatment zone: kWhr/m³ kWhr/yd³
- Other energy: kWhr/m³ kWhr/yd³
- Please note other energy: kWhr/m³ kWhr/yd³

### Cost

Total Project Cost:

- Consultant Cost:
- Thermal Vendor Cost:
- Energy Cost: m³ yd³
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:
- Please note other cost:
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:
Type of treatment: x Conductive  x Steam  ___ ERH  ___ Other: ________________
Type of Contaminant: x Chlorinated Solvents  ___ Petroleum Hydrocarbons  ___ Pesticides
___ Wood Treating  ___ Other: ________________
Treatment Status: ___ Active  ___ Post
Type of Test: x Pilot Test  ___ Full Scale System
Start of Test: 1997  End of Test: 1997  Duration: ___________
Type of Site: ___ Non-DOD  x DoD

Facility Name: Hill Air Force Base
Address: ________________________________________________________________
City, State, Zip Code: Odgen, UT
OU# or Site #: OU-1
Primary point of contact: Dr. Lloyd Stewart
Organization: ____________________________________________________________
Address: ______________________________________________________________
City, State, Zip Code: ____________________________________________________
Phone #: 877-763-8564  email: bo@praxis-enviro.com

Other contacts or vendors who worked on site: ___ None
Point of contact: _________________________________________________________
Type: ___ Vendor, Consultant  ___ Vendor, Technical Applications  ___ Other  ___ Other
Organization: __________________________________________________________
Address: ______________________________________________________________
City, State, Zip Code: ____________________________________________________
Phone #: ______________________________________________________________
email: ________________________________________________________________

QA/QC

Characteristics of Interest
___ Good pre- and post-treatment groundwater data
___ Good pre- and post-treatment soil data
___ Good temperature profile vs. time information
___ Flux assessment
___ Groundwater elevations  ___ Geologic cross-section
___ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0830

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
</tr>
</thead>
</table>

- Impacted zone as defined by documentation
- Map attachment

<table>
<thead>
<tr>
<th>Monitor Wells:</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Types of Contaminants</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
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<td>trans-1,2-dichloroethene</td>
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<td>None</td>
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</tr>
<tr>
<td>1,1-dichloroethane</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
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<td>Ethylbenzene</td>
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<tr>
<td>Chlorinated Solvents</td>
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<tr>
<td>1,2-dichloroethane</td>
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<td>None</td>
<td>None</td>
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<td>1,1,1-trichloroethane</td>
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<td>1,1,2-trichloroethane</td>
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</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- None

### Attachments:

- None
### Geology:

**Vadose Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
<thead>
<tr>
<th>Height amsl</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

- Is more than 1 aquifer present?
  - No
  - Yes (number): _____________
  - Unknown (assume single aquifer)

**Aquifer 1**
- Depth to water:
  - Low value (ft bgs): _____________
  - High value (ft bgs): _____________
  - Unknown: _____________

**Aquifer 2**
- Depth to water:
  - Low value (ft bgs): _____________
  - High value (ft bgs): _____________
  - Unknown: _____________

**Aquifer 3**
- Depth to water:
  - Low value (ft bgs): _____________
  - High value (ft bgs): _____________
  - Unknown: _____________

**Flow direction**

**Horizontal hydraulic gradient (feet/foot):** _____________

**Vertical hydraulic gradient (feet/foot):** _____________

**K range (ft/day)**

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>_____________</td>
<td>_____________</td>
<td>_____________</td>
</tr>
<tr>
<td>High</td>
<td>_____________</td>
<td>_____________</td>
<td>_____________</td>
</tr>
</tbody>
</table>

**Transmissivity (ft²/day):**

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>_____________</td>
<td>_____________</td>
<td>_____________</td>
</tr>
<tr>
<td>High</td>
<td>_____________</td>
<td>_____________</td>
<td>_____________</td>
</tr>
</tbody>
</table>

### Comments:

- _______________________________________________________________________________________
- _______________________________________________________________________________________
- _______________________________________________________________________________________
- _______________________________________________________________________________________

### Attachments:

- _______________________________________________________________________________________
- _______________________________________________________________________________________
- _______________________________________________________________________________________
- _______________________________________________________________________________________

---

Facility ID# 0830
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - 6 phase
  - AC power
  - DC power

- Steam
  - Steam
  - Steam + air
  - Steam + O2

Other (describe)

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
Duration:  

Hydraulic Control  
- Yes
- No

Treatment Cell Design:  
Size of target zone (ft²):  
- 160
- Unknown

Thickness of target zone (ft):  
- 10
- Unknown

Depth to top of target zone (ft bgs):  
- 0
- Unknown

Thickness of target zone below water table (ft):  
- Unknown

Number of energy delivery points:  
- Unknown

Number of extraction points:  
- Unknown

Temperature Profile:  
Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C):  
Time to reach maximum representative temperature (days):  
Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:

- Via liquid pumping:  
  - Unknown

- In vapor stream:
  - 34 lb
  - kg

Total:  
- Unknown

Date
Temperature (deg C)

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: ______ kWh ______ kWh/m³ ______ kWh/yd³

Total energy applied to treatment zone: ______ kWh/m³ ______ kWh/yd³

Other energy: ______ kWh/m³ ______ kWh/yd³

Please note other energy:

Cost

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost: ______ m³ ______ yd³

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
General Site Information

File Analyzed By: JT PD ERH Other: __________________________ Date: 10/26/2006

Type of treatment: ______ Conductive ______ Steam ______ ERH ______ Other: ____________

Type of Contaminant: ______ Chlorinated Solvents ______ Petroleum Hydrocarbons ______ Pesticides

 ______ Wood Treating ______ Other: __________________________

Treatment Status: ______ Active ______ Post
type: ______ Pilot Test ______ Full Scale System
Start of Test: ______ Sep-00 ______ End of Test: ____________ Duration: 3.5 Years

Type of Site: ______ Non-DOD ______ DoD

Facility Name: Yorktown Naval Shipyards

City, State, Zip Code: Norfolk, VA
OU# or Site #: ____________

Primary point of contact: Linda Cole
Organization: ____________

City, State, Zip Code: ____________
Phone #: 752-322-4734 email: __________________________

Other contacts or vendors who worked on site: ______ None

Point of contact: Jennifer Davis
Type: ______ Vendor, Consultant ______ Vendor, Technical Applications ______ Other ____________
Organization: Navy

City, State, Zip Code: ____________
Phone #: 752-322-4775 email: __________________________

QA/QC

Characteristics of Interest

 ______ Good pre- and post-treatment groundwater data ______ Good pre- and post-treatment soil data

 ______ Good temperature profile vs. time information ______ Flux assessment

 ______ Groundwater elevations ______ Geologic cross-section

 ______ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** (660)

#### Impacted Zone:
- **Length (parallel to flow direction)(ft.):**
- **Width (ft.):**
- **Thickness (ft.):**
- **Impacted zone as defined by documentation:**
- **Alternative method for determining size of impacted zone (See source zone definition attachments):**
- **Map attachment:**

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data:
  - **Pre-treatment:**
  - **Post-treatment:** None

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number inside treatment zone:
- Number outside treatment zone:

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Bencene</td>
<td>Crossgradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Bencene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Bunker Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:

8000 L of Bunker Fuel estimated to have been released.

#### Attachments:

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________
<table>
<thead>
<tr>
<th></th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>x Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>x Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>x Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td>x Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Saturated Zone: | Relatively homogeneous and permeable unconsolidated sediments | x Largely permeable sediments with inter-bedded lenses of lower permeability material |
|                | Relatively homogeneous and impermeable unconsolidated sediments | x Largely impermeable sediments with inter-bedded layers of higher permeability material |
|                | Competent, but fractured bedrock (i.e. crystalline rock) | x Weathered bedrock, limestone, sandstone |

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>No</td>
<td>Yes (number):</td>
<td>Unknown (assume single aquifer)</td>
<td></td>
</tr>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction: __________ __________ __________ __________ __________

Horizontal hydraulic gradient (feet/foot): __________ __________ __________ __________ Unknown
Vertical hydraulic gradient (feet/foot): __________ __________ __________ __________ Unknown

K range (ft/day) Measured using: Slug Test Laboratory Field data
low: __________ __________ __________ __________ Unknown
high: __________ __________ __________ __________

Transmissivity (ft²/day): Measured using: Slug Test Laboratory Field data
low: __________ __________ __________ __________ Unknown
high: __________ __________ __________ __________

Comments:

Attachments:
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#</th>
<th>0840</th>
</tr>
</thead>
</table>

**Thermal treatment:**
- [ ] Conductive
- [ ] Electrical Resistance
- [x] 3 phase
- [ ] 6 phase
- [ ] AC power
- [ ] DC power
- [x] Steam
- [ ] Steam + air
- [ ] Steam + O2
- [ ] Other (describe)

**Type of Test:**
- [ ] Pilot test
- [x] Full-scale System

**Geology of Treatment Zone:**
- [x] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [x] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [x] Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- [ ] Saturated only
- [x] Vadose only
- [x] Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- [x] Sep-00
- Duration: 3.5 yrs

**Hydraulic Control:**
- [ ] Yes
- [ ] No

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>900</th>
<th>Unknown</th>
<th>( x ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>30</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bg):</td>
<td>10</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Temperature Profile:**

| Initial formation temperature (deg C): | Unknown |
| Maximum representative formation temperature (deg C): | Unknown |
| Time to reach maximum representative temperature (days): | Unknown |
| Duration of treatment at representative temperature (days): | Unknown |
| Formation temperature immediately post-treatment: | Date | Temperature (deg C) |
| Formation temperature post-treatment monitoring event 1: | Date | Temperature (deg C) |
| Duration of post-treatment monitoring (days): | Date | Temperature (deg C) |

**Mass of contaminant removed:**

| Via liquid pumping: | 5000 gal / month | lb | kg | Unknown |
| In vapor stream: | 50000 gal / month | lb | kg | Unknown |
| Total: | | lb | kg | Unknown |

**Comments:**

**Attachments:**

---

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- x In Groundwater: 
  0.1 ft of free product or asymptotic removal rates of fuel
- ___ In Soil:

Was the Remediation Goal Achieved:

- ___ In Groundwater
  Comment:

- ___ In Soil
  Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ___ kWh, ___ kWh/m³, ___ kWh/yd³

- ___ Total energy applied to treatment zone: ___ kWh/m³, ___ kWh/yd³
- ___ Other energy: ___ kWh/m³, ___ kWh/yd³

- Please note other energy:

Cost

Total Project Cost: 10000000

- ___ Consultant Cost:
- ___ Thermal Vendor Cost:
- ___ Energy Cost: ___ m³, ___ yd³

- x Other Cost 1: 1000000 / yr
- x Other Cost 2: 600000

- x Please note other cost:
  - x Other Cost 1: O&M
  - x Other Cost 2: Construction
  - ___ Other Cost 3:
### General Site Information

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Analyzed By</td>
<td>JT PD</td>
</tr>
<tr>
<td>Type of treatment:</td>
<td>x ERH x Other:</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>x Chlorinated Solvents</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>x Active x Post</td>
</tr>
<tr>
<td>Type of Test:</td>
<td>x Pilot Test</td>
</tr>
<tr>
<td>Start of Test:</td>
<td>x Full Scale System</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>x Non-DOD x DoD</td>
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<tr>
<td>Facility ID#:</td>
<td>0845</td>
</tr>
<tr>
<td>Date</td>
<td>10/30/2006</td>
</tr>
<tr>
<td>Facility Name:</td>
<td>Richmond, VA</td>
</tr>
<tr>
<td>Address</td>
<td></td>
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<tr>
<td>City, State, Zip Code:</td>
<td>Richmond, VA</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td></td>
</tr>
<tr>
<td>Primary point of contact:</td>
<td>David Fleming</td>
</tr>
<tr>
<td>Organization:</td>
<td>TRS</td>
</tr>
<tr>
<td>Address</td>
<td>7421-A Warren SE</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Snoqualmie, WA 98065</td>
</tr>
<tr>
<td>Phone #</td>
<td>425-396-4266</td>
</tr>
<tr>
<td>email</td>
<td><a href="mailto:dfleming@thermalrs.com">dfleming@thermalrs.com</a></td>
</tr>
<tr>
<td>Other contacts or vendors who worked on site</td>
<td>None</td>
</tr>
<tr>
<td>Point of contact</td>
<td>Art Taddeo</td>
</tr>
<tr>
<td>Type</td>
<td>x Vendor, Consultant x Vendor, Technical Applications x Other</td>
</tr>
<tr>
<td>Organization</td>
<td>ENSR</td>
</tr>
<tr>
<td>Address</td>
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</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Phone #</td>
<td>978-589-3095</td>
</tr>
<tr>
<td>email</td>
<td><a href="mailto:ataddeo@ensr.com">ataddeo@ensr.com</a></td>
</tr>
</tbody>
</table>

### QA/QC

**Characteristics of Interest**

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:**

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Hexane</td>
<td>Crossvane</td>
<td>5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Soil Borings:**

- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number inside treatment zone:
- Number outside treatment zone:

**Monitor Wells:**

- Number of relevant monitoring wells with groundwater data:
- Pre-treatment:
- Post-treatment:

**Map attachment:**

**Impacted Zone:**

- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

**Chemicals of Concern**

- Chlorinated Solvents: Tetrachloroethene, 1,1-dichloroethene, cis,1,2-dichloroethene, trans,1,2-dichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethene, Vinyl Chloride
- Petroleum Hydrocarbons: Hexane, Naphthalene, Benzene, Toluene, Ethylbenzene, m,p-xylene, o-xylene

**Comments:**

- None

**Attachments:**

- None
### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>x Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>x Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>x Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>x Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>x Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>x Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>x Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>x Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>x Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>x Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>x Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

---

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Depth to water:

| low value (ft bgs): | x |               |                                 |
| high value (ft bgs):|   |               |                                 |
| Unknown:            |   |               |                                 |

### Flow direction

---

### Horizontal hydraulic gradient (feet/foot):

---

### Vertical hydraulic gradient (feet/foot):

---

### K range (ft/day)

- Measured using:
  - Slug Test
  - Laboratory
  - Field data

<table>
<thead>
<tr>
<th>low</th>
<th>high</th>
<th>Unknown</th>
</tr>
</thead>
</table>

### Transmissivity (ft2/day)

- Measured using:
  - Slug Test
  - Laboratory
  - Field data

<table>
<thead>
<tr>
<th>low</th>
<th>high</th>
<th>Unknown</th>
</tr>
</thead>
</table>

---

### Attachments:

---

### Comments:

---

### Facility ID:

0845
### Notes and Information

**Thermal Treatment - Design**

- **Thermal treatment:**
  - Conductive
  - Electrical Resistance

- **Type of Test:**
  - Pilot test
  - Full-scale System

- **Geology of Treatment Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded layers of lower permeability material
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Treatment Target Zone:**
  - Saturated only
  - Vadose only
  - Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - Duration: __________

- **Hydraulic Control:**
  - Yes
  - No

- **Treatment Cell Design:**
  - Size of target zone (ft²): __________
  - Thickness of target zone (ft): __________
  - Depth to top of target zone (ft bgs): __________
  - Thickness of target zone below water table (ft): __________
  - Number of energy delivery points: __________
  - Number of extraction points: __________

- **Temperature Profile:**
  - Initial formation temperature (deg C): __________
  - Maximum representative formation temperature (deg C): __________
  - Time to reach maximum representative temperature (days): __________
  - Duration of treatment at representative temperature (days): __________

- **Formation temperature immediately post-treatment:**

- **Formation temperature post-treatment monitoring event 1:**

- **Duration of post-treatment monitoring (days):**

- **Mass of contaminant removed:**
  - Via liquid pumping: __________ lb __________ kg __________
  - In vapor stream: __________ lb __________ kg __________
  - Total: __________ lb __________ kg __________

- **Comments:**

- **Attachments:**

- **Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: 
  - PCE at ≤ 5 μg/L or 99.93% reduction

- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment:

- In Soil
  - Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ___________ kWhr ___________ kWhr/m³ ___________ kWhr/yd³

- Total energy applied to treatment zone: ___________ kWhr/m³ ___________ kWhr/yd³

- Other energy: ___________ kWhr/m³ ___________ kWhr/yd³

- Please note other energy: __________________________________________________________________________

Cost

Total Project Cost:

- Consultant Cost: _______________________________________________________________________________

- Thermal Vendor Cost: ___________________________________________________________________________

- Energy Cost: ___________ m³ ___________ yd³

- Other Cost 1: _________________________________________________________________________________

- Other Cost 2: _________________________________________________________________________________

- Other Cost 3: _________________________________________________________________________________

- Please note other cost: __________________________________________________________________________
File Analyzed By: JT PD Date: 11/15/2006

Type of treatment: Conductive, Steam, ERH, Other: ____________

Type of Contaminant: Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides, Wood Treating, Other: ____________

Treatment Status: Active, Post

Type of Test: Pilot Test, Full Scale System

Start of Test: 12/17/2003 Duration: 231 d

Type of Site: Non-DOD, DoD

Facility Name: Ft. Lewis, Washington Area 1

City, State, Zip Code: Ft. Lewis, Washington

OU# or Site #: East Gate Disposal Yard NAPL Area 1

Primary point of contact: Travis Shaw

Organization: USACE - Seattle

Phone #: 206-764-3527 email: travis.c.shaw@usace.army.mil

Other contacts or vendors who worked on site: None

Point of contact: ____________

Type: Vendor, Consultant, Vendor, Technical Applications, Other

Organization: ____________

Address: ____________

City, State, Zip Code: ____________

Phone #: ____________ email: ____________

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________ Width (ft): __________ Thickness (ft): __________ Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: ______
- Pre-treatment: 35 Post-treatment: 35
- Number of wells relative to treatment zone:
  - Pre-treatment: In: 11 Upgradient: 4 Downgradient: 15 Crossgradient: 4
  - Post-treatment: In: 11 Upgradient: 4 Downgradient: 15 Crossgradient: 4

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: ______
- Number outside treatment zone: ______

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossdi</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>0.001 mg/L</td>
<td>None</td>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>Toluene</td>
<td></td>
<td>0.5 mg/L</td>
<td>None</td>
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<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>Ethylbenzene</td>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>m+p-xylene</td>
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<td>1,1-dichloroethane</td>
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<td>0.01 mg/L</td>
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<td>Vinyl Chloride</td>
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<td>0.005 mg/L</td>
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<td>TCE - deep</td>
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<td>0.01 mg/L</td>
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<td>cis-1,2-DCE - deep</td>
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<td>1,1,1-TCA - deep</td>
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<td>PCE - deep</td>
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<td>0.001 mg/L</td>
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<td>Vinyl chloride - deep</td>
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<td>0.001 mg/L</td>
<td>None</td>
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</table>

**Comments:**
- Post-treatment samples for 1,1,1-TCA and vinyl chloride in shallow - non-detect
- Pre-treatment samples in cis-1,2-DCE, PCE, TCE, vinyl chloride in deep wells - non-detect
- Post-treatment samples in 1,1,1-TCA and vinyl chloride in deep wells - non-detect

**Attachments:**

---

None
**Hydrogeologic Conceptual Model**

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<tr>
<td>Vadose Zone:</td>
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<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<td>Weathered bedrock, limestone, sandstone</td>
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<td>Saturated Zone:</td>
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<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- **Ground surface elevation based on wells in or adjacent to treatment zone:** 278 ft amsl

- **Aquifer Characteristics:**
  - Is more than 1 aquifer present? No
  - Yes (number): Unknown (assume single aquifer)
  - Depth to water:
    - low value (ft bgs): 11
    - high value (ft bgs): 
    - Unknown:
  - Flow direction: SW
  - Horizontal hydraulic gradient (feet/foot): 0.001
  - Vertical hydraulic gradient (feet/foot): 
  - K range (ft/day)
    - Measured using: Slug Test, Laboratory, Field data
    - low: 
    - high: Unknown
  - Transmissivity (ft²/day)
    - Measured using: Slug Test, Laboratory, Field data
    - low: 
    - high: Unknown

- **Comments:****
- **Attachments:****
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
<th>3 phase</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
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<tbody>
<tr>
<td>Steam</td>
<td>Steam</td>
<td>Steam + air</td>
<td>Steam + O2</td>
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<tr>
<td>Other (describe)</td>
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</tbody>
</table>

Type of Test: Pilot test

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 12/17/2003
Duration: 271 day

Hydraulic Control: Yes

Treatment Cell Design:
- Size of target zone (ft²): 25400
- Thickness of target zone (ft): 56
- Depth to top of target zone (ft bg): 2
- Thickness of target zone below water table (ft): 25
- Number of energy delivery points: 106
- Number of extraction points: 106

Temperature Profile:
- Initial formation temperature (deg C): 22
- Maximum representative formation temperature (deg C): 56
- Time to reach maximum representative temperature (days): 161
- Duration of treatment at representative temperature (days): 70

Formation temperature immediately post-treatment:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
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<tbody>
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</tbody>
</table>

Formation temperature post-treatment monitoring event 1:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
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<tbody>
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</tbody>
</table>

Duration of post-treatment monitoring (days):

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
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<tbody>
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</tbody>
</table>

Mass of contaminant removed:
- Via liquid pumping: 2.0785 lb x kg
- In vapor stream: 43152 lb x kg
- Total: 43154 lb x kg

Comments:

Total volume - 30900 yd³

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater:
  
- In Soil:
  
Was the Remediation Goal Achieved:

- In Groundwater:
  
  Comment:

- In Soil:
  
  Comment:

General comments on the thermal application:

Target temps - 100C in saturated zone and 90C in vadose zone, then temperature specifics will be maintained for 60 days

Lessons Learned

Energy

Total Energy Used: 8387050 kWhr

Total energy applied to treatment zone: 7913000 kWhr

Other energy: ______________________ kWhr/m³ ______________________ kWhr/yd³

Please note other energy: ______________________

Cost

Total Project Cost:

- Consultant Cost: ______________________

- Thermal Vendor Cost: ______________________

- Energy Cost: ______________________ m³ ______________________ yd³

- Other Cost 1: ______________________

- Other Cost 2: ______________________

- Other Cost 3: ______________________

Please note other cost: ______________________ Other Cost 1: ______________________

Other Cost 2: ______________________

Other Cost 3: ______________________
Facility ID#: 0863

Type of treatment: 
- Conductive
- Steam
- ERH
- Other: 

Type of Contaminant: 
- Chlorinated Solvents
- Petroleum Hydrocarbons
- Pesticides
- Wood Treating
- Other: 

Treatment Status: 
- Active
- Post

Type of Test: 
- Pilot Test
- Full Scale System

Start of Test: 2/14/2005
End of Test: 8/5/2005
Duration: 172 days

Type of Site: 
- Non-DOD
- DoD

Facility Name: Ft. Lewis, Washington Area 2
Address: 
City, State, Zip Code: Ft. Lewis, Washington
OU# or Site #: East Gate Disposal Yard NAPL Area 2

Primary point of contact: Travis Shaw
Organization: USACE - Seattle
Address: 
City, State, Zip Code: 
Phone #: 206-764-3527
email: travis.c.shaw@usace.army.mil

Other contacts or vendors who worked on site: None

Point of contact: 
Type: Vendor, Consultant
Vendor, Technical Applications
Other

Organization: 
Address: 
City, State, Zip Code: 
Phone #: 
email: 

QA/QC

Characteristics of Interest
- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 125
- Width (ft.): 200
- Thickness (ft.): variable to 57
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: None
- Pre-treatment: 22
- Post-treatment: 22
- Number of wells relative to treatment zone:
  - Pre-treatment: In: 11, Upgradient: 1, Downgradient: 6, Crossgradient: 6
  - Post-treatment: In: 11, Upgradient: 1, Downgradient: 6, Crossgradient: 6

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: 4
- Number of relevant soil borings with post-treatment data: 4
- Number inside treatment zone: 12
- Number outside treatment zone: 0

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr.</td>
<td></td>
<td>5 mg/L</td>
<td>100 mg/kg</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
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<td>None</td>
<td>None</td>
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<td>1,1-dichloroethene</td>
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<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>0.5 mg/L</td>
<td></td>
<td>1 mg/kg</td>
<td>0.01 mg/kg</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
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<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
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<td>Vinyl Chloride</td>
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</table>

#### Comments:

- ...

#### Attachments:

- Map attachment

---

**Facility ID#:** 0863
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Saturated Zone: | Relatively homogeneous and permeable unconsolidated sediments |
|                | Relatively homogeneous and impermeable unconsolidated sediments |
|                | Largely permeable sediments with inter-bedded lenses of lower permeability material |
|                | Largely impermeable sediments with inter-bedded layers of higher permeability material |
|                | Competent, but fractured bedrock (i.e. crystalline rock) |
|                | Weathered bedrock, limestone, sandstone |

| x | Ground surface elevation based on wells in or adjacent to treatment zone: 278 ft amsl | Unknown |

| x | Aquifer Characteristics: |
|   | Is more than 1 aquifer present? No | Yes (number): | Unknown (assume single aquifer) |
|   | Aquifer 1 | Aquifer 2 | Aquifer 3 |
| Depth to water: | low value (ft bgs): 0 | | |
|                  | high value (ft bgs): 10 | | |
|                  | Unknown: | | |

| Flow direction | SW | |

| Horizontal hydraulic gradient (feet/foot): | 0.001 to 0.004 | Unknown |
| Vertical hydraulic gradient (feet/foot): | | Unknown |

| K range (ft/day) | Measured using: Slug Test Laboratory Field data |
| low: | 24.2 | | |
| high: | 200 | | |

| Transmissivity (ft2/day): | Measured using: Slug Test Laboratory Field data |
| low: | | | |
| high: | | | |

Shallow aquifer only is affected by NAPL. There is a deeper aquifer separated by a glacial till & lacustrine silt unit but it is not believed to be impacted by NAPL.

Comments: 

Attachments:
<table>
<thead>
<tr>
<th><strong>Thermal Treatment - Design</strong></th>
<th>Facility ID#: 0863</th>
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</thead>
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<tr>
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### Cost and Performance

#### Facility ID#: 0863

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<tr>
<th>x</th>
<th>Performance</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Remediation Goal:</td>
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<tr>
<td></td>
<td>x In Groundwater:</td>
</tr>
<tr>
<td></td>
<td>Remove CVOCs to maximum extent practicable (No strict numerical goal)</td>
</tr>
<tr>
<td></td>
<td>x In Soil:</td>
</tr>
<tr>
<td></td>
<td>Same as above</td>
</tr>
</tbody>
</table>

Was the Remediation Goal Achieved:

<table>
<thead>
<tr>
<th></th>
<th>In Groundwater</th>
</tr>
</thead>
</table>
|   |   x  
|   | Yes |
|   |   x  
|   | Yes |

General comments on the thermal application:

**Performance goals:** 100°C in saturated zone, 90°C in vadose zone, and keep temperature at these for 7 days.

**Lessons Learned**

Performance goals of 100/90-deg C within treatment zone were not achieved although remedy goal still achieved; restate performance goal requirements in contract.

### Energy

<table>
<thead>
<tr>
<th></th>
<th>x Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Energy Used: 9,547,000 kWhr</td>
</tr>
<tr>
<td></td>
<td>x Total energy applied to treatment zone: 9,181,000 kWhr</td>
</tr>
<tr>
<td></td>
<td>x Other energy: Please note other energy:</td>
</tr>
</tbody>
</table>

### Cost

<table>
<thead>
<tr>
<th></th>
<th>x Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Project Cost:</td>
</tr>
<tr>
<td></td>
<td>x Consultant Cost:</td>
</tr>
<tr>
<td></td>
<td>x Thermal Vendor Cost:</td>
</tr>
<tr>
<td></td>
<td>x Energy Cost: m³ yd³</td>
</tr>
<tr>
<td></td>
<td>x Other Cost 1:</td>
</tr>
<tr>
<td></td>
<td>x Other Cost 2:</td>
</tr>
<tr>
<td></td>
<td>x Other Cost 3:</td>
</tr>
<tr>
<td></td>
<td>x Please note other cost:</td>
</tr>
<tr>
<td></td>
<td>x Other Cost 1:</td>
</tr>
<tr>
<td></td>
<td>x Other Cost 2:</td>
</tr>
<tr>
<td></td>
<td>x Other Cost 3:</td>
</tr>
</tbody>
</table>
General Site Information

File Analyzed By: JT PD

Type of treatment: Conductive Steam ERH Other: __________

Type of Contaminant: x Chlorinated Solvents x Petroleum Hydrocarbons __________ Pesticides

Wood Treating Other: __________

Treatment Status: Active x Post

Type of Test: x Pilot Test x Full Scale System

Start of Test: 10/10/2006 End of Test: 1/26/2007 Duration: 108 days

Type of Site: x Non-DOD x DoD

Facility Name: Ft. Lewis, Washington Area 3

Address:

City, State, Zip Code: Ft. Lewis, Washington

OU# or Site #: East Gate Disposal Yard NAPL Area 3

Primary point of contact: Kira Lynch

Organization: USACE - Seattle

Address:

City, State, Zip Code: ________________________________

Phone #: 206-764-6918 email: kira.p.lynch@usace.army.mil

Other contacts or vendors who worked on site: None

Point of contact:

Type: x Vendor, Consultant x Vendor, Technical Applications x Other

Organization: ________________________________

Address:

City, State, Zip Code: ________________________________

Phone #: ________________________________ email: ________________________________

QA/QC

Characteristics of Interest

x Good pre- and post-treatment groundwater data

x Good pre- and post-treatment soil data

x Good temperature profile vs. time information

x Flux assessment

x Groundwater elevations

x Geologic cross-section

x Hydraulic Conductivity information
### General Site Assessment Data

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>benzene</td>
<td>cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>jet fuel</td>
<td>cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>napthalene</td>
<td>cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>benzene</td>
<td>cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>toluene</td>
<td>cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>1,35-trimethylbenzene</td>
<td>cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>1,24-trimethylbenzene</td>
<td>cross</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

| Facility ID#: 0865 |

**Attachments:**

- Map attachment
- Impacted Zone: as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
### Geology:

**Zone** | **Unconsolidated Sediments**
--- | ---
**Vadose Zone:** |  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

**Saturated Zone:** |  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

### Aquifer Characteristics:

**Is more than 1 aquifer present?** | **No** | **Yes (number):** | **Unknown (assume single aquifer)**
--- | --- | --- | ---
**Depth to water:** |  
- low (ft bgs): |  
- high (ft bgs): |  
- Unknown: |  

**Flow direction:** | NW

### Ground surface elevation based on wells in or adjacent to treatment zone:

| 278 ft amsl | Unknown |

### Horizontal hydraulic gradient (feet/foot):

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
<th>Unknown</th>
</tr>
</thead>
</table>

### Vertical hydraulic gradient (feet/foot):

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
<th>Unknown</th>
</tr>
</thead>
</table>

### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0865</th>
</tr>
</thead>
</table>

#### Thermal treatment:
- Conductive
- Electrical Resistance
- 3 phase
- 6 phase
- AC power
- DC power

#### Type of Test:
- Pilot test
- Full-scale System

#### Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

#### Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

#### Start of Thermal Test:
- 10/10/2006
- Duration: 108 days

#### Hydraulic Control:
- Yes
- No

#### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²):</td>
<td>18200</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>30</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>0</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>21</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>93</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>93</td>
</tr>
</tbody>
</table>

#### Temperature Profile:

| Initial formation temperature (deg C): | 13                      |
| Maximum representative formation temperature (deg C): | 89                      |
| Time to reach maximum representative temperature (days): | 38                      |
| Duration of treatment at representative temperature (days): | 13                      |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/27/2007</td>
<td>68</td>
</tr>
<tr>
<td>4/9/2007</td>
<td>39</td>
</tr>
</tbody>
</table>

#### Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Source</th>
<th>Mass Removed</th>
<th>Form</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

#### Attachments:

---

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater:

Comment:

In Soil:

Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: __________ kWhr __________ kWhr/m³ __________ kWhr/yd³

Total energy applied to treatment zone: __________ kWhr/m³ __________ kWhr/yd³

Other energy: __________ kWhr/m³ __________ kWhr/yd³

Please note other energy: ____________________________

Cost

Total Project Cost: ____________________________

Consultant Cost: __________

Thermal Vendor Cost: __________

Energy Cost: __________ m³ __________ yd³

Other Cost 1: __________

Other Cost 2: __________

Other Cost 3: __________

Please note other cost: __________ Other Cost 1: __________

Other Cost 2: __________

Other Cost 3: __________
### General Site Information

- **Type of treatment:**
  - x Conductive
  - x Steam
  - ERH
  - Other:
- **Type of Contaminant:**
  - x Chlorinated Solvents
  - Petroleum Hydrocarbons
  - Pesticides
  - Wood Treating
  - Other:
- **Treatment Status:**
  - x Active
  - Post
- **Type of Test:**
  - x Pilot Test
  - Full Scale System
- **Start of Test:** 5/24/2004
- **End of Test:** ongoing
- **Duration:**
- **Type of Site:**
  - x Non-DOD
  - DoD

### Facility Information

- **Facility Name:** Lake River Industrial Site
- **Address:**
- **City, State, Zip Code:** Ridgefield, WA
- **OU# or Site #:**

### Primary Point of Contact

- **Primary point of contact:** Steve Taylor
- **Organization:**
- **Address:**
- **City, State, Zip Code:**
- **Phone #:**
- **email:**

### Other Contacts or Vendors

- **Other contacts or vendors who worked on site:** None
- **Point of contact:**
  - Type: Vendor, Consultant
  - Vendor, Technical Applications
  - Other
  - Organization:
  - Address:
  - City, State, Zip Code:
  - Phone #: 
  - email:

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________
- Post-treatment: __________
- Upgradient: __________
- Downgradient: __________
- Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Toluene</td>
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<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>None</td>
<td>None</td>
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<td>trans-1,2-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>1,1-dichloroethene</td>
<td>m/p-xylene</td>
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<td>None</td>
<td>None</td>
</tr>
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<td>1,2-dichloroethane</td>
<td>a-xylene</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**
- Impacted area of 4 acres and may contain 100,000 gallons of wood-treating chemicals.

**Attachments:**
- __________________________________________________________________________________________
- __________________________________________________________________________________________
- __________________________________________________________________________________________
- __________________________________________________________________________________________
- __________________________________________________________________________________________
- __________________________________________________________________________________________
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impervious unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impervious unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
<thead>
<tr>
<th></th>
<th>ft amsl</th>
<th>Unknown</th>
</tr>
</thead>
</table>

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Depth to water:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Flow direction:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

#### Horizontal hydraulic gradient (feet/foot):

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Unknown</th>
</tr>
</thead>
</table>

#### Vertical hydraulic gradient (feet/foot):

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Unknown</th>
</tr>
</thead>
</table>

#### K range (ft/day)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Transmissivity (ft2/day)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Field data</th>
</tr>
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<tr>
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<tr>
<td>high</td>
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#### Field data

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

### Comments:

- [Write comments here]

### Attachments:

- [Attach files here]
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power

Steam  
- Phase I  
- Steam  
- Steam + air  
- Steam + O2

Type of Test:  
- Pilot test
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
Duration:  
Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>Thickness of target zone (ft):</th>
<th>Depth to top of target zone (ft bgs):</th>
<th>Thickness of target zone below water table (ft):</th>
<th>Number of energy delivery points:</th>
<th>Number of extraction points:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>6</td>
<td>17</td>
</tr>
</tbody>
</table>

Temperature Profile:

Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C):  
Time to reach maximum representative temperature (days):  
Duration of treatment at representative temperature (days):  
Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th>In vapor stream:</th>
<th>Total:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Date  Temperature (deg C)

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
## Performance

**Remediation Goal:**

- **In Groundwater:**
  - ________
  - ________
  - ________

- **In Soil:**
  - ________
  - ________
  - ________

**Was the Remediation Goal Achieved:**

- **In Groundwater**
  - ________
  - ________
  - ________

- **In Soil**
  - ________
  - ________
  - ________

**General comments on the thermal application:**

- ________

**Lessons Learned**

- ________

## Energy

**Total Energy Used:**

- ________ ________ ________ ________ ________ ________ ________ ________ ________ ________

- **Total energy applied to treatment zone:**
  - ________ ________ ________ ________

- **Other energy:**
  - ________ ________ ________ ________

*Please note other energy:*

## Cost

**Total Project Cost:**

- ________

- **Consultant Cost:**

- **Thermal Vendor Cost:**

- **Energy Cost:**

- **Other Cost 1:**

- **Other Cost 2:**

- **Other Cost 3:**

*Please note other cost:*
General Site Information

File Analyzed By: JT x PD ______ Date: ___________
Type of treatment: ______ Conductive x Steam ______ ERH ______ Other: ________________
Type of Contaminant: ______ Chlorinated Solvents x Petroleum Hydrocarbons ______ Pesticides ______ Wood Treating ______ Other: ________________
Treatment Status: ______ Active x Post
Type of Test: ______ Pilot Test ______ Full Scale System
Start of Test: ______ End of Test: ____________ Duration: ____________
Type of Site: ______ Non-DOD x DoD

Facility Name: Bremerton Naval Complex: Puget Sound Naval Shipyard (Pilot)
Address: ___________________________________________________________________________
City, State, Zip Code: Washington
OU# or Site #: OU C

Primary point of contact: Brad Gross
Organization: Navy
Address: ___________________________________________________________________________
City, State, Zip Code: Washington
Phone #: 360-396-0028 email: r.gross@navy.mil

Other contacts or vendors who worked on site ______ None
Point of contact: Cindy O'Hare
Type: ______ Vendor, Consultant ______ Vendor, Technical Applications x Other ________________
Organization: Navy
Address: Engineering Field Activity Northwest; Naval Facilities Engineering Command; 19917 7th Avenue NE
City, State, Zip Code: Poulsbo, WA 98370
Phone #: 360-396-0014 email: cindy.o'hare@navy.mil

QA/QC

Characteristics of Interest
____ Good pre- and post-treatment groundwater data
____ Good pre- and post-treatment soil data
____ Good temperature profile vs. time information
____ Flux assessment
____ Groundwater elevations
____ Geologic cross-section
____ Hydraulic Conductivity information
### General Site Assessment Data

#### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________
  - Post-treatment: __________
  - In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________
- None

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

#### Soil Borings:
- Number of relevant soil borings with post-treatment data: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
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<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,2-trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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</tr>
</tbody>
</table>

#### Comments:

- __________
- __________
- __________

#### Attachments:

- __________
- __________
- __________
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>✔️ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>✔️ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>✗ Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>✗ Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>✔️ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>✗ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>✔️ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>✔️ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>✗ Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>✗ Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>✔️ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>✗ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Ground surface elevation based on wells in or adjacent to treatment zone:

-35 ft amsl

#### Aquifer Characteristics:

- Is more than 1 aquifer present? No

- Depth to water:
  - low value (ft bgs): 100
  - high value (ft bgs): 
  - Unknown:

- Flow direction: SE

- Horizontal hydraulic gradient (feet/foot):
  - Measured using:
  - Slug Test: ✔️
  - Laboratory: 
  - Field data: 
  - K range (ft/day): Unknown

- Vertical hydraulic gradient (feet/foot):
  - Measured using:
  - Slug Test: ✔️
  - Laboratory: 
  - Field data: 
  - Unknown

#### K range (ft/day)

- Measured using:
  - Slug Test: ✔️
  - Laboratory: 
  - Field data: 
  - K range (ft/day): Unknown

- Transmissivity (ft^2/day):
  - Measured using:
  - Slug Test: ✔️
  - Laboratory: 
  - Field data: 
  - Unknown

#### Comments:

- Facility ID#: 0880

#### Attachments:

- Facility ID#: 0880

---
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  

Steam:  
- Steam  
- Steam + air  
- Steam + O₂  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
- Jul-96  
- Duration: 9 months  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  
- Size of target zone (ft²):  
- Thickness of target zone (ft):  
- Depth to top of target zone (ft bgs): 50  
- Thickness of target zone below water table (ft): 10  
- Number of energy delivery points: 1  
- Number of extraction points: 1  

Temperature Profile:  
- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C):  
- Time to reach maximum representative temperature (days):  
- Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:  
- Date  
- Temperature (deg C)  

Formation temperature post-treatment monitoring event 1:  
- Date  
- Temperature (deg C)  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
- Via liquid pumping:  
- In vapor stream:  
- Total:  
  - unknown  

Comments:  

The extraction and injection wells were at depths of 50, 80 and 110 feet.  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:

___ In Soil

Comment:

General comments on the thermal application:

System was expanded in August 1997

Lessons Learned

Cost during 1st nine months = $61/yd³

Energy

Total Energy Used: ______________________ __kWhr __kWhr/m³ __kWhr/yd³

Total energy applied to treatment zone: ______________________ __kWhr/m³ __kWhr/yd³

Other energy: ______________________ __kWhr/m³ __kWhr/yd³

Please note other energy: ______________________

Cost

Total Project Cost:

Consultant Cost: ______________________

Thermal Vendor Cost: ______________________

Energy Cost: ______________________ __m³ __yd³

Other Cost 1: ______________________

Other Cost 2: ______________________

Other Cost 3: ______________________

Please note other cost: __Other Cost 1: ______________________

Other Cost 2: ______________________

Other Cost 3: ______________________
General Site Information

File Analyzed By: JT PD ERH Date: 
Type of treatment: Conductive Steam ERH Other: 
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 
Treatment Status: Active Post 
Type of Test: Pilot Test Full Scale System 
Start of Test: Aug-97 End of Test: Sep-99 Duration: 2 years 1 month 
Type of Site: Non-DOD DoD 

Facility Name: Bremerton Naval Complex: Puget Sound Naval Shipyard (Full) 
Address: 
City, State, Zip Code: Washington 
OU# or Site #:OU C 

Primary point of contact: Brad Gross 
Organization: Navy 
Address: 
Phone #: 360-396-0028 email: r.gross@navy.mil 

Other contacts or vendors who worked on site None 
Point of contact: Cindy O'Hare 
Type: Vendor, Consultant Vendor, Technical Applications Other 
Organization: Navy 
Address: Engineering Field Activity Northwest; Naval Facilities Engineering Command; 19917 7th Avenue NE 
City, State, Zip Code: Poulsbo, WA 98370 
Phone #: 360-396-0014 email: cindy.o'hare@navy.mil 

QA/QC 

Characteristics of Interest 
Good pre- and post-treatment groundwater data Good pre- and post-treatment soil data 
Good temperature profile vs. time information Flux assessment 
Groundwater elevations Geologic cross-section 
Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 1951

**Map attachment:**
```
Alt method for determining size of impacted zone (See source zone definition attachments)
```

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

**Map attachment:**
- Impacted zone as defined by documentation

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Hexane</td>
<td>Crosssuit</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Jet Fuel</td>
<td>No. 6 Fuel Oil</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>Diesel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzen</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>1,1-dichloroethene</td>
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<td>None</td>
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<tr>
<td>1,2-dichloroethene</td>
<td>m+p-xylene</td>
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<td></td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
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<td>None</td>
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<td>1,1,2-trichloroethene</td>
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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
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<td>None</td>
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<td>None</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**
```

```

**Attachments:**
```

```

---

**Number inside treatment zone:**
- Number of soil borings with pre-treatment data: __________

**Number of wells relative to treatment zone:**
- Pre-treatment: __________
- In: __________
- Upgradient: __________
- Downgradient: __________
- Crossgradient: __________
- Post-treatment: __________
- In: __________
- Upgradient: __________
- Downgradient: __________
- Crossgradient: __________

---

**Number of wells relative to treatment zone:**
- Number of relevant monitoring wells with groundwater data: __________

**Number of wells relative to treatment zone:**
- Number of relevant monitoring wells with groundwater data: __________

**Number of wells relative to treatment zone:**
- Number of relevant monitoring wells with groundwater data: __________

---

**Facility ID:** 0881
### Hydrogeologic Conceptual Model

**Facility ID#:** 0001

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Ground surface elevation based on wells in or adjacent to treatment zone:** -35 ft amsl

**Aquifer Characteristics:**
- **Is more than 1 aquifer present?** No
- **Yes (number):** Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low (ft bgs):</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>high (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flow direction:** SE

**Horizontal hydraulic gradient (feet/foot):**
- Unknown

**Vertical hydraulic gradient (feet/foot):**
- Unknown

**K range (ft/day):**
- Measured using: Slug Test Laboratory Field data
- Low
- High

**Transmissivity (ft²/day):**
- Measured using: Slug Test Laboratory Field data
- Low
- High

**Comments:**

**Attachments:**

---
Thermal Treatment: Conductive

Electrical Resistance

- 3 phase
- 6 phase
- AC power
- DC power

Steam

- Steam
- Steam + air
- Steam + O₂

Other (describe)

Type of Test: Pilot test

Full-scale System

Geology of Treatment Zone:

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:

Aug-97

Duration: 2 years 1 month

Hydraulic Control

- Yes
- No

Treatment Cell Design:

- Size of target zone (ft²):
- Thickness of target zone (ft):
- Depth to top of target zone (ft bgs):
- Thickness of target zone below water table (ft):
- Number of extraction points:
- Number of energy delivery points:

Temperature Profile:

- Initial formation temperature (deg C):
- Maximum representative formation temperature (deg C):
- Time to reach maximum representative temperature (days):
- Duration of treatment at representative temperature (days):

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

- Via liquid pumping: ___ lb ___ kg
- In vapor stream: ___ lb ___ kg
- Total: ___ lb ___ kg

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
The system ended in Sept. 1999 because the expanded system was ineffective at extraction more petroleum products from the groundwater table. The system was averaging slightly more than 800 gallons per month removal. The reasons for the ineffective extraction were: 1) equipment difficulties, 2) unknown site conditions, 3) impacts of groundwater flow from the drydock operation - all of these were considered the primary production problems of the expanded system.
General Site Information

File Analyzed By: JT PD Date: 10/18/2006

Type of treatment: Conductive Steam ERH Other: ____________

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: ____________

Treatment Status: Active Post ____________

Type of Test: Pilot Test Full Scale System ____________

Start of Test: May-99 End of Test: Aug-99 Duration: 25 d

Type of Site: Non-DOD DoD ____________

Facility Name: Former Dry Cleaners

Address: ____________

City, State, Zip Code: Western Washington

OU# or Site #: ____________

Primary point of contact: Bill Heath

Organization: CES

Address: 419 Entiat St., Suite A

City, State, Zip Code: Kennewick, WA 99336

Phone #: 509-727-4276 email: bill@cesiweb.com

Other contacts or vendors who worked on site: None

Point of contact: ____________

Type: Vendor, Consultant Vendor, Technical Applications Other ____________

Organization: ____________

Address: ____________

City, State, Zip Code: ____________

Phone #: ____________ email: ____________

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID#:** (699)

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________
  - Width (ft.): __________
  - Thickness (ft.): __________
  - Unknown
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: __________
  - Pre-treatment: __________
  - Post-treatment: __________
  - None
  - Number of wells relative to treatment zone:
    - Pre-treatment: In: __________
    - U pgrad en t: __________
    - D ow ngrad en t: __________
    - C rossgrad en t: __________
  - Post-treatment: In: __________
  - U pgrad en t: __________
  - D ow ngrad en t: __________
  - C rossgrad en t: __________

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: __________
  - Number of relevant soil borings with post-treatment data: __________
  - Number inside treatment zone: __________
  - Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical:</th>
<th>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
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<td>None</td>
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</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
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<td>None</td>
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</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1-Dichloroethene</td>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
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<tr>
<td>1,2-Dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
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<tr>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>m-p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________
- __________________________________________________________________________

### Attachments:

- __________________________________________________________________________
### Hydrogeologic Conceptual Model

#### Facility ID:

<table>
<thead>
<tr>
<th>Facility ID#</th>
<th>0890</th>
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</table>

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Depth to water:                  |     |                |                                 |
| low value (ft bgs):              |     |                |                                 |
| high value (ft bgs):             |     |                |                                 |
| Unknown:                         |     |                |                                 |

| Flow direction                   |     |                |                                 |

| Horizontal hydraulic gradient (feet/foot): |     |                |                                 |
| Vertical hydraulic gradient (feet/foot):   |     |                |                                 |

| K range (ft/day)                  |     |                |                                 |
| low                              |     |                |                                 |
| high                             |     |                |                                 |

| Measured using:                  |     |                |                                 |
| Slug Test                        |     |                |                                 |
| Laboratory                       |     |                |                                 |
| Field data                       |     |                |                                 |

| Transmissivity (ft²/day):         |     |                |                                 |
| low                              |     |                |                                 |
| high                             |     |                |                                 |

| Measured using:                  |     |                |                                 |
| Slug Test                        |     |                |                                 |
| Laboratory                       |     |                |                                 |
| Field data                       |     |                |                                 |

#### Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
<thead>
<tr>
<th>ft amsl</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Weathered bedrock, limestone, sandstone

#### Vadose Zone

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

#### Saturated Zone

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

---

### Notes:

- Unknown: high value (ft bgs):
- Unknown: low value (ft bgs):

---

### Attachments:

- Comments:
- Additional data and information:
- Relevant documents and records:

---
Thermal Treatment - Design

Thermal treatment: [x] Conductive [x] Electrical Resistance

- 6 phase
- Steam
- Other (describe)

Type of Test: [x] Pilot test [x] Full-scale System

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded lenses of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone: [x] Saturated only [x] Vadose only [x] Both (Saturated and Vadose zones)

Start of Thermal Test: May-99 Duration: 75 d

Hydraulic Control: [ ] Yes [ ] No

Treatment Cell Design:

Size of target zone (ft^2):
Thickness of target zone (ft):
Depth to top of target zone (ft bgs):
Thickness of target zone below water table (ft):
Number of extraction points:
Number of energy delivery points:

Temperature Profile:

Initial formation temperature (deg C):
Maximum representative formation temperature (deg C):
Time to reach maximum representative temperature (days):
Duration of treatment at representative temperature (days):
Formation temperature immediately post-treatment:
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping: ___________ lb ___________ kg ___________ Unknown
In vapor stream: ___________ lb ___________ kg ___________ Unknown
Total: ___________ x lb ___________ kg ___________ Unknown

Notes: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater: PCE = 5 ug/L
- In Soil: PCE = 500 ug/kg

Was the Remediation Goal Achieved:

- In Groundwater
- In Soil

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: ______ kWhr ______ kWhr/m³ ______ kWhr/yd³

- Total energy applied to treatment zone: ______ kWhr/m³ ______ kWhr/yd³
- Other energy: ______ kWhr/m³ ______ kWhr/yd³

Please note other energy: ______

Cost

Total Project Cost:

- Consultant Cost: ______
- Thermal Vendor Cost: ______
- Energy Cost: ______ m³ ______ yd³
- Other Cost 1: ______
- Other Cost 2: ______
- Other Cost 3: ______

Please note other cost: ______ Other Cost 1: ______
- Other Cost 2: ______
- Other Cost 3: ______

Other energy: ______ kWhr/yd³
<table>
<thead>
<tr>
<th>Date: 11/9/2006</th>
<th>File Analyzed By: JT PD X</th>
<th>Facility ID#: 0900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td><em>Conductive</em> X Steam ERH Other:</td>
<td>Type of treatment:</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td><em>Chlorinated Solvents</em> Petroleum Hydrocarbons Pesticides</td>
<td>Type of Contaminant:</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td><em>Wood Treating</em> Other:</td>
<td>Treatment Status:</td>
</tr>
<tr>
<td>Type of Test:</td>
<td><em>Pilot Test</em> Full Scale System</td>
<td>Type of Test:</td>
</tr>
<tr>
<td>Start of Test: 10/1/2002</td>
<td>End of Test: 4/15/2003 Duration: 6.5 months</td>
<td>Type of Site:</td>
</tr>
<tr>
<td>Facility Name: Wyckoff / Eagle Harbor</td>
<td>Address:</td>
<td>City, State, Zip Code: Bainbridge Island, Washington</td>
</tr>
<tr>
<td>Organization: EPA</td>
<td>Address:</td>
<td>Former Process Area</td>
</tr>
<tr>
<td>Primary point of contact: Mary Jane Nearman</td>
<td>Phone #: 206-553-6642 email:</td>
<td>Phone #: 206-764-3697 email: <a href="mailto:matthew.s.allen@usace.army.mil">matthew.s.allen@usace.army.mil</a></td>
</tr>
<tr>
<td>Other contacts or vendors who worked on site:</td>
<td>Type: X Vendor, Consultant Vendor, Technical Applications Other</td>
<td>Other contacts or vendors who worked on site:</td>
</tr>
<tr>
<td>Point of contact: Matt Allen</td>
<td>Organization: US Army Corp of Engineers</td>
<td>Organization: US Army Corp of Engineers</td>
</tr>
<tr>
<td>Type: X Vendor, Consultant Vendor, Technical Applications Other</td>
<td>Address:</td>
<td>Address:</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
<td>City, State, Zip Code:</td>
</tr>
<tr>
<td>Phone #: 206-764-3697 email: <a href="mailto:matthew.s.allen@usace.army.mil">matthew.s.allen@usace.army.mil</a></td>
<td></td>
<td>Phone #: 206-764-3697 email: <a href="mailto:matthew.s.allen@usace.army.mil">matthew.s.allen@usace.army.mil</a></td>
</tr>
</tbody>
</table>

**QA/QC**

- Characteristics of Interest
  - ____ Good pre- and post-treatment groundwater data
  - ____ Good pre- and post-treatment soil data
  - ____ Good temperature profile vs. time information
  - ____ Flux assessment
  - ____ Groundwater elevations
  - ____ Geologic cross-section
  - ____ Hydraulic Conductivity information
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________

- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Post-treatment: __________

  - Pre-treatment: In: __________
  - Post-treatment: In: __________

  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________

- Number inside treatment zone: __________
- Number outside treatment zone: __________

Types of Contaminants

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
</tbody>
</table>

- Trichloroethene
- Tetrachloroethene
- 1,1-dichloroethene
- cis-1,2-dichloroethene
- trans-1,2-dichloroethene
- 1,1-dichloroethylene
- 1,2-dichloroethane
- 1,1,1-trichloroethane
- 1,2-dichloroethane
- Vinyl Chloride
- 1,1,2-trichloroethane
- 1,1,2,2-tetrachloroethane

- Benzene
- Jet Fuel
- Naphthalene
- Toluene
- Ethylbenzene
- m,p-xylene
- o-xylene
- None

Comments:

Estimated loss of 17,000 to 41,000 gallons of product. No real pre-treatment GW samples. Temperatures as high as 50 to 60 deg C in upper aquifer around injection well, whereas temperatures around extraction well remained close to ambient temperatures.
<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs): 6</td>
<td>80</td>
<td>200</td>
</tr>
<tr>
<td>high value (ft bgs): 10</td>
<td>200</td>
<td>1500+</td>
</tr>
<tr>
<td>Unknown:</td>
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<table>
<thead>
<tr>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radially toward Eagle Harbor and Puget Sound</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
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</table>

<table>
<thead>
<tr>
<th>Vertical hydraulic gradient (feet/foot):</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
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</tbody>
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<table>
<thead>
<tr>
<th>K range (ft/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured using: Slug Test</td>
</tr>
<tr>
<td>low 15</td>
</tr>
<tr>
<td>high 10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmissivity (ft²/day):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured using: Slug Test</td>
</tr>
<tr>
<td>low</td>
</tr>
<tr>
<td>high</td>
</tr>
</tbody>
</table>

Comments:
Average K=26 ft/day. Vertical anisotropy = 4.7

Attachments:
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
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<tbody>
<tr>
<td><strong>Thermal Treatment:</strong></td>
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</tr>
<tr>
<td>Conductive</td>
<td></td>
</tr>
<tr>
<td>Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td>3 phase</td>
<td></td>
</tr>
<tr>
<td>6 phase</td>
<td></td>
</tr>
<tr>
<td>AC power</td>
<td></td>
</tr>
<tr>
<td>DC power</td>
<td></td>
</tr>
<tr>
<td><strong>Steam</strong></td>
<td></td>
</tr>
<tr>
<td>Steam + air</td>
<td></td>
</tr>
<tr>
<td>Steam + O2</td>
<td></td>
</tr>
<tr>
<td><strong>Other (describe)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type of Test:</strong></td>
<td>Pilot test</td>
</tr>
<tr>
<td><strong>Geology of Treatment Zone:</strong></td>
<td></td>
</tr>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
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<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<tr>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td><strong>Treatment Target Zone:</strong></td>
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</tr>
<tr>
<td>Saturated only</td>
<td></td>
</tr>
<tr>
<td>Vadose only</td>
<td></td>
</tr>
<tr>
<td>Both (Saturated and Vadose zones)</td>
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<tr>
<td><strong>Start of Thermal Test:</strong></td>
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<tr>
<td><strong>Duration:</strong></td>
<td></td>
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<tr>
<td><strong>Hydraulic Control:</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Yes</strong></td>
<td>No</td>
</tr>
<tr>
<td><strong>Thermal Treatment Design:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Facility ID:</strong></td>
<td>0900</td>
</tr>
<tr>
<td><strong>Size of target zone (ft²):</strong></td>
<td>20175</td>
</tr>
<tr>
<td><strong>Thickess of target zone (ft):</strong></td>
<td>19 to 29</td>
</tr>
<tr>
<td><strong>Depth to top of target zone (ft bgs):</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Thickness of target zone below water table (ft):</strong></td>
<td>10 to 20</td>
</tr>
<tr>
<td><strong>Number of energy delivery points:</strong></td>
<td>16</td>
</tr>
<tr>
<td><strong>Number of extraction points:</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Temperature Profile:</strong></td>
<td></td>
</tr>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>15</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>70</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>128</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>42</td>
</tr>
<tr>
<td><strong>Formation temperature immediately post-treatment:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Formation temperature post-treatment monitoring event 1:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Duration of post-treatment monitoring (days):</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mass of contaminant removed:</strong></td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td>-9300</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>-11000+</td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Attachments:</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater: Meet Puget Sound marine water quality and surface water quality.
- In Soil: Puget Sound marine sediment standards at the mud line.

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment:
- In Soil
  - Comment:

General comments on the thermal application:

Objectives: 1) demonstrate that steam will remove almost all mobile NAPL; 2) show post treatment GW concentrations will not exceed Puget Sound marine water quality, surface water quality, and sediment standards at the mud line; 3) demo that surface soil (0-15') concentrations within pilot test area attain WA State Mode 1 Toxic Control Act (MTCA) Method B cleanup levels. Costs as of summer 2004. Notes: system injection and extraction rates were not achieved.

Lessons Learned


Total Energy Used:

- Total energy applied to treatment zone: __________ kWhr/m^3 __________ kWhr/yd^3
- Other energy: __________ kWhr/m^3 __________ kWhr/yd^3

Please note other energy: 9400 x 10E6 BTU ????

Cost

- Total Project Cost: 9,750,000
  - Consultant Cost: __________
  - Thermal Vendor Cost: __________
  - Energy Cost: __________ m^3 __________ yd^3
  - Other Cost 1: 1,193,000
  - Other Cost 2: 5,644,000
  - Other Cost 3: 2,370,000

Please note other cost: Other Cost 1: Steam operation and maintenance
Other Cost 2: Installation and treatment system upgrades
Other Cost 3: Resign and planning and construction oversight
General Site Information

File Analyzed By: JT PD

Type of treatment: Conductive Steam ERH Other:

Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System

Start of Test: Nov-00 End of Test: Mar-01 Duration: 4 months

Type of Site: Non-DOD DoD

Facility Name: Delevan Municipal Well No. 4

Address: Delevan, WI

City, State, Zip Code: Delevan, WI

OU# or Site #: 

Primary point of contact: Tom Wentland

Organization: WI Department of Natural Resources

Address: 115 Pilgram Road

City, State, Zip Code: Plymouth, WI 53073-4294

Phone #: 920-892-8756 x 3028 email: wentlt@dnr.state.wi.us

Other contacts or vendors who worked on site None

Point of contact: Jon Raymond

Type: Vendor, Consultant Vendor, Technical Applications Other

Organization: Pentair Water

Address: 

City, State, Zip Code: 

Phone #: 262-728-7216 email: jon.raymond@pentairwater.com

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

#### Impacted Zone:
- Length (parallel to flow direction)(ft.):   
- Width (ft.):   
- Thickness (ft.):   
- Impacted zone as defined by documentation   
- Alternative method for determining size of impacted zone (See source zone definition attachments)   
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data:   
- Pre-treatment:   
- Post-treatment:   
- Number of wells relative to treatment zone:
  - Pre-treatment: In:   Upgradient:   Downgradient:   Crossgradient:   
  - Post-treatment: In:   Upgradient:   Downgradient:   Crossgradient:   

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data:   
- Number of relevant soil borings with post-treatment data:   
- Number inside treatment zone:   
- Number outside treatment zone:   

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

#### Comments:

- Comments:

#### Attachments:

- Attachments:
### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Vadose Zone
- Weathered bedrock, limestone, sandstone
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Ground surface elevation based on wells in or adjacent to treatment zone:
- Below treatment zone
- Unknown
- amsl

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Flow direction
- Unknown

### Horizontal hydraulic gradient (feet/foot):
- Unknown

### Vertical hydraulic gradient (feet/foot):
- Unknown

### K range (ft/day)
- Measured using: Slug Test, Laboratory, Field data
- low
- high
- Unknown

### Transmissivity (ft²/day)
- Measured using: Slug Test, Laboratory, Field data
- low
- high
- Unknown

### Comments:

- Additional comments and observations

### Attachments:

- Additional supporting documents and data

---
Thermal Treatment: Conductive

Electrical Resistance:
   ___ 3 phase
   ___ 6 phase
   ___ AC power
   ___ DC power

Steam
   ___ Steam
   ___ Steam + air
   ___ Steam + O2

Other (describe)

Type of Test: Pilot test

Geology of Treatment Zone:
   ___ Relatively homogeneous and permeable unconsolidated sediments
   ___ Relatively homogeneous and impermeable unconsolidated sediments
   ___ Largely permeable sediments with inter-bedded lenses of lower permeability material
   ___ Largely impermeable sediments with inter-bedded layers of higher permeability material
   ___ Weathered bedrock, limestone, sandstone

Treatment Target Zone:
   ___ Saturated only
   ___ Vadose only
   ___ Both (Saturated and Vadose zones)

Start of Thermal Test: ____________

Duration of treatment at representative temperature (days): ____________

Time to reach maximum representative temperature (days): ____________

Maximum representative formation temperature (deg C): ____________

Initial formation temperature (deg C): ____________

Temperature Profile:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days): ____________

Mass of contaminant removed:

<table>
<thead>
<tr>
<th></th>
<th>____________</th>
<th>____________</th>
<th>____________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping</td>
<td>____________</td>
<td>____________</td>
<td>Unknown</td>
</tr>
<tr>
<td>In vapor stream</td>
<td>____________</td>
<td>____________</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total</td>
<td>____________</td>
<td>____________</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Comments:

1540 yd³ - treated

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater:

In Soil:

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: _____ kWh _____ kWh/m³ _____ kWh/yd³

Total energy applied to treatment zone: _____ kWh _____ kWh/m³ _____ kWh/yd³

Other energy: _____ kWh _____ kWh/m³ _____ kWh/yd³

Please note other energy:

Cost

Total Project Cost: $42/yd³

Consultant Cost: __________________________

Thermal Vendor Cost: __________________________

Energy Cost: __________________________ m³ _____ yd³

Other Cost 1: 50000

Other Cost 2: 20000

Other Cost 3: __________________________

Please note other cost:

Other Cost 1: capital cost

Other Cost 2: O&M cost

Other Cost 3: __________________________
Facility Name: Confidential, Racine, WI
Address: ____________________________________________________________

City, State, Zip Code: Racine, WI

OU# or Site #: ____________________________________________________________

Primary point of contact: Dacre Bush
Organization: McMillian-McGee
Address: ____________________________________________________________

City, State, Zip Code: ____________________________________________________

Phone #: 805-295-9071 email: dacre.bush@mcmillian-mcgee.com

Other contacts or vendors who worked on site: None

Point of contact: Mark M. Mejac
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: STS Consulting
Address: 11425 West lake Park Drive
City, State, Zip Code: Milwaukee, WI 53224-3025
Phone #: 414-359-3030 email: mejac@stsconsultants.com

QA/QC

Characteristics of Interest

- Good pre- and post-treatment groundwater data
- Good pre- and post-treatment soil data
- Good temperature profile vs. time information
- Flux assessment
- Groundwater elevations
- Geologic cross-section
- Hydraulic Conductivity information
**General Site Assessment Data**

- **Impacted Zone:**
  - Length (parallel to flow direction) (ft.): unknown
  - Width (ft.): unknown
  - Thickness (ft.): 18 to 24
  - Impacted zone as defined by documentation:
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: none
  - Number of wells relative to treatment zone:
    - Pre-treatment:
      - In:
      - Upgradient:
      - Downgradient:
      - Crossgradient:
    - Post-treatment:
      - In:
      - Upgradient:
      - Downgradient:
      - Crossgradient:

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: unknown
  - Number of relevant soil borings with post-treatment data:
  - Number inside treatment zone:
  - Number outside treatment zone:

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Cross</td>
<td>None</td>
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<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
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<td>1,1-dichloroethane</td>
<td>Naphthalene</td>
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<td>None</td>
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<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>Ethylbenzene</td>
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<tr>
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<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>None</td>
<td>None</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Impacted area - 10,500 ft² to depth ranging between 18 and 24 ft (ie 7200 yd³ impacted)**

**Comments:**

---

**Attachments:**

---
## Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

---

### Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
<thead>
<tr>
<th>Ft amsl</th>
<th>Unknown</th>
</tr>
</thead>
</table>

---

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): ________</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Depth to water:

- Low value (ft bgs): 0.5
- High value (ft bgs): 5
- Unknown: ____________

#### Flow direction

---

#### Horizontal hydraulic gradient (feet/foot):

---

#### Vertical hydraulic gradient (feet/foot):

---

#### K range (ft/day):

- Measured using: Slug Test, Laboratory, Field data
- Low: ____________
- High: ____________
- Unknown: ____________

#### Transmissivity (ft²/day):

- Measured using: Slug Test, Laboratory, Field data
- Low: ____________
- High: ____________
- Unknown: ____________

---

### Comments:

---

### Attachments:

---
Thermal Treatment - Design

Facility ID#: 0915

Thermal treatment:  

- Conductive
- Electrical Resistance

Electricity:  

- 3 phase
- 6 phase
- AC power
- DC power

Steam:  

- Steam
- Steam + air
- Steam + O2

Other (describe):  

Type of Test:  

- Pilot test
- Full-scale System

Geology of Treatment Zone:  

- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  

Duration:  

Hydraulic Control:  

- Yes
- No

Treatment Cell Design:

Size of target zone (ft^2):  

Thickness of target zone (ft):  

Depth to top of target zone (ft bgs):  

Thickness of target zone below water table (ft):  

Number of extraction points:  

Number of energy delivery points:  

Temperature Profile:

Initial formation temperature (deg C):  

Maximum representative formation temperature (deg C):  

Time to reach maximum representative temperature (days):  

Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):  

Mass of contaminant removed:

Via liquid pumping:  

In vapor stream:  

Total:  

Attachments:

Spacing 23'

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
**Cost and Performance**

**Remediation Goal:**

___ In Groundwater:

___ In Soil:

**Was the Remediation Goal Achieved:**

___ In Groundwater

___ In Soil

**General comments on the thermal application:**

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

**Lessons Learned**

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

**Energy**

Total Energy Used: 215 kWhr

___ kWhr/m³ ___ kWhr/yd³

___ Total energy applied to treatment zone: ___ kWhr/m³ ___ kWhr/yd³

___ Other energy: ___ kWhr/m³ ___ kWhr/yd³

___ Please note other energy:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

**Cost**

Total Project Cost:

___ Consultant Cost:

___ Thermal Vendor Cost:

___ Energy Cost:

___ Other Cost 1:

___ Other Cost 2:

___ Other Cost 3:

___ Please note other cost:

___ Other Cost 1:

___ Other Cost 2:

___ Other Cost 3:
**General Site Information**

- **Type of treatment:**
  - [ ] Conductive
  - [ ] Steam
  - [ ] ERH
  - [x] Other: RFH

- **Type of Contaminant:**
  - [ ] Chlorinated Solvents
  - [x] Petroleum Hydrocarbons
  - [ ] Pesticides
  - [ ] Wood Treating
  - [x] Other: JP-4

- **Treatment Status:**
  - [ ] Active
  - [x] Post

- **Type of Test:**
  - [x] Pilot Test
  - [ ] Full Scale System

- **Start of Test:** ____________
- **End of Test:** ____________
- **Duration:** ____________

- **Type of Site:**
  - [ ] Non-DOD
  - [x] DoD

- **Facility Name:** Volk Airfield National Guard
  - **Address:**
  - **City, State, Zip Code:** Camp Douglas, WI
  - **OU# or Site #:**

- **Primary point of contact:** Steve Buston
  - **Organization:** National Guard
  - **Address:**
  - **City, State, Zip Code:**
  - **Phone #:** 608-427-1587
  - **email:**

- **Other contacts or vendors who worked on site:** None
  - **Point of contact:**
    - **Type:**
      - [ ] Vendor, Consultant
      - [ ] Vendor, Technical Applications
      - [ ] Other
    - **Organization:**
    - **Address:**
    - **City, State, Zip Code:**
    - **Phone #:**
    - **email:**

- **QA/QC**

- **Characteristics of Interest**
  - [ ] Good pre- and post-treatment groundwater data
  - [ ] Good pre- and post-treatment soil data
  - [ ] Good temperature profile vs. time information
  - [ ] Flux assessment
  - [ ] Groundwater elevations
  - [ ] Geologic cross-section
  - [ ] Hydraulic Conductivity information
### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Chlorinated Solvents</td>
<td></td>
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<tr>
<td>Tetrachloroethene</td>
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<td>Benzene</td>
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<tr>
<td>Ethylene</td>
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<td>n-Butyl alcohol</td>
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<td>None</td>
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<tr>
<td>Trans-1,2-dichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
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<td>1,2-dichloroethane</td>
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<td>Vinyl Chloride</td>
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<td>Other</td>
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<td>Petroleum Hydrocarbons</td>
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<td>None</td>
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<tr>
<td>Other</td>
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</tbody>
</table>

### General Site Assessment Data

- **Map attachment:**
- **Alternative method for determining size of impacted zone (See source zone definition attachments):**
- **Impacted zone as defined by documentation:**
- **Number of wells relative to treatment zone:**
  - Pre-treatment: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________
  - Post-treatment: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________
- **Number of wells with post-treatment data:**
  - Number inside treatment zone: __________
  - Number outside treatment zone: __________

### Comments:

- Additional information or notes

### Attachments:

- Additional documentation or files
## Hydrogeologic Conceptual Model

### Geology:

**Zone** | **Unconsolidated Sediments**
---|---
Vadose Zone: | - Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone
Saturated Zone: | - Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Aquifer Characteristics:

- Ground surface elevation based on wells in or adjacent to treatment zone: \[ \text{ft amsl} \]
- Is more than 1 aquifer present? \[ \text{No} \] \[ \text{Yes (number):} \]
- Depth to water: \[ \text{low value (ft bgs):} \] \[ \text{high value (ft bgs):} \] \[ \text{Unknown:} \]
- Flow direction

### Aquifer 1

- Horizontal hydraulic gradient (feet/foot): \[ \text{X} \] \[ \text{Unknown} \]
- Vertical hydraulic gradient (feet/foot): \[ \text{X} \] \[ \text{Unknown} \]

### Aquifer 2

- K range (ft/day): \[ \text{X} \] \[ \text{Unknown} \]

### Aquifer 3

- Transmissivity (ft²/day): \[ \text{X} \] \[ \text{Unknown} \]

### Measured using:

- Slug Test
- Laboratory
- Field data

### Comments:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

### Attachments:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

---

**Facility ID#:** 0920
## Thermal Treatment - Design

**Facility ID#: 0920**

### Type of Test:
- **Pilot test**
- **Full-scale System**

### Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Treatment Target Zone:
- **Saturated only**
- **Vadose only**
- **Both (Saturated and Vadose zones)**

### Start of Thermal Test: **Duration:**

### Hydraulic Control: **Yes**

### Treatment Cell Design:
- **Thermal treatment:**
  - **Conductive**
  - **Electrical Resistance**
  - **Steam**
  - **Steam + air**
  - **Steam + O2**

### Size of target zone (ft²):
- **72**

### Thickness of target zone (ft):
- **7**

### Depth to top of target zone (ft bgf):
- **0**

### Thickness of target zone below water table (ft):
- **x**

### Number of energy delivery points:
- **x**

### Number of extraction points:
- **x**

### Temperature Profile:
- **Initial formation temperature (deg C):**
- **Maximum representative formation temperature (deg C):**
- **Time to reach maximum representative temperature (days):**
- **Duration of treatment at representative temperature (days):**
  - Date: **Unknown**
  - Temperature (deg C): **Unknown**

### Mass of contaminant removed:
- **Via liquid pumping:**
  - **lb**
  - **kg**

### Duration of post-treatment monitoring (days):

### Notes:
- When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.

---

**Notes:**
- **Attachments:**
Remediation Goal:

In Groundwater: ____________________________________________

In Soil: ____________________________________________

Was the Remediation Goal Achieved:

In Groundwater: ____________________________________________

Comment: ____________________________________________

X In Soil

Comment: Unknown but did see 99% reduction in volatile hydrocarbons, 94 to 99% reduction in semi-volatile hydrocarbons, and 83% reduction on average in hexadecane with a boiling point of 289°C

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: _____kWh _____kWh/m³ _____kWh/yd³

Total energy applied to treatment zone: _____kWh/m³ _____kWh/yd³

Other energy: _____kWh/m³ _____kWh/yd³

Please note other energy: ____________________________________________

Cost

Total Project Cost:

Consultant Cost: ____________________________________________

Thermal Vendor Cost: ____________________________________________

Energy Cost: _____m³ _____yd³

Other Cost 1: ____________________________________________

Other Cost 2: ____________________________________________

Other Cost 3: ____________________________________________

Please note other cost:

Other Cost 1: ____________________________________________

Other Cost 2: ____________________________________________

Other Cost 3: ____________________________________________
Facility Name: Mobil Oil

Address:

City, State, Zip Code: TX

OU# or Site #:

Primary point of contact: Ray Kasevich

Organization: KSN Energies

Address: 291 Main St., 3rd Floor, PO Box 612

City, State, Zip Code: Great Barrington, MA 01230

Phone #: 413-528-4651 email: rkasevich@ksnenergies.com

Other contacts or vendors who worked on site: None

Point of contact:

Type: Vendor, Consultant Vendor, Technical Applications Other

Organization:

Address:

City, State, Zip Code:

Phone #: email:

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:** 0010

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
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<tbody>
<tr>
<td>Map attachment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative method for determining size of impacted zone (See source zone definition attachments)</td>
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**Map attachment:**

<table>
<thead>
<tr>
<th>Monitor Wells:</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
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</thead>
</table>

Number of wells relative to treatment zone:

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>In:</th>
<th>Upgradient:</th>
<th>Downgradient:</th>
<th>Crossgradient:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-treatment</td>
<td>In:</td>
<td>Upgradient:</td>
<td>Downgradient:</td>
<td>Crossgradient:</td>
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</table>

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>Number inside treatment zone:</th>
<th>Number outside treatment zone:</th>
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</table>

Number of wells relative to treatment zone:

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>In:</th>
<th>Upgradient:</th>
<th>Downgradient:</th>
<th>Crossgradient:</th>
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<tr>
<td>Post-treatment</td>
<td>In:</td>
<td>Upgradient:</td>
<td>Downgradient:</td>
<td>Crossgradient:</td>
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Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
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</table>

<table>
<thead>
<tr>
<th>Tetrachloroethene</th>
<th>Benzene</th>
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<td>Vinyl Chloride</td>
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</table>

Comments:

Attachments:
### Geology:

**Zone**

**Unconsolidated Sediments**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

### Aquifer Characteristics:

**Is more than 1 aquifer present?**
- No
- Yes (number): _____________
- Unknown (assume single aquifer)

**Depth to water:**
- Low value (ft bgs): _____________
- High value (ft bgs): _____________
- Unknown: _____________

**Flow direction:**

**Horizontal hydraulic gradient (feet/foot):**

**Vertical hydraulic gradient (feet/foot):**

**K range (ft/day):**
- Measured using: ___ Slug Test ___ Laboratory ___ Field data
- Low: _____________ ___ ___ ___ ___ ___未知
- High: _____________ ___ ___ ___ ___ ___

**Transmissivity (ft²/day):**
- Measured using: ___ Slug Test ___ Laboratory ___ Field data
- Low: _____________ ___ ___ ___ ___ ___未知
- High: _____________ ___ ___ ___ ___ ___

### Ground surface elevation based on wells in or adjacent to treatment zone:
- ______ ft amsl
- Unknown

### Comments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

### Attachments:
Thermal Treatment - Design

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<tr>
<th>Thermal treatment:</th>
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<tbody>
<tr>
<td>Conductive</td>
</tr>
<tr>
<td>Electrical Resistance</td>
</tr>
<tr>
<td>3 phase</td>
</tr>
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<td>6 phase</td>
</tr>
<tr>
<td>AC power</td>
</tr>
<tr>
<td>DC power</td>
</tr>
<tr>
<td>Steam</td>
</tr>
<tr>
<td>Steam + air</td>
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<td>Steam + O2</td>
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<table>
<thead>
<tr>
<th>Type of Test:</th>
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</thead>
<tbody>
<tr>
<td>Pilot test</td>
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<tr>
<td>Full-scale System</td>
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<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
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</thead>
<tbody>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>Weathered bedrock, limestone, sandstone</td>
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<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
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<tbody>
<tr>
<td>Saturated only</td>
</tr>
<tr>
<td>Vadose only</td>
</tr>
<tr>
<td>Both (Saturated and Vadose zones)</td>
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<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
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<table>
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<thead>
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<th>Hydraulic Control</th>
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<td>No</td>
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<table>
<thead>
<tr>
<th>Temperature Profile:</th>
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</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
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<tr>
<td>Maximum representative formation temperature (deg C):</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

| Formation temperature immediately post-treatment: |
| Formtion temperature post-treatment monitoring event 1: |
| Duration of post-treatment monitoring (days): |

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
</tr>
<tr>
<td>In vapor stream:</td>
</tr>
<tr>
<td>Total:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
</table>

| Attachments: |

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

- In Groundwater:
  - Comment:

- In Soil:
  - Comment:

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment:

- In Soil
  - Comment:

General comments on the thermal application:

- 
  - 
  - 
  - 

Lessons Learned

- 
  - 
  - 
  - 

Energy

Total Energy Used: ________ ________ ________ ________ ________ ________
  - Total energy applied to treatment zone: ________ ________ ________ ________ ________ ________
  - Other energy: ________ ________ ________ ________ ________ ________

Cost

Total Project Cost: 
  - Consultant Cost: 
  - Thermal Vendor Cost: 
  - Energy Cost: ________ ________ ________
  - Other Cost 1: 
  - Other Cost 2: 
  - Other Cost 3: 

Other Cost 1:
  - Other Cost 2:
  - Other Cost 3:

Please note other cost:

- Other Cost 1:
  - Other Cost 2:
  - Other Cost 3:

Other energy:

- kWhr/m³
  - kWhr/yd³

Lessons Learned

- 
  - 
  - 
  - 

Total Project Cost:

Cost and Performance Facility ID#: 0930
General Site Information

File Analyzed By: JT PD Date: 10/18/2006
Type of treatment: Conductive Steam ERH Other: __________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: __________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 1-Nov End of Test: 1-Jun Duration: 9 months
Type of Site: Non-DOD DoD

Facility Name: Baker Petrolite
Address: ___________________________________________________________________________________________
City, State, Zip Code: Calgary, Alberta, Canada
OU# or Site #: ______________________________________________________________________________________

Primary point of contact: Lacy Rosson
Organization: Baker Petrolite
Address: ___________________________________________________________________________________________
City, State, Zip Code: ______________________________________________________________________________
Phone #: 281-276-5400 email: lacy.rosson@bakerpetrolite.com

Other contacts or vendors who worked on site: None
Point of contact: Katherine Lundy
Type: Vendor, Consultant Vendor, Technical Applications Other __________
Organization: Kaizen Environmental Services
Address: ___________________________________________________________________________________________
City, State, Zip Code: ______________________________________________________________________________
Phone #: 403-297-0216 (1-888-525-5902) email: ________________________________

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
General Site Assessment Data

Facility ID: 0940

Impacted Zone: Length (parallel to flow direction)(ft.): Width (ft.): Thickness (ft.): Unknown

Impacted zone as defined by documentation

Alternative method for determining size of impacted zone (See source zone definition attachments)

Map attachment

Monitor Wells: Number of relevant monitoring wells with groundwater data: None

Number of wells relative to treatment zone:

Pre-treatment In: Upgradient: Downgradient: Crossgradient:
Post-treatment In: Upgradient: Downgradient: Crossgradient:

Soil Borings: Number of relevant soil borings with pre-treatment data:

Number of relevant soil borings with post-treatment data:

Number inside treatment zone: Number outside treatment zone:

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>Benzene</td>
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<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
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Comments:

Attachments:
### Geology

<table>
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<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<tbody>
<tr>
<td>Vadose Zone</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
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<tr>
<td></td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
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<tr>
<td></td>
<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
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<td>Saturated Zone</td>
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<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
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<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics

- **Ground surface elevation based on wells in or adjacent to treatment zone:** __________ ft amsl  
  - **Unknown:** __________ ft amsl

- **Is more than 1 aquifer present?**  
  - **No:** __________  
  - **Yes (number):** __________  
  - **Unknown (assume single aquifer):** __________

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<tr>
<th>Aquifer</th>
<th>Depth to water</th>
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<td></td>
<td>low (ft bgs): 13</td>
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<tr>
<td></td>
<td>high (ft bgs):</td>
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- **Flow direction:**

- **Horizontal hydraulic gradient (feet/foot):**

- **Vertical hydraulic gradient (feet/foot):**

- **K range (ft/day):**
  - **Measured using:** Slug Test, Laboratory, Field data
  - **low:** 0.028 ft/day
  - **high:**

- **Transmissivity (ft²/day):**
  - **Measured using:** Slug Test, Laboratory, Field data
  - **low:**
  - **high:**

**Comments:**

- **K = 10E-6 cm/s**

**Attachments:**

- Additional data or information related to the hydrogeologic conceptual model.
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<th><strong>Thermal Treatment - Design</strong></th>
<th><strong>Facility ID:</strong> 9940</th>
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<td><strong>x</strong> Thermal treatment:</td>
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<tr>
<td>_____ Conductive</td>
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<tr>
<td>x Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td>_____ 3 phase AC power DC power</td>
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<td>_____ 6 phase AC power DC power</td>
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<td>Steam + air</td>
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<td>Steam + O2</td>
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<tr>
<td>Other (describe)</td>
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<tr>
<td>x Pilot test</td>
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<tr>
<td>_____ Full-scale System</td>
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<tr>
<td><strong>Geology of Treatment Zone:</strong></td>
<td></td>
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<tr>
<td>_____ Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td>x Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
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<tr>
<td>_____ Relatively homogeneous and impermeable unconsolidated sediments</td>
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<tr>
<td>_____ Largely permeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td>_____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
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<tr>
<td>_____ Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td><strong>Treatment Target Zone:</strong></td>
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</tr>
<tr>
<td>_____ Saturated only</td>
<td></td>
</tr>
<tr>
<td>_____ Vadose only</td>
<td></td>
</tr>
<tr>
<td>x _____ Both (Saturated and Vadose zones)</td>
<td></td>
</tr>
<tr>
<td><strong>Start of Thermal Test:</strong></td>
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</tr>
<tr>
<td>x 1-Nov</td>
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<tr>
<td>Duration: 9 months</td>
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<td><strong>Hydraulic Control:</strong></td>
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<tr>
<td>x Yes</td>
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<td>Size of target zone (ft²):</td>
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<td>Thickness of target zone (ft):</td>
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</tr>
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<td>Depth to top of target zone (ft bgs):</td>
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</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
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<tr>
<td>Number of energy delivery points:</td>
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</tr>
<tr>
<td>Number of extraction points:</td>
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<td><strong>Temperature Profile:</strong></td>
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<td>Initial formation temperature (deg C):</td>
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<tr>
<td>Maximum representative formation temperature (deg C):</td>
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<tr>
<td><strong>Date</strong></td>
<td><strong>Temperature (deg C)</strong></td>
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<tr>
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<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
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<tr>
<td>Duration of post-treatment monitoring (days):</td>
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</tr>
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<td><strong>Mass of contaminant removed:</strong></td>
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<tr>
<td>In vapor stream:</td>
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<tr>
<td>Total:</td>
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</table>

**Comments:**

**Attachments:**

---

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

- In Groundwater: source reduction target >95% total recovery
- In Soil: 

Was the Remediation Goal Achieved:

- In Groundwater
  Comment: >99.9% source reduction, all MCLs met
- In Soil

General comments on the thermal application:

Lessons Learned:

Energy

- Total Energy Used: kWh m³ yd³
  - Total energy applied to treatment zone: kWh m³ yd³
  - Other energy: kWh m³ yd³

Cost

- Total Project Cost: 
  - Consultant Cost: 
  - Thermal Vendor Cost: 
  - Energy Cost: m³ yd³ 
  - Other Cost 1: 
  - Other Cost 2: 
  - Other Cost 3: 

Please note other cost:

Other Cost 1: 
Other Cost 2: 
Other Cost 3: 

## General Site Information

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<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
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<tr>
<td>Type of treatment:</td>
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<td>Conductive</td>
<td>Steam</td>
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<tr>
<td>Type of Contaminant:</td>
<td>___</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>___</td>
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<td>Post</td>
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<td>Type of Test:</td>
<td>___</td>
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<td>Full Scale System</td>
</tr>
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<td>Start of Test:</td>
<td>___</td>
<td>End of Test:</td>
<td>___</td>
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<td>___</td>
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## Facility Information

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<th>Safety Kleen</th>
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<td>City, State, Zip Code:</td>
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<td>OU# or Site #:</td>
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## Primary point of contact

<table>
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<tr>
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<th>Lynn Longshore</th>
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<tr>
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<tr>
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<tr>
<td>Phone #:</td>
<td>18006695740</td>
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<td>email:</td>
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___ Other contacts or vendors who worked on site: __________ None

| Point of contact: | __________________ |
| Type:             | Vendor, Consultant | Vendor, Technical Applications | Other | ___ |
| Organization:     | __________________ |
| Address:          | __________________ |
| City, State, Zip Code: | ________________ |
| Phone #:          | __________________ |
| email:            | __________________ |

## QA/QC

### Characteristics of Interest

___ Good pre- and post-treatment groundwater data
___ Good pre- and post-treatment soil data
___ Good temperature profile vs. time information
___ Flux assessment
___ Groundwater elevations
___ Geologic cross-section
___ Hydraulic Conductivity information
### General Site Assessment Data

- **Impacted Zone**: Length (parallel to flow direction)(ft.): ______, Width (ft.): ______, Thickness (ft.): ______, Unknown
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment
- **Monitor Wells**: Number of relevant monitoring wells with groundwater data: ______, Pre-treatment: ______, Post-treatment: ______, None
- **Soil Borings**: Number of relevant soil borings with pre-treatment data: ______, Number of relevant soil borings with post-treatment data: ______, Number inside treatment zone: ______, Number outside treatment zone: ______

### Types of Contaminants

<table>
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<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<td>Jet Fuel</td>
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<td>Naphthalene</td>
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### Comments:

- ___________________________________________________________________________
- ___________________________________________________________________________
- ___________________________________________________________________________

### Attachments:

- ___________________________________________________________________________
- ___________________________________________________________________________
- ___________________________________________________________________________
Hydrogeologic Conceptual Model

Geology: 

Zone       Unconsolidated Sediments
            Relatively homogeneous and permeable unconsolidated sediments
            Relatively homogeneous and impermeable unconsolidated sediments
            Largely permeable sediments with inter-bedded lenses of lower permeability material
            Largely impermeable sediments with inter-bedded layers of higher permeability material
            Competent, but fractured bedrock (i.e. crystalline rock)
            Weathered bedrock, limestone, sandstone

Vadose Zone: __ Relatively homogeneous and permeable unconsolidated sediments
            __ Relatively homogeneous and impermeable unconsolidated sediments
            __ Largely permeable sediments with inter-bedded layers of lower permeability material
            __ Largely impermeable sediments with inter-bedded layers of higher permeability material
            __ Competent, but fractured bedrock (i.e. crystalline rock)
            __ Weathered bedrock, limestone, sandstone

Saturated Zone: __ Relatively homogeneous and permeable unconsolidated sediments
                __ Relatively homogeneous and impermeable unconsolidated sediments
                __ Largely permeable sediments with inter-bedded lenses of lower permeability material
                __ Largely impermeable sediments with inter-bedded layers of higher permeability material
                __ Competent, but fractured bedrock (i.e. crystalline rock)
                __ Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: _____ ft amsl  _____ Unknown

Aquifer Characteristics:

Is more than 1 aquifer present?  No  Yes (number): _____________  Unknown (assume single aquifer)

Aquifer 1  Aquifer 2  Aquifer 3

Depth to water: low value (ft bgs):  __________  __________  __________
high value (ft bgs):  __________  __________  __________
Unknown:  __________  __________  __________

Flow direction

Horizontal hydraulic gradient (feet/foot):  __________  __________  __________  __________  Unknown
Vertical hydraulic gradient (feet/foot):   __________  __________  __________  __________  Unknown

K range (ft/day) Measured using: ___ Slug Test  ___ Laboratory  ___ Field data
low  __________  __________  __________  Unknown
high __________  __________  __________

Transmissivity (ft²/day): Measured using: ___ Slug Test  ___ Laboratory  ___ Field data
low  __________  __________  __________  Unknown
high __________  __________  __________

Comments:

Attachments:
Thermal Treatment - Design

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<th>Electrical Resistance</th>
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<th>AC power</th>
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<th>Other (describe)</th>
<th>Steam + air</th>
<th>Steam + O2</th>
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<th>Full-scale System</th>
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<th>Relatively homogeneous and permeable unconsolidated sediments</th>
<th>Relatively homogeneous and impermeable unconsolidated sediments</th>
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<td>Largely permeable sediments with inter-bedded layers of lower permeability material</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<tr>
<td>x</td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td>Weathered bedrock, limestone, sandstone</td>
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<table>
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<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
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<th>Size of target zone (ft²):</th>
<th>1520</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thickness of target zone (ft):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth to top of target zone (ft bgs):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thickness of target zone below water table (ft):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of energy delivery points:</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of extraction points:</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
<th>Initial formation temperature (deg C):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum representative formation temperature (deg C):</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Duration of treatment at representative temperature (days):</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Formation temperature immediately post-treatment:</th>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Formation temperature post-treatment monitoring event 1:</th>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Duration of post-treatment monitoring (days):</th>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
<th>Via liquid pumping:</th>
<th>4 lb</th>
<th>4 kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td>4 lb</td>
<td>4 kg</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>8 lb</td>
<td>8 kg</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>--------------</td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
### Performance

**Remediation Goal:**

- **In Groundwater:**
  - ____________________________
  - ____________________________
  - ____________________________

- **In Soil:**
  - ____________________________
  - ____________________________
  - ____________________________

**Was the Remediation Goal Achieved:**

- **In Groundwater**
  - ____________________________
  - ____________________________
  - ____________________________
  - Comment:

- **In Soil**
  - ____________________________
  - ____________________________
  - ____________________________
  - Comment:

**General comments on the thermal application:**

- ____________________________
  - ____________________________
  - ____________________________
  - ____________________________
  - ____________________________

### Lessons Learned

- ____________________________
  - ____________________________
  - ____________________________
  - ____________________________
  - ____________________________

### Energy

**Total Energy Used:**

<table>
<thead>
<tr>
<th>kWhr</th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
</table>

- **Total energy applied to treatment zone:**
  - ____________________________
  - ____________________________
  - ____________________________

- **Other energy:**
  - ____________________________
  - ____________________________
  - ____________________________

  - Please note other energy:

### Cost

**Total Project Cost:**

<table>
<thead>
<tr>
<th>Consultant Cost:</th>
<th>____________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Vendor Cost:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Energy Cost:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Other Cost 1:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Other Cost 2:</td>
<td>____________________________</td>
</tr>
<tr>
<td>Other Cost 3:</td>
<td>____________________________</td>
</tr>
</tbody>
</table>

- Please note other cost:
  - Other Cost 1: ____________________________
  - Other Cost 2: ____________________________
  - Other Cost 3: ____________________________
General Site Information

File Analyzed By: JT PD Date: 11/6/2006
Type of treatment: ___________ Conductive ___________ Steam ___________ ERH ___________ Other: ___________
Type of Contaminant: ___________ Chlorinated Solvents ___________ Petroleum Hydrocarbons ___________ Pesticides
_________ Wood Treating ___________ Other: ___________
Treatment Status: ___________ Active ___________ Post
Type of Test: ___________ Pilot Test ___________ Full Scale System
Start of Test: Aug-99 End of Test: 1-Sep Duration: ~2 years
Type of Site: ___________ Non-DOD ___________ DoD

Facility Name: Muehlacher Germany
Address: Muehlacher Germany
City, State, Zip Code: Muehlacher Germany
OU# or Site #: ___________

Primary point of contact: Dr. Hans-Peter Koschitsky
Organization: University of Stuttgart
Address: Pfaffenwaldring 61 D-70569
City, State, Zip Code: Stuttgart, Germany
Phone #: email: kasch@iws.uni-stuttgart.de

Other contacts or vendors who worked on site: ___________ None
Point of contact: ___________
Type: ___________ Vendor, Consultant ___________ Vendor, Technical Applications ___________ Other ___________
Organization: ___________
Address: ___________
City, State, Zip Code: ___________
Phone #: email: ___________

QA/QC

Characteristics of Interest
_________ Good pre- and post-treatment groundwater data
_________ Good pre- and post-treatment soil data
_________ Good temperature profile vs. time information
_________ Flux assessment
_________ Groundwater elevations
_________ Geologic cross-section
_________ Hydraulic Conductivity information
General Site Assessment Data

Imposed Zone: Length (parallel to flow direction)(ft.): Width (ft.): Thickness (ft.): Unknown

Imposed zone as defined by documentation
Alternative method for determining size of imposed zone (See source zone definition attachments)
Map attachment

Monitor Wells: Number of relevant monitoring wells with groundwater data:

Number of wells relative to treatment zone:
Pre-treatment: Post-treatment: None

Soil Borings: Number of relevant soil borings with pre-treatment data:

Number of relevant soil borings with post-treatment data:
Number inside treatment zone: Number outside treatment zone:

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>X</td>
<td>X</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>X</td>
<td>X</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>X</td>
<td>X</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>X</td>
<td>X</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>X</td>
<td>X</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>X</td>
<td>X</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>X</td>
<td>X</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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</table>

Comments:

Attachments:
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>X</td>
<td>Vadose Zone:</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Ground surface elevation based on wells in or adjacent to treatment zone: | 0 ft amsl | Unknown |

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
</tr>
<tr>
<td>Depth to water:</td>
</tr>
<tr>
<td>low value (ft bgs):</td>
</tr>
<tr>
<td>high value (ft bgs):</td>
</tr>
<tr>
<td>Unknown:</td>
</tr>
</tbody>
</table>

| Flow direction: |  |

| Horizontal hydraulic gradient (feet/foot): |  |
|                                           |  |

| Vertical hydraulic gradient (feet/foot): |  |
|                                         |  |

| K range (ft/day): | Measured using: | Slug Test | Laboratory | Field data |
|                  | low | high | low | high | Unknown |

| Transmissivity (ft2/day): | Measured using: | Slug Test | Laboratory | Field data |
|                          | low | high | Unknown |
|                          |    |     |          |

| Comments: |  |
|           |  |

| Attachments: |  |
|             |  |
## Thermal Treatment - Design

**Thermal treatment:**
- ____ Conductive
- ____ Electrical Resistance

**Facility ID#:** 1010

### Geology of Treatment Zone:
- ____ Relatively homogeneous and permeable unconsolidated sediments
- ____ Largely permeable sediments with inter-bedded lenses of lower permeability material
- ____ Largely impermeable sediments with inter-bedded layers of higher permeability material
- ____ Competent, but fractured bedrock (i.e. crystalline rock)
- ____ Weathered bedrock, limestone, sandstone

### Treatment Target Zone:
- ____ Saturated only
- ____ Vadose only
- ____ Both (Saturated and Vadose zones)

### Type of Test:
- ____ Pilot test
- ____ Full-scale System

### Start of Thermal Test:
- Aug-99
- Duration: ~2 years

### Hydraulic Control:
- ____ Yes
- ____ No

### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²):</td>
<td>4036</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>26.2</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>23</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>0</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>1</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>6</td>
</tr>
</tbody>
</table>

### Temperature Profile:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### Notes:
- Formation temperature immediately post-treatment:
- Formation temperature post-treatment monitoring event 1:
- Duration of post-treatment monitoring (days):

### Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Method</th>
<th>Quantity (lb)</th>
<th>Unit</th>
<th>Quantity (kg)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping</td>
<td>140</td>
<td>lb</td>
<td>X</td>
<td>kg</td>
</tr>
<tr>
<td>In vapor stream</td>
<td>2660</td>
<td>lb</td>
<td>X</td>
<td>kg</td>
</tr>
<tr>
<td>Total</td>
<td>2800</td>
<td>lb</td>
<td>X</td>
<td>kg</td>
</tr>
</tbody>
</table>

**Notes:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

Lessons Learned:

Energy

Total Energy Used: _______ kWhr _______ kWhr/m³ _______ kWhr/ yd³

Total energy applied to treatment zone: _______ kWhr/m³ _______ kWhr/ yd³

Other energy: _______ kWhr/m³ _______ kWhr/ yd³

Please note other energy:

Cost

Total Project Cost: 950,900

Consultant Cost:

Thermal Vendor Cost: 290.81 / yd³

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
General Site Information

Type of treatment: □ Conductive □ Steam □ ERH □ Other: __________________________
Type of Contaminant: □ Chlorinated Solvents □ Petroleum Hydrocarbons □ Pesticides
□ Wood Treating □ Other: __________________________
Treatment Status: □ Active □ Post
Type of Test: □ Pilot Test □ Full Scale System
Start of Test: 9/26/2001 End of Test: 4/30/2002 Duration: 217 d
Type of Site: □ Non-DOD □ DoD

Facility Name: North Hill Manor
Address: Shell Canada
City, State, Zip Code: Calgary, Alberta, Canada
OU# or Site #: __________________________

Primary point of contact: Randall Warren
Organization: Shell Canada
Address: __________________________
City, State, Zip Code: __________________________
Phone #: 403-691-2954 email: __________________________

Other contacts or vendors who worked on site □ None
Point of contact: Gary Millard
Type: □ Vendor, Consultant □ Vendor, Technical Applications □ Other □
Organization: Shell Canada
Address: __________________________
City, State, Zip Code: __________________________
Phone #: 403-216-5558 email: gary.millard@shell.com

QA/QC

□ Characteristics of Interest
□ Good pre- and post-treatment groundwater data □ Good pre- and post-treatment soil data
□ Good temperature profile vs. time information □ Flux assessment
□ Groundwater elevations □ Geologic cross-section
□ Hydraulic Conductivity information
**General Site Assessment Data**

**Facility ID#: 1030**

### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): 13.5
- Impacted zone as defined by documentation: __________
- Alternative method for determining size of impacted zone (See source zone definition attachments): __________
- Map attachment: __________

### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
  - Pre-treatment: __________
  - Post-treatment: __________
- Number of relevant monitoring wells with post-treatment data: __________
- Number of relevant monitoring wells with pre-treatment data: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: __________
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________
  - Post-treatment: __________
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________

### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants:

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>0.01 mg/L</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>0.05 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m+p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>xylenes</td>
<td></td>
<td>0.1 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>TPH</td>
<td></td>
<td>1 mg/L</td>
<td>500 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- __________
- __________
- __________
- __________

### Attachments:
- __________
- __________
- __________
Hydrogeologic Conceptual Model

Geology:

Vadose Zone:
- X Relevant homogenous and permeable unconsolidated sediments
- X Largely permeable sediments with inter-bedded lenses of lower permeability material
- X Largely impermeable sediments with inter-bedded layers of higher permeability material
- X Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- X Relevant homogenous and permeable unconsolidated sediments
- X Largely permeable sediments with inter-bedded lenses of lower permeability material
- X Largely impermeable sediments with inter-bedded layers of higher permeability material
- X Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: X Unknown

Aquifer Characteristics:
- X Is more than 1 aquifer present? No Yes (number): Unknown (assume single aquifer)

Aquifer 1 Aquifer 2 Aquifer 3
Depth to water:
- low value (ft bgs): 14.1
- high value (ft bgs): 16.7
- Unknown:

Flow direction: West

Horizontal hydraulic gradient (feet/foot): Unknown
Vertical hydraulic gradient (feet/foot): Unknown

K range (ft/day) Measured using: Slug Test Laboratory Field data
- low: Unknown
- high: Unknown

Transmissivity (ft²/day): Measured using: Slug Test Laboratory Field data
- low: Unknown
- high: Unknown

Comments:

k=10e-6 cm/s

Attachments:
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 1030</th>
</tr>
</thead>
</table>

**Thermal treatment:**
- **Conductive**
- **Electrical Resistance**
  - 3 phase
  - 6 phase
  - AC power
  - DC power

**Steam**
- Steam
- Steam + air
- Steam + O2
- Other (describe)

**Type of Test:**
- Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- 9/26/2001
- Duration: 217 d

** Hydraulic Control:**
- Yes
- No

**Treatment Cell Design:**
- Size of target zone (ft²): 4000
- Thickness of target zone (ft): 13
- Depth to top of target zone (ft bg): 8
- Thickness of target zone below water table (ft): 5
- Number of energy delivery points: 10
- Number of extraction points: 15

**Temperature Profile:**
- Initial formation temperature (deg C): Unknown
- Maximum representative formation temperature (deg C): 78
- Time to reach maximum representative temperature (days): Unknown
- Duration of treatment at representative temperature (days): Unknown

**Formation temperature immediately post-treatment:**
- Date: [ ]
- Temperature (deg C): [ ]

**Formation temperature post-treatment monitoring event 1:**
- Date: [ ]
- Temperature (deg C): [ ]

**Duration of post-treatment monitoring (days):**
- [ ]

**Mass of contaminant removed:**
- Via liquid pumping: [ ] lb [ ] kg [ ] Unknown
- In vapor stream: 1740 Liters [ ] lb [ ] kg [ ] Unknown
- Total: [ ] lb [ ] kg [ ] Unknown

**Comments:**
- 15 vapor extraction wells and 20 groundwater extraction wells

**Attachments:**

*Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.*
Remediation Goal:

Alberta, Canada Tier 1 - <5 ppb benzene.
Benzene-0.4mg/L, toluene-25mg/L, ethylbenzene-50mg/L, xylenes-80mg/L

In Soil:
Benzene-0.2mg/Kg, toluene-40mg/Kg, ethylbenzene-300mg/Kg, xylenes-110mg/Kg, TPH-2000mg/Kg

Was the Remediation Goal Achieved:

X In Groundwater
Comment: Yes

XX In Soil
Comment: Yes

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: __________ kWhr __________ kWhr/m³ __________ kWhr/yd³

Total energy applied to treatment zone: __________ kWhr/m³ __________ kWhr/yd³

Other energy: __________ kWhr/m³ __________ kWhr/yd³

Please note other energy: __________

Cost

Total Project Cost: __________

Consultant Cost: __________

Thermal Vendor Cost: __________

Energy Cost: __________ m³ __________ yd³

Other Cost 1: __________

Other Cost 2: __________

Other Cost 3: __________

Please note other cost: __________ Other Cost 1: __________

Other Cost 2: __________

Other Cost 3: __________
<table>
<thead>
<tr>
<th><strong>General Site Information</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X</strong> File Analyzed By:</td>
<td>JT X PD</td>
</tr>
<tr>
<td><strong>Date:</strong></td>
<td>10/18/2006</td>
</tr>
<tr>
<td><strong>Type of treatment:</strong></td>
<td></td>
</tr>
<tr>
<td>Conductive</td>
<td>Steam</td>
</tr>
<tr>
<td><strong>Type of Contaminant:</strong></td>
<td></td>
</tr>
<tr>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
</tr>
<tr>
<td><strong>Treatment Status:</strong></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>Post</td>
</tr>
<tr>
<td><strong>Type of Test:</strong></td>
<td></td>
</tr>
<tr>
<td>Pilot Test</td>
<td>Full Scale System</td>
</tr>
<tr>
<td><strong>Start of Test:</strong></td>
<td>8/14/2003</td>
</tr>
<tr>
<td><strong>End of Test:</strong></td>
<td>3/xx/04</td>
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<tr>
<td><strong>Duration:</strong></td>
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<tr>
<td><strong>Type of Site:</strong></td>
<td></td>
</tr>
<tr>
<td>Non-DOD</td>
<td>DoD</td>
</tr>
</tbody>
</table>

| **Facility Name:** | Rosslyn Turbo |
| **Organization:** | Shell Canada Products, Ltd |
| **Primary point of contact:** | Randall Warren |
| **Phone #:** | 403-691-2954 |
| **Email:** | gary.millard@shell.com |
| **Other contacts or vendors who worked on site:** |  |
| **Point of contact:** | Gary Millard |
| **Type:** | Vendor, Consultant | Vendor, Technical Applications | Other |
| **Organization:** | Shell Canada Products, Ltd |
| **Phone #:** | 403-216-5558 403-560-4340 |
| **Email:** | gary.millard@shell.com |

<table>
<thead>
<tr>
<th><strong>QA/QC</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristics of Interest</strong></td>
</tr>
<tr>
<td>Good pre- and post-treatment groundwater data</td>
</tr>
<tr>
<td>Good pre- and post-treatment soil data</td>
</tr>
<tr>
<td>Good temperature profile vs. time information</td>
</tr>
<tr>
<td>Flux assessment</td>
</tr>
<tr>
<td>Groundwater elevations</td>
</tr>
<tr>
<td>Geologic cross-section</td>
</tr>
<tr>
<td>Hydraulic Conductivity information</td>
</tr>
</tbody>
</table>
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): see below
- Width (ft): ___
- Thickness (ft): ___
- Impact zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

- Monitor Wells: Number of wells relative to treatment zone:
  - Pre-treatment: _______
  - Post-treatment: _______

- Soil Borings: Number of relevant soil borings with pre-treatment data:
  - Number inside treatment zone: _______
  - Number outside treatment zone: _______

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>X Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>X Toluene</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
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<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
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<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>X o-xylene</td>
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<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
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</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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</tbody>
</table>

**Comments:**

- Impacted area of 1500 m³

**Attachments:**
### Hydrogeologic Conceptual Model

**Facility ID#: 1040**

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X</strong></td>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

**Aquifer Characteristics:**

- Is more than 1 aquifer present? **X** Unknown (assume single aquifer)
  - No
  - Yes (number): ____________

<table>
<thead>
<tr>
<th>Depth to water:</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
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</thead>
<tbody>
<tr>
<td>Low value (ft bgs):</td>
<td>13</td>
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<td></td>
</tr>
<tr>
<td>High value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

- Flow direction

- Horizontal hydraulic gradient (feet/foot): ____________ ____________ ____________ Unknown
- Vertical hydraulic gradient (feet/foot): ____________ ____________ ____________ Unknown

- K range (ft/day) Measured using: Slug Test Laboratory Field data
  - Low | | | Unknown
  - High | | |
- Transmissivity (ft²/day): Measured using: Slug Test Laboratory Field data
  - Low | | | Unknown
  - High | | |

**Comments:**

- K=10E-6 cm/s

**Attachments:**

____________________________________________________________________________________________
__________

____________________________________________________________________________________________
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>X</th>
<th>Thermal treatment:</th>
<th>___ Conductive</th>
<th>___ Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td>___ 3 phase</td>
<td>___ 6 phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ AC power</td>
<td>___ DC power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Steam</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Steam + air</td>
<td>___ Steam + O2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Other (describe)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| ___ Type of Test: | ___ Pilot test | ___ Full-scale System |

<table>
<thead>
<tr>
<th>X</th>
<th>Geology of Treatment Zone:</th>
<th>___ Relatively homogeneous and permeable unconsolidated sediments</th>
<th>___ Largely permeable sediments with inter-bedded lenses of lower permeability material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>___ Largely permeable sediments with inter-bedded layers of higher permeability material</td>
<td>___ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
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</table>

<table>
<thead>
<tr>
<th>X</th>
<th>Treatment Target Zone:</th>
<th>___ Saturated only</th>
<th>___ Vadose only</th>
<th>___ Both (Saturated and Vadose zones)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Start of Thermal Test:</td>
<td></td>
<td>Duration:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydraulic Control:</td>
<td>___ Yes</td>
<td>___ No</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Treatment Cell Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size of target zone (ft²):</td>
</tr>
<tr>
<td></td>
<td>Thickness of target zone (ft):</td>
</tr>
<tr>
<td></td>
<td>Depth to top of target zone (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>Thickness of target zone below water table (ft):</td>
</tr>
<tr>
<td></td>
<td>Number of energy delivery points:</td>
</tr>
<tr>
<td></td>
<td>Number of extraction points:</td>
</tr>
<tr>
<td></td>
<td>Temperature Profile:</td>
</tr>
<tr>
<td></td>
<td>Initial formation temperature (deg C):</td>
</tr>
<tr>
<td></td>
<td>Maximum representative formation temperature (deg C):</td>
</tr>
<tr>
<td></td>
<td>Time to reach maximum representative temperature (days):</td>
</tr>
<tr>
<td></td>
<td>Duration of treatment at representative temperature (days):</td>
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<tr>
<td></td>
<td>Formation temperature immediately post-treatment:</td>
</tr>
<tr>
<td></td>
<td>Formation temperature post-treatment monitoring event 1:</td>
</tr>
<tr>
<td></td>
<td>Duration of post-treatment monitoring (days):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>___ Mass of contaminant removed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
</tr>
<tr>
<td>In vapor stream:</td>
</tr>
<tr>
<td>Total:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachments:</td>
</tr>
</tbody>
</table>

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

X In Groundwater: Alberta, Canada Tier 1 remediation - <5 ppb benzene

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

Comment: ____________________________________________________________________________________________

___ In Soil

Comment: ____________________________________________________________________________________________

General comments on the thermal application:

______________________________________________________________________________________________

______________________________________________________________________________________________

______________________________________________________________________________________________

______________________________________________________________________________________________

______________________________________________________________________________________________

Lessons Learned

______________________________________________________________________________________________

______________________________________________________________________________________________

______________________________________________________________________________________________

______________________________________________________________________________________________

______________________________________________________________________________________________

__________________________________________

Total energy applied to treatment zone:

Total Energy Used: ________________________ kWhr __________________ kWhr/m³ __________________ kWhr/yd³

___ Total energy applied to treatment zone: ________________________ kWhr/m³ __________________ kWhr/yd³

___ Other energy: ________________________ kWhr/m³ __________________ kWhr/yd³

___ Please note other energy: __________________________________________________________________________

Cost

Total Project Cost:

___ Consultant Cost: ________________________

___ Thermal Vendor Cost: ________________________

___ Energy Cost: ________________________ m³ __________________ yd³

___ Other Cost 1: ________________________

___ Other Cost 2: ________________________

___ Other Cost 3: ________________________

___ Please note other cost: ___ Other Cost 1: ________________________

___ Other Cost 2: ________________________

___ Other Cost 3: ________________________
General Site Information

File Analyzed By: JT  PD  ERH  Date: 10/30/2006
Type of treatment: Conductive  Steam  ERH  Other: RFH
Type of Contaminant: Chlorinated Solvents  Petroleum Hydrocarbons  Pesticides
Wood Treating  Other:  
Treatment Status: Active  Post
Type of Test: Pilot Test  Full Scale System
Start of Test: 1990  End of Test:  
Duration: 
Type of Site: Non-DOD  DoD

Facility Name: East Coast Naval Shipyard
Address: 
City, State, Zip Code: 
OU# or Site #: 

Primary point of contact: 
Organization: 
Address: 
City, State, Zip Code: 
Phone #:  email: 

Other contacts or vendors who worked on site: None
Point of contact: 
Type: Vendor, Consultant  Vendor, Technical Applications  Other
Organization: 
Address: 
City, State, Zip Code: 
Phone #:  email: 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data  Good pre- and post-treatment soil data
Good temperature profile vs. time information  Flux assessment
Groundwater elevations  Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

| Facility ID#: | 1050 |

#### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
  - Pre-treatment: __________
  - Post-treatment: __________
- Number of wells relative to treatment zone:
  - Pre-treatment: In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________
  - Post-treatment: In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical (Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Average Post-treatment Concentration per Chemical (Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Crossdr</td>
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<td>None</td>
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<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>None</td>
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<td>None</td>
<td>None</td>
<td>None</td>
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<td>cis,1,2-dichloroethene</td>
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<td>1,1,2,2-tetrachloroethane</td>
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<td>None</td>
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</tr>
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</table>

#### Comments:

- None

#### Attachments:

- None
### Hydrogeologic Conceptual Model

#### Geology:

**Vadose Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

#### Ground surface elevation based on wells in or adjacent to treatment zone:
- __________ ft amsl
- __________ ft amsl
- __________ ft amsl
- __________ ft amsl

#### Aquifer Characteristics:

- Is more than 1 aquifer present?  
  - No
  - Yes (number): ___________
  - Unknown (assume single aquifer)

**Aquifer 1**
- Depth to water:
  - Low value (ft bgs): ___________
  - High value (ft bgs): ___________
  - Unknown: ___________

**Aquifer 2**
- Depth to water:
  - Low value (ft bgs): ___________
  - High value (ft bgs): ___________
  - Unknown: ___________

**Aquifer 3**
- Depth to water:
  - Low value (ft bgs): ___________
  - High value (ft bgs): ___________
  - Unknown: ___________

- Flow direction
- ___________

- Horizontal hydraulic gradient (feet/foot): ___________
- Vertical hydraulic gradient (feet/foot): ___________

- K range (ft/day)
  - Measured using: Slug Test
  - Low: ___________
  - High: ___________
  - Transmissivity (ft²/day)
  - Measured using: Slug Test
  - Low: ___________
  - High: ___________

#### Comments:

- ___________
- ___________
- ___________

#### Attachments:

- ___________
- ___________
- ___________
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
- Steam  
- Steam + air  
- Steam + O2  
- Other (describe)  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
Duration:  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  

Size of target zone (ft²):  
Thickness of target zone (ft):  
Depth to top of target zone (ft bgs):  
Thickness of target zone below water table (ft):  
Number of extraction points:  
Number of energy delivery points:  

Temperature Profile:  
Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C):  
Time to reach maximum representative temperature (days):  
Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
Via liquid pumping:  
In vapor stream:  
Total:  

Comments:  
Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
**Performance**

Remediation Goal:

<table>
<thead>
<tr>
<th>In Groundwater</th>
<th>__________</th>
</tr>
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<tbody>
<tr>
<td>In Soil</td>
<td>__________</td>
</tr>
</tbody>
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Was the Remediation Goal Achieved:

<table>
<thead>
<tr>
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<th>__________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment</td>
<td>__________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In Soil</th>
<th>__________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment</td>
<td>__________</td>
</tr>
</tbody>
</table>

**General comments on the thermal application:**

| __________ |
| __________ |
| __________ |
| __________ |

**Lessons Learned**

| __________ |
| __________ |
| __________ |
| __________ |

**Energy**

Total Energy Used: __________ kWh, __________ kWh/m³, __________ kWh/yd³

| Total energy applied to treatment zone: | __________ kWh/m³, __________ kWh/yd³ |
| Other energy:                           | __________ kWh/m³, __________ kWh/yd³ |
| Please note other energy:              | __________ kWh/m³, __________ kWh/yd³ |

**Cost**

Total Project Cost: __________

| Consultant Cost: | __________ |
| Thermal Vendor Cost: | __________ |
| Energy Cost: | __________ m³, __________ yd³ |
| Other Cost 1: | __________ |
| Other Cost 2: | __________ |
| Other Cost 3: | __________ |
| Please note other cost: | __________ |
| Other Cost 1: | __________ |
| Other Cost 2: | __________ |
| Other Cost 3: | __________ |
File Analyzed By: JT  PD 
Type of treatment: x Conductive  Steam  ERH  Other: 
Type of Contaminant: x Chlorinated Solvents  x Petroleum Hydrocarbons  Pesticides  Other: 
Treatment Status: x Active  Post 
Type of Test: x Pilot Test  Full Scale System 
Start of Test: 12/5/2005  End of Test: 1/10/2006  Duration: 36 d
Type of Site: x Non-DOD  DoD

Facility Name: UK Atomic Energy Authority's Harwell Site
Address: 
City, State, Zip Code: Oxfordshire, England
OU# or Site #: Western storage area

Primary point of contact: Steve Langford
Organization: AIG Engineering Group
Address: 9 Kingsdale Business Centre  Regina Road  Chelmsford  Essex CM1 1PE
City, State, Zip Code: ________________________________
Phone #: 01245 505 601  email: steve.langford@aig.com

________ Other contacts or vendors who worked on site
Point of contact: 
Type: Vendor, Consultant  Vendor, Technical Applications  Other  
Organization: 
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: ________________________________  email: ________________________________

QA/QC

________ Characteristics of Interest
________ Good pre- and post-treatment groundwater data  ______ Good pre- and post-treatment soil data
________ Good temperature profile vs. time information  ______ Flux assessment
________ Groundwater elevations  ______ Geologic cross-section
________ Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:**  

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________  
- Width (ft.): __________  
- Thickness (ft.): __________  
- Impacted zone as defined by documentation: None  
- Alternative method for determining size of impacted zone (See source zone definition attachments): None  
- Map attachment: None

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: None
- Number of wells relative to treatment zone:
  - Pre-treatment: In: _______  
  - Uppgradient: _______  
  - Downgradient: _______  
  - Crossgradient: _______  
- Post-treatment: In: _______  
  - Uppgradient: _______  
  - Downgradient: _______  
  - Crossgradient: _______

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: None
- Number of relevant soil borings with post-treatment data: None
- Number inside treatment zone: _______  
- Number outside treatment zone: _______

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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<tbody>
<tr>
<td></td>
<td></td>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
<td>трхлорэтилен</td>
<td>Benzene</td>
<td>Crossite</td>
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<td>тетрахлорэтилен</td>
<td>Jet Fuel</td>
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<td>0.005 mg/L</td>
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**Comments:**

- None

**Attachments:**

- None
### Hydrogeologic Conceptual Model

#### Unconsolidated Sediments

<table>
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<tr>
<th>Zone</th>
<th>Geology:</th>
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<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
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<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?** No
- **Depth to water:**
  - **Low value (ft bgs):** 16.4
  - **High value (ft bgs):** 75.5
  - **Unknown:**
- **Flow direction:** below
- **Horizontal hydraulic gradient (feet/foot):**

#### K range (ft/day)

- **Measured using:** Slug Test Laboratory Field data
  - **Low**
  - **High**

#### Transmissivity (ft²/day)

- **Measured using:** Slug Test Laboratory Field data
  - **Low:** 6458
  - **High**

**Flow direction for high groundwater levels - N to NE  for low groundwater levels - E to SE**

**Attachments:**

---

**Ground surface elevation based on wells in or adjacent to treatment zone:**

- **ft amsl:**
- **Unknown:**
Thermal Treatment - Design

Thermal treatment:  
- Conductive:  
- Electrical Resistance:  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  
- Steam:  
  - Steam  
  - Steam + air  
  - Steam + O2  
- Other (describe):  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-beded lenses of lower permeability material  
- Largely impermeable sediments with inter-beded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
- 12/5/2005  
- Duration: 36d  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  
- Size of target zone (ft^2): 10  
- Thickness of target zone (ft): 46  
- Depth to top of target zone (ft bgs): 16  
- Thickness of target zone below water table (ft): 0  
- Number of energy delivery points: 1  
- Number of extraction points: 1  

Temperature Profile:  
- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C): 90  
- Time to reach maximum representative temperature (days): 60  
- Duration of treatment at representative temperature (days): 1  

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
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</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
- Via liquid pumping:  
- In vapor stream:  
- Total: 214 lb  

Comments:  

Total volume treated - 35.2 cubic meters (46 yd^3, 1243 ft^3)  
2.5 m spacing of heater wells (16 ft)  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

Objective: reduce mass of VOCs in unsaturated zone in the source area to the extent economically feasible resulting in a diminishing flux of mass to groundwater over time.

Lessons Learned

General comments on the thermal application:

Was the Remediation Goal Achieved:

Comment:

Energy

Total Energy Used: 

Total energy applied to treatment zone: 

Other energy: 

Please note other energy: 

Cost

Total Project Cost:

Consultant Cost: 

Thermal Vendor Cost: 

Energy Cost: 

Other Cost 1: 

Other Cost 2: 

Other Cost 3: 

Please note other cost: 

Other Cost 1: 

Other Cost 2: 

Other Cost 3: 

kWhr

kWhr/m³

kWhr/yd³

m³

yd³
### General Site Information

<table>
<thead>
<tr>
<th>x</th>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
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<tbody>
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<td>Steam</td>
<td>ERH</td>
<td>Other:</td>
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<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
<td>Wood Treating</td>
</tr>
<tr>
<td>x</td>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
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<tr>
<td>x</td>
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<td>Start of Test:</td>
<td>Jan-01</td>
<td>End of Test:</td>
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<tr>
<td></td>
<td>Phone #:</td>
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<table>
<thead>
<tr>
<th>x</th>
<th>Other contacts or vendors who worked on site</th>
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<tr>
<td></td>
<td>Point of contact:</td>
<td>Petr Kvapil</td>
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<td>Type:</td>
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<tr>
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</table>

### QA/QC

| ____ Characteristics of Interest |
| --- | --- |
| ____ Good pre- and post-treatment groundwater data | ____ Good pre- and post-treatment soil data |
| ____ Good temperature profile vs. time information | ____ Flux assessment |
| ____ Groundwater elevations | ____ Geologic cross-section |
| ____ Hydraulic Conductivity information | |
### General Site Assessment Data

**Facility ID#:** 1070

#### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Any alternative method for determining size of impacted zone (see source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of wells relative to treatment zone:
  - Pre-treatment In: _______ Upgradient: _______ Downgradient: _______ Crossgradient: _______
  - Post-treatment In: _______ Upgradient: _______ Downgradient: _______ Crossgradient: _______

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Chemical</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
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<tr>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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**Comments:**

- 
- 
- 

**Attachments:**

- 
- 
- 
-
**Hydrogeologic Conceptual Model**

**Zone**

- **Vadose Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

- **Saturated Zone:**
  - Relatively homogeneous and permeable unconsolidated sediments
  - Relatively homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability material
  - Largely impermeable sediments with inter-bedded layers of higher permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)
  - Weathered bedrock, limestone, sandstone

**Ground surface elevation based on wells in or adjacent to treatment zone:**

- Low: ______ ft
- High: ______ ft

**Aquifer Characteristics:**

- Is more than 1 aquifer present?
  - No
  - Yes (number): 4

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to Water (ft bgsl)</th>
<th>Flow Direction</th>
<th>Horizontal Hydraulic Gradient (feet/foot)</th>
<th>Vertical Hydraulic Gradient (feet/foot)</th>
<th>K Range (ft/day)</th>
<th>Transmissivity (ft²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>Low: 16.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>Low: 23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td>Low: 16.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**K range (ft/day)**

- Low: ______ ft/day
- High: ______ ft/day

**Transmissivity (ft²/day):**

- Measured using: Slug Test Laboratory Field data
- Low: ______ ft²/day
- High: ______ ft²/day

**Comments:**

- 2nd aquifer permeability - $10^{-5}$ m/s

**Contamination in first 2 aquifers**

- A list of contamination issues affecting the first two aquifers, if any.

**Attachments:**

- A list of any attachments or supplementary information relevant to the conceptual model.
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
   - 3 phase  
   - 6 phase  
   - AC power  
   - DC power  
- Steam  
- Steam + air  
- Steam + O2  
- Other (describe)  

Type of Test:  
- Pilot test  
- Full-scale System  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Relatively homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded lenses of lower permeability material  
- Largely impermeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  
- Jan-01  
Duration:  
- 3 months  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  
Size of target zone (ft2):  
Thickness of target zone (ft):  
Depth to top of target zone (ft bgs):  
Thickness of target zone below water table (ft):  
Number of energy delivery points:  
Number of extraction points:  

Temperature Profile:  
Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C):  
Time to reach maximum representative temperature (days):  
Duration of treatment at representative temperature (days):  
Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  
Via liquid pumping:  
In vapor stream:  
Total:  

Comments:  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

1) Facility area = total (CHCs) = 0.8 mg/L

2) Environment of facility area where domestic wells are located. Total (CHCs) = 0.2 mg/L

Was the Remediation Goal Achieved:

_____ In Groundwater

Comment:

_____ In Soil

Comment:

General comments on the thermal application:

Target temperature of - 89-100C

Lessons Learned

Total Energy Used:

_____ Total energy applied to treatment zone: _____ kWhr _____ kWhr/m³ _____ kWhr/yd³

_____ Other energy: _____ kWhr/m³ _____ kWhr/yd³

Please note other energy:

Total Project Cost:

_____ Consultant Cost:

_____ Thermal Vendor Cost:

_____ Energy Cost: _____ m³ _____ yd³

_____ Other Cost 1:

_____ Other Cost 2:

_____ Other Cost 3:

Please note other cost:

_____ Other Cost 1:

_____ Other Cost 2:

_____ Other Cost 3:
Facility Name: Bruel & Kjaer A/S (Project No. 552)

City, State, Zip Code: Denmark

OU# or Site #: ______________________

Primary point of contact:

Organization: Danish EPA, Soil Contamination Division

Address: __________________________

City, State, Zip Code: ______________________

Phone #: +45 3266 0100

email: __________________________

Other contacts or vendors who worked on site: None

Point of contact:

Type: Vendor, Consultant

Vendor, Technical Applications

Other

Organization: __________________________

Address: __________________________

City, State, Zip Code: ______________________

Phone #: __________________________

email: __________________________

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data

Good pre- and post-treatment soil data

Good temperature profile vs. time information

Flux assessment

Groundwater elevations

Geologic cross-section

Hydraulic Conductivity information
### General Site Assessment Data

#### Impacted Zone:
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

#### Monitor Wells:
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- Number of wells relative to treatment zone:
  | Pre-treatment | Post-treatment |
  | In: | Upgradient: | Downgradient: | Crossgradient: |
  | | | | |

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
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<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
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<td>trans,1,2-dichloroethene</td>
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<td>Vinyl Chloride</td>
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<td>Sum TCE and PCE</td>
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### Comments:

- None

### Attachments:

- None
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<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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<tr>
<td></td>
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<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<td></td>
<td>Largely permeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
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<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

- **Ground surface elevation based on wells in or adjacent to treatment zone:**  __________ ft amsl  __________ Unknown

**Aquifer Characteristics:**

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): __________
  - Unknown (assume single aquifer)

- **Depth to water:**
  - low value (ft bgs): __________
  - high value (ft bgs): __________
  - Unknown: __________

- **Flow direction:** __________

- **Horizontal hydraulic gradient (feet/foot):** __________
  - Unknown

- **Vertical hydraulic gradient (feet/foot):** __________
  - Unknown

- **K range (ft/day):**
  - Measured using: __________ Slug Test  __________ Laboratory  __________ Field data
  - low: __________
  - high: __________
  - Unknown

- **Transmissivity (ft²/day):**
  - Measured using: __________ Slug Test  __________ Laboratory  __________ Field data
  - low: __________
  - high: __________
  - Unknown

**Comments:**

- __________________________________________________________________________________
- __________________________________________________________________________________
- __________________________________________________________________________________

**Attachments:**

- __________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment: 
- Conductive
- Electrical Resistance

Steam: 
- 3 phase
- 6 phase
- AC power
- DC power

Steam: 
- Steam
- Steam + air
- Steam + O2

Other (describe)

Type of Test: 
- Pilot test
- Full-scale System

Geology of Treatment Zone: 
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone: 
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Type of Test: 
- Pilot test
- Full-scale System

Start of Thermal Test: 
- Duration: 6 months

Start of Thermal Test: 
- Duration of treatment at representative temperature (days): 
- Time to reach maximum representative temperature (days): 
- Maximum representative formation temperature (deg C): 
- Initial formation temperature (deg C): 
- Temperature Profile:

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Treatment Cell Design: 
- Size of target zone (ft²): 
- Thickness of target zone (ft): 
- Depth to top of target zone (ft bgs): 50
- Thickness of target zone below water table (ft): 
- Number of energy delivery points: 
- Number of extraction points: 

<table>
<thead>
<tr>
<th>Thickness of target zone below water table (ft):</th>
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</thead>
<tbody>
<tr>
<td>Number of energy delivery points:</td>
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<tr>
<td>Number of extraction points:</td>
<td>Unknown</td>
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</table>

Temperature Profile:

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<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
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</thead>
<tbody>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
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</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature immediately post-treatment:
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:
- Via liquid pumping: 
- In vapor stream: 
- Total: 3000 to 4000

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Please note other energy:

General comments on the thermal application:

Lessons Learned

Energy
Total Energy Used: ____________ kWhr ____________ kWhr/m³ ____________ kWhr/yd³

Total energy applied to treatment zone: ____________ kWhr/m³ ____________ kWhr/yd³

Other energy: ____________ kWhr/m³ ____________ kWhr/yd³

Please note other energy: ________________________________________________

Cost
Total Project Cost: ________________________________________________

Consultant Cost: ________________________________________________

Thermal Vendor Cost: ________________________________________________

Energy Cost: __________________________________________ m³ ____________ yd³

Other Cost 1: ________________________________________________

Other Cost 2: ________________________________________________

Other Cost 3: ________________________________________________

Please note other cost: Other Cost 1: ________________________________________________

Other Cost 2: ________________________________________________

Other Cost 3: ________________________________________________
### General Site Information

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Odense, Denmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td>Odense, Denmark</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Denmark</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td>____________________________</td>
</tr>
</tbody>
</table>

### Primary point of contact

- **Organization:** Danish EPA website
- **Address:** ____________________________
- **City, State, Zip Code:** ____________________________
- **Phone #:** ____________________________
- **email:** ____________________________

### Other contacts or vendors who worked on site

- **Type:** None
- **Point of contact:** ____________________________
- **Organization:** ____________________________
- **Address:** ____________________________
- **City, State, Zip Code:** ____________________________
- **Phone #:** ____________________________
- **email:** ____________________________

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
General Site Assessment Data

Facility ID#:

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Pre-treatment: __________
- Post-treatment: __________
- None
- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Post-treatment: __________
  - In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossx</td>
<td>10 mg/L</td>
<td>0.1 mg/L</td>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benene</td>
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<td>None</td>
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<td>trans-1,2-dichloroethene</td>
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<td>1,1,1-trichloroethane</td>
<td>α-xylene</td>
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<td>Vinyl Chloride</td>
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**Comments:**

________________________________________

________________________________________

Attachments:

______________________________
### Geology:

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<tr>
<th>Zone</th>
<th>Aquifer Characteristics</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>___ Relatively homogenous and permeable unconsolidated sediments</td>
<td>___ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>___ Relatively homogenous and impermeable unconsolidated sediments</td>
<td>___ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>___ Largely impermeable sediments with inter-bedded layers of lower permeability material</td>
<td>___ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>___ Relatively homogenous and permeable unconsolidated sediments</td>
<td>___ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
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<td></td>
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<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone:

| Facility ID# | 1080 |

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
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<tbody>
<tr>
<td>Depth to water:</td>
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<tr>
<td>low value (ft bgs):</td>
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<td>high value (ft bgs):</td>
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</tr>
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### Flow direction:

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### Horizontal hydraulic gradient (feet/foot):

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### Vertical hydraulic gradient (feet/foot):

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### K range (ft/day)

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<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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<tr>
<td>high</td>
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### Transmissivity (ft^2/day):

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<th>Field data</th>
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</thead>
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<tr>
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<tr>
<td>high</td>
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### Comments:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

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____________________________________________________________________________________________

____________________________________________________________________________________________

### Attachments:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________
<table>
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</tr>
<tr>
<td></td>
<td>- Electrical Resistance</td>
</tr>
<tr>
<td></td>
<td>- 3 phase</td>
</tr>
<tr>
<td></td>
<td>- 6 phase</td>
</tr>
<tr>
<td></td>
<td>- AC power</td>
</tr>
<tr>
<td></td>
<td>- DC power</td>
</tr>
<tr>
<td><strong>Steam</strong></td>
<td>- Steam</td>
</tr>
<tr>
<td></td>
<td>- Steam + air</td>
</tr>
<tr>
<td></td>
<td>- Steam + O2</td>
</tr>
<tr>
<td><strong>Other</strong> (describe)</td>
<td></td>
</tr>
<tr>
<td><strong>Type of Test</strong></td>
<td>- Pilot test</td>
</tr>
<tr>
<td></td>
<td>- Full-scale System</td>
</tr>
<tr>
<td><strong>Geology of Treatment Zone</strong></td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower</td>
</tr>
<tr>
<td></td>
<td>- Largely impermeable sediments with inter-bedded layers of higher</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td><strong>Treatment Target Zone</strong></td>
<td>- Saturated only</td>
</tr>
<tr>
<td></td>
<td>- Vadose only</td>
</tr>
<tr>
<td></td>
<td>- Both (Saturated and Vadose zones)</td>
</tr>
<tr>
<td><strong>Start of Thermal Test</strong></td>
<td>- Duration: 3.5 months</td>
</tr>
<tr>
<td><strong>Hydraulic Control</strong></td>
<td>- Yes</td>
</tr>
<tr>
<td></td>
<td>- No</td>
</tr>
<tr>
<td><strong>Size of target zone (ft2):</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Thickness of target zone (ft):</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Depth to top of target zone (ft bgs):</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Thickness of target zone below water table (ft):</strong></td>
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</tr>
<tr>
<td><strong>Number of energy delivery points:</strong></td>
<td>140</td>
</tr>
<tr>
<td><strong>Number of extraction points:</strong></td>
<td>Unknown</td>
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<tr>
<td><strong>Initial formation temperature (deg C):</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Maximum representative formation temperature (deg C):</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Time to reach maximum representative temperature (days):</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Duration of treatment at representative temperature (days):</strong></td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Formation temperature immediately post-treatment:</strong></td>
<td>Date:</td>
</tr>
<tr>
<td></td>
<td>Temperature (deg C):</td>
</tr>
<tr>
<td><strong>Formation temperature post-treatment monitoring event 1:</strong></td>
<td>Date:</td>
</tr>
<tr>
<td></td>
<td>Temperature (deg C):</td>
</tr>
<tr>
<td><strong>Duration of post-treatment monitoring (days):</strong></td>
<td>Date:</td>
</tr>
<tr>
<td></td>
<td>Temperature (deg C):</td>
</tr>
<tr>
<td><strong>Mass of contaminant removed:</strong></td>
<td>- Via liquid pumping:</td>
</tr>
<tr>
<td></td>
<td>- In vapor stream:</td>
</tr>
<tr>
<td></td>
<td>- Total:</td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Attachments:</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Performance

Remediation Goal:

In Groundwater: ___________________________________________

In Soil: ___________________________________________

Was the Remediation Goal Achieved:

In Groundwater:

Comment: ___________________________________________

In Soil:

Comment: ___________________________________________

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ___________ kWhr ___________ kWhr/m³ ___________ kWhr/yd³

Total energy applied to treatment zone: ___________ kWhr/m³ ___________ kWhr/yd³

Other energy: ___________ kWhr/m³ ___________ kWhr/yd³

Please note other energy: ___________________________________________

Cost

Total Project Cost: ___________

Consultant Cost: ___________

Thermal Vendor Cost: ___________

Energy Cost: ___________ m³ ___________ yd³

Other Cost 1: ___________

Other Cost 2: ___________

Other Cost 3: ___________

Please note other cost: ___________

Energy Cost: ___________

Other Cost 2: ___________

Other Cost 3: ___________
General Site Information

File Analyzed By: JT x PD x Date: 10/26/2006

Type of treatment: x Conductive x Steam x ERH x Other: ______________

Type of Contaminant: x Chlorinated Solvents x Petroleum Hydrocarbons x Pesticides

Wood Treating x Other: ______________

Treatment Status: x Active x Post

Type of Test: x Pilot Test x Full Scale System

Start of Test: 2003 End of Test: 2003 Duration: 3.5 months

Type of Site: x Non-DOD x DoD

Facility Name: United Kingdom

Address: _________________________________

City, State, Zip Code: United Kingdom

OU# or Site #: _________________________________

Primary point of contact: Helen Stevens

Organization: IMS Marketing Communications

Address: _________________________________

City, State, Zip Code: _________________________________

Phone #: 0117 929 3041 email: helen.stevens@imsplc.com

Other contacts or vendors who worked on site: None

Point of contact: Duncan Sanders

Type: Vendor, Consultant x Vendor, Technical Applications x Other: ______________

Organization: Churngold Remediation Ltd

Address: _________________________________

City, State, Zip Code: _________________________________

Phone #: 07881 815391 or 0117 916 0510 email: _________________________________

QA/QC

Characteristics of Interest

x Good pre- and post-treatment groundwater data

x Good pre- and post-treatment soil data

x Good temperature profile vs. time information

x Flux assessment

x Groundwater elevations

x Geologic cross-section

x Hydraulic Conductivity information
## General Site Assessment Data

**Facility ID:**

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown</th>
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</thead>
<tbody>
<tr>
<td>Monitor Wells:</td>
<td>Number of relevant monitoring wells with groundwater data:</td>
<td>Pre-treatment:</td>
<td>Post-treatment:</td>
<td>None</td>
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<tr>
<td>Number of wells relative to treatment zone:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-treatment</td>
<td>In:</td>
<td>Upgradient:</td>
<td>Downgradient:</td>
<td>Crossgradient:</td>
</tr>
<tr>
<td>Post-treatment</td>
<td>In:</td>
<td>Upgradient:</td>
<td>Downgradient:</td>
<td>Crossgradient:</td>
</tr>
<tr>
<td>Soil Borings:</td>
<td>Number of relevant soil borings with pre-treatment data:</td>
<td>Number of relevant soil borings with post-treatment data:</td>
<td>Number inside treatment zone:</td>
<td>Number outside treatment zone:</td>
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</tbody>
</table>

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
<td></td>
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<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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</tr>
<tr>
<td>1,1,2-trichloroethane</td>
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<td>None</td>
<td>None</td>
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<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

- 
- 
- 

### Attachments:

- 
- 
- 
-
Hydrogeologic Conceptual Model

Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl  __________ Unknown

Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): ___________</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction: __________

Horizontal hydraulic gradient (feet/foot): __________
Vertical hydraulic gradient (feet/foot): __________

K range (ft/day) | Measured using: | Slug Test | Laboratory | Field data |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Transmissivity (ft^2/day): | Measured using: | Slug Test | Laboratory | Field data |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments: ________________________________________________________________
Attachments: ______________________________________________________________
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
- 3 phase  
- 6 phase  
- AC power  
- DC power  

Steam:  
- Steam  
- Steam + air  
- Steam + O2  
- Other (describe)  

Type of Test:  
- Pilot test  
- Full-scale System  

Type of Test:  
- Yes  
- No  

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded layers of higher permeability material  
- Competent, but fractured bedrock (i.e. crystalline rock)  
- Weathered bedrock, limestone, sandstone  

Treatment Target Zone:  
- Saturated only  
- Vadose only  
- Both (Saturated and Vadose zones)  

Start of Thermal Test:  

Duration of treatment at representative temperature (days):  

Time to reach maximum representative temperature (days):  

Maximum representative formation temperature (deg C):  

Initial formation temperature (deg C):  

Temperature Profile:  

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formation temperature immediately post-treatment:  
Formation temperature post-treatment monitoring event 1:  
Duration of post-treatment monitoring (days):  

Mass of contaminant removed:  

Via liquid pumping:  

In vapor stream:  

Total:  

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:  
When applicable, mass flux measurements from Groundwater Services, Inc. freeware are attached.
Cost and Performance

Remediation Goal:

- In Groundwater: ____________________________________________________________
- In Soil: ________________________________________________________________

Was the Remediation Goal Achieved:

- In Groundwater: ____________________________________________________________
  Comment: ____________________________
- In Soil: ________________________________________________________________
  Comment: ____________________________

General comments on the thermal application:

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Lessons Learned

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Energy

Total Energy Used: ___________________________ kWhr  __________________________ kWhr/m³  __________________________ kWhr/yd³

- Total energy applied to treatment zone: ___________________________ kWhr/m³  __________________________ kWhr/yd³
- Other energy: ___________________________ kWhr/m³  __________________________ kWhr/yd³
  Please note other energy: ___________________________

Cost

Total Project Cost: 292950 (155000 GBP)

- Consultant Cost: ___________________________
- Thermal Vendor Cost: ___________________________
- Energy Cost: ___________________________ m³  __________________________ yd³
  Other Cost 1: ___________________________
  Other Cost 2: ___________________________
  Other Cost 3: ___________________________
  Please note other cost: ___________________________
  Other Cost 1: ___________________________
  Other Cost 2: ___________________________
  Other Cost 3: ___________________________
### General Site Information

- **File Analyzed By:** JT PD
- **Date:** 
- **Type of treatment:**
  - Conductive
  - Steam ERH
  - Other: 
- **Type of Contaminant:**
  - Chlorinated Solvents
  - Petroleum Hydrocarbons
  - Pesticides
  - Wood Treating
  - Other: 
- **Treatment Status:**
  - Active
  - Post
- **Type of Test:**
  - Pilot Test
  - Full Scale System
- **Start of Test:** 5/12/99
- **End of Test:** 10/30/1999
- **Duration:** 5.5 months
- **Type of Site:**
  - Non-DOD
  - DoD

### Facility Name:
- **Taiwan**
- **Address:**
- **City, State, Zip Code:** Taiwan
- **OU# or Site #:**

### Primary point of contact:
- **Ken K. C. Tse**
- **Organization:** Institute of Environmental Engineering, National Taiwan University, Taipei
- **Address:** 106 Taiwan
- **City, State, Zip Code:** Republic of China
- **Phone #:** 886-2-23963505
- **email:** ktse@envs17.hinet.net

### Other contacts or vendors who worked on site
- **Point of contact:** Jerry W. H. Wang
- **Type:** Vendor, Consultant
- **Organization:** Wang Engineering Inc
- **Address:** 105 Sherry Dr.
- **City, State, Zip Code:** West Chicago, IL 60185
- **Phone #:** 630-953-9928
- **email:** 

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
### General Site Assessment Data

**Facility ID:**

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Unknown
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Number of relevant monitoring wells with groundwater data:**
- Pre-treatment: 
- Post-treatment: 

**Number of wells relative to treatment zone:**
- Pre-treatment: 
- Upgradient: 
- Downgradient: 
- Crossgradient:

**Number of relevant soil borings with pre-treatment data:**
- Pre-treatment: 
- In:
- Upgradient:
- Downgradient:
- Crossgradient:

**Number of relevant soil borings with post-treatment data:**
- Post-treatment: 
- In:
- Upgradient:
- Downgradient:
- Crossgradient:

**Number inside treatment zone:**
- 
- Number outside treatment zone:

### Types of Contaminants

#### Chlorinated Solvents

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetrachloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Trichloroethene</td>
<td>Jet Fuel</td>
<td>PCP</td>
<td>10 mg/L</td>
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<td>5 mg/L</td>
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<tr>
<td>1,1-dichloroethene</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
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<td>None</td>
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<td>None</td>
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<td>None</td>
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<td>None</td>
</tr>
</tbody>
</table>

#### Petrochemical Hydrocarbons

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Hexane</td>
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<td>Benzene</td>
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<tr>
<td>Toluene</td>
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<tr>
<td>Ethylbenzene</td>
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### Comments:

- 
- 
- 

### Attachments:

- 
- 
- 

## Hydrogeologic Conceptual Model

### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Vadose Zone:</th>
<th>Saturated Zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
</tbody>
</table>

**Aquifer Characteristics:**

- **Is more than 1 aquifer present?**
  - Yes (number): _____________
  - Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Depth to water:</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low value (ft bgs):</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction**
  - SE

- **Horizontal hydraulic gradient (feet/foot):**
  - 0.001 to 0.00033

- **Vertical hydraulic gradient (feet/foot):**
  - Unknown

- **K range (ft/day):**
  - Measured using: x Slug Test
  - low: 0.0709
  - high: 0.1672

- **Transmissivity (ft²/day):**
  - Measured using: Slug Test
  - low: |
  - high: |

**Ground surface elevation based on wells in or adjacent to treatment zone:** _____________ ft amsl _____________ Unknown

**Attachments:**

**Comments:**

____________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________
## Thermal Treatment - Design

**Thermal treatment:**
- [x] Conductive
- [ ] Electrical Resistance
- [ ] 3 phase
- [x] 6 phase
- [ ] AC power
- [ ] DC power
- [x] Steam
- [ ] Steam + air
- [ ] Steam + O2
- [ ] Other (describe)

**Type of Test:**
- [x] Pilot test
- [ ] Full-scale System

**Geology of Treatment Zone:**
- [x] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [x] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [x] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- [x] Saturated only
- [x] Vadose only
- [x] Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- [x] 5/12/1999
- [ ] Duration: 5.5 months

**Hydraulic Control**
- [x] Yes
- [ ] No

### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>7401</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>11</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>0</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>10</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>1</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Temperature Profile:**

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>100</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>30</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>135</td>
</tr>
</tbody>
</table>

**Formation temperature immediately post-treatment:**

**Formation temperature post-treatment monitoring event 1:**

**Duration of post-treatment monitoring (days):**

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Via liquid pumping</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Comments:**

**Attachments:**

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
General comments on the thermal application:

Cost doesn't include technical consultation or design cost.

Lessons Learned

When treating SVOCs like PCP, soil vapor extraction system is not enough to remove all the steam stripped contaminants. Groundwater pumping is still crucial for the success of in-situ thermal treatment. Besides the locations of pumping wells, the extraction depth is also important.

Energy

Total Energy Used:

Total energy applied to treatment zone: ______ kWhr/m³ ______ kWhr/yd³

Other energy: ______ kWhr/m³ ______ kWhr/yd³

Please note other energy:________________________________________________________

Cost

Total Project Cost:

Consultant Cost:______________________________________________________________

Thermal Vendor Cost: 17/m³

Energy Cost: ______ m³ ______ yd³

Other Cost 1:______________________________________________________________

Other Cost 2:______________________________________________________________

Other Cost 3:______________________________________________________________

Please note other cost: ____________

Other Cost 1:______________________________________________________________

Other Cost 2:______________________________________________________________

Other Cost 3:______________________________________________________________
General Site Information

File Analyzed By: JT  PD  Date: 10/18/2006
Type of treatment: Conductive  Steam  ERH  Other:  
Type of Contaminant: Chlorinated Solvents  Petroleum Hydrocarbons  pesticides
Wood Treating  Other:  
Treatment Status: Active  Post  
Type of Test: Pilot Test  Full Scale System  
Start of Test: Nov-02  End of Test:  
Type of Site: Non-DOD  DoD

Facility Name: Residential Site in Holland
Address: 
City, State, Zip Code: Zwijndrecht, Netherlands
OU# or Site #: 

Primary point of contact: Bill Heath
Organization: CES
Address: 419 Entiat St., Suite A
City, State, Zip Code: Kennewick, WA 99336
Phone #: 509-727-4276  email: bill@cesiweb.com

Other contacts or vendors who worked on site: None
Point of contact: Ing. Marcel Kolle
Type: Vendor, Consultant  Vendor, Technical Applications  Other
Organization: TerraVista, BV
Address: 
City, State, Zip Code: Hoofdoorp, Netherlands
Phone #: 
email: 

QA/QC

Characteristics of Interest

Good pre- and post-treatment groundwater data  Good pre- and post-treatment soil data
Good temperature profile vs. time information  Flux assessment
Groundwater elevations  Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): __________
- Width (ft.): __________
- Thickness (ft.): __________
- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: __________
- Number of walls relative to treatment zone:
  - Pre-treatment:
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________
  - Post-treatment:
    - In: __________
    - Upgradient: __________
    - Downgradient: __________
    - Crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: __________
- Number of relevant soil borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossvit</td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Napthalene</td>
<td></td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
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<td>None None None None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>1,2-dichloroethane</td>
<td></td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,1,1,2-tetrachloroethene</td>
<td>1,1-dichloroethane</td>
<td></td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
</tbody>
</table>

**Comments:**

2000 m³ impacted (2615 yd³)

**Attachments:**

---

2000 m³ impacted (2615 yd³)
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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<td>- Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>- Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>- Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>- Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
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</tr>
<tr>
<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

Ground surface elevation based on wells in or adjacent to treatment zone: f amsl

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>No</td>
</tr>
<tr>
<td>Depth to water:</td>
<td>5</td>
</tr>
<tr>
<td>low value (ft bgss):</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgss):</td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
</tr>
<tr>
<td>Flow direction</td>
<td></td>
</tr>
</tbody>
</table>

| Horizontal hydraulic gradient (feet/foot): |  |  |  | Unknown |
| Vertical hydraulic gradient (feet/foot):   |  |  |  | Unknown |

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Transmissivity (ft2/day): | Measured using: | Slug Test | Laboratory | Field data |
|                          |                  |           |            |            |
| low                      |                  |           |            |            |
| high                     |                  |           |            |            |

Comments:

Attachments:
### Thermal Treatment - Design

**Facility ID:** 1200

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td>x Full-scale System</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>x Full-scale System</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
<th>Relatively homogeneous and permeable unconsolidated sediments</th>
<th>Relatively homogeneous and impermeable unconsolidated sediments</th>
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<th>Weathered bedrock, limestone, sandstone</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Target Zone:</th>
<th>Saturated only</th>
<th>Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>Nov-02</th>
<th>Duration: 60 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydraulic Control:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Treatment Cell Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²):</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
</tr>
<tr>
<td>Number of extraction points:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
</tr>
<tr>
<td>Formation temperature immediately post-treatment:</td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
</tr>
<tr>
<td>In vapor stream:</td>
</tr>
<tr>
<td>Total:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 ft spacing: Treated - 2.000m³</td>
</tr>
<tr>
<td>Attachments:</td>
</tr>
</tbody>
</table>

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

x In Groundwater: Meet Dutch "C" MCLs

x In Soil: Meet Dutch "C" MCLs

Was the Remediation Goal Achieved:

___ In Groundwater

Comment:

___ In Soil

Comment:

General comments on the thermal application:

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Lessons Learned

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

___ Energy

Total Energy Used: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

___ Total energy applied to treatment zone: ___________ kWh/m³ ___________ kWh/yd³

___ Other energy: ___________ kWh/m³ ___________ kWh/yd³

___ Please note other energy:

___ Cost

Total Project Cost: ___________

___ Consultant Cost: ___________

___ Thermal Vendor Cost: ___________

___ Energy Cost: ___________ m³ ___________ yd³

___ Other Cost 1: ___________

___ Other Cost 2: ___________

___ Other Cost 3: ___________

___ Please note other cost: ___________ Other Cost 1: ___________

___ Other Cost 2: ___________

___ Other Cost 3: ___________
### General Site Information

- **Type of treatment:**
  - **Conductive:**
  - **Steam:**
  - **ERH:**
  - **Other:**

- **Type of Contaminant:**
  - **Chlorinated Solvents:**
  - **Petroleum Hydrocarbons:**
  - **Pesticides:**
  - **Wood Treating:**
  - **Other:**

- **Treatment Status:**
  - **Active:**
  - **Post:**

- **Type of Test:**
  - **Pilot Test:**
  - **Full Scale System:**

- **Start of Test:**
  - **Dec-03**

- **End of Test:**
  - **May-04**

- **Duration:** 28 weeks

### Facility Name:

- **Former Tarmac Plant**

### Address:

- **City, State, Zip Code:** Zoetermeer, Netherlands

### Primary point of contact:

- **Bill Heath**
- **Organization:** CES
- **Address:** 419 Entiat St., Suite A
- **City, State, Zip Code:** Kennewick, WA 99336
- **Phone #:** 509-727-4276
- **email:** bill@cesiweb.com

### Other contacts or vendors who worked on site

- **None**

### QA/QC

#### Characteristics of Interest

- **Good pre- and post-treatment groundwater data**
- **Good pre- and post-treatment soil data**
- **Good temperature profile vs. time information**
- **Flux assessment**
- **Groundwater elevations**
- **Geologic cross-section**
- **Hydraulic Conductivity information**
General Site Assessment Data

Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>BTEX</td>
<td>NA</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Jet Fuel</td>
<td>NA</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>NA</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>Benzene</td>
<td>NA</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Toluene</td>
<td>NA</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td>NA</td>
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<td>None</td>
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<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
<td>NA</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>1,1,2-trichloroethane</td>
<td>naphthalene</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>BTEX</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>Benzene</td>
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<td>None</td>
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<td></td>
<td>Dichloromethane</td>
<td>Toluene</td>
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</table>

Comments:

Attachments:
### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>☑ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>☑ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>☑ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>☑ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>☑ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>☑ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>☑ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>☑ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>☑ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>☑ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>☑ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>☑ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl  __________ Unknown

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): __________</th>
<th>☑ Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td>2</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>low value (ft bgs):</td>
<td>high value (ft bgs):</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow direction</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Horizontal hydraulic gradient (feet/foot):

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Vertical hydraulic gradient (feet/foot):

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Transmissivity (ft²/day):

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

### Attachments:

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
### Thermal Treatment - Design

- **Thermal treatment:**
  - [x] Conductive
  - [x] Electrical Resistance

- **Type of Test:**
  - [x] Pilot test
  - [ ] Full-scale System

- **Geology of Treatment Zone:**
  - [x] Relatively homogeneous and permeable unconsolidated sediments
  - [ ] Relatively homogeneous and impermeable unconsolidated sediments
  - [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
  - [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
  - [ ] Competent, but fractured bedrock (i.e. crystalline rock)
  - [ ] Weathered bedrock, limestone, sandstone

- **Treatment Target Zone:**
  - [ ] Saturated only
  - [ ] Vadose only
  - [ ] Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - Dec-03

- **Duration:**
  - 28 weeks

- **Hydraulic Control:**
  - [ ] Yes
  - [ ] No

- **Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²)</td>
<td>10868</td>
</tr>
<tr>
<td>Thickness of target zone (ft)</td>
<td>Unknown</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs)</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft)</td>
<td>32</td>
</tr>
<tr>
<td>Number of energy delivery points</td>
<td>41</td>
</tr>
<tr>
<td>Number of extraction points</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

- **Temperature Profile:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C)</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C)</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Formation temperature immediately post-treatment:</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

- **Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
<td>Unknown</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

- **Notes:**

28 weeks of operation with three phases of heating

- **Attachments:**

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Remediation Goal:

In Groundwater:
- DCE = 10 ppb, VC = 2.5 ppb

In Soil:

Was the Remediation Goal Achieved:

In Groundwater
- Yes

In Soil

General comments on the thermal application:

$38.87/ton

Lessons Learned

Energy

Total Energy Used: 1200000 kWh, kWh/m^3, kWh/yd^3

Total energy applied to treatment zone: 135 kWh/m^3, kWh/yd^3

Other energy: kWh/m^3, kWh/yd^3

Cost

Total Project Cost: Consultant Cost, Thermal Vendor Cost, Energy Cost, Other Cost 1, Other Cost 2, Other Cost 3

Please note other cost: Other Cost 1, Other Cost 2, Other Cost 3
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date: 10/26/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td></td>
<td></td>
<td>Conductive Steam ERH Other:</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents Petroleum Hydrocarbons</td>
<td>Wood Treating Other:</td>
<td></td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test Full Scale System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start of Test:</td>
<td></td>
<td>End of Test:</td>
<td>Duration: 60 d</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD DoD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Confidential (Exxon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Regina, SK</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary point of contact:</th>
<th>Dacre Bush</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>McMillian-McGee</td>
</tr>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<td>805-295-9071</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:dacre.bush@mcmillian-mcgee.com">dacre.bush@mcmillian-mcgee.com</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other contacts or vendors who worked on site</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point of contact:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td>Vendor, Consultant Vendor, Technical Applications Other</td>
</tr>
<tr>
<td>Organization:</td>
<td></td>
</tr>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<td></td>
</tr>
<tr>
<td>email:</td>
<td></td>
</tr>
</tbody>
</table>

### QA/QC

- Characteristics of Interest
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
### General Site Assessment Data

<table>
<thead>
<tr>
<th>Impact Zone</th>
<th>Length (parallel to flow direction)(ft.)</th>
<th>Width (ft.)</th>
<th>Thickness (ft.)</th>
<th>Unknown</th>
</tr>
</thead>
</table>

- Impacted zone as defined by documentation
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Map attachment

<table>
<thead>
<tr>
<th>Monitor Wells</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
<th>None</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Soil Borings</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>Number inside treatment zone:</th>
<th>Number outside treatment zone:</th>
<th>______</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Types of Contaminants</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chemicals of Concern</td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pre-treatment:</td>
<td>Post-treatment:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In: Upgradient:</td>
<td>Downgradient:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Number of wells relative to treatment zone:</td>
<td>Number of relevant monitoring wells with groundwater data:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Number inside treatment zone:</td>
<td>Number outside treatment zone:</td>
</tr>
</tbody>
</table>

### Comments:

- __________________________________________________________________________________________
- __________________________________________________________________________________________
- __________________________________________________________________________________________

### Attachments:

- __________________________________________________________________________________________
- __________________________________________________________________________________________
## Ground surface elevation based on wells in or adjacent to treatment zone:
- Low (ft amsl): _______
- High (ft amsl): _______

## Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): _______</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low value (ft bgm):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High value (ft bgm):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Flow direction
- _______

## Horizontal hydraulic gradient (feet/foot):
- _______

## Vertical hydraulic gradient (feet/foot):
- _______

## K range (ft/day)
- Measured using: Slug Test, Laboratory, Field data
- Low: _______
- High: _______

## Transmissivity (ft²/day)
- Measured using: Slug Test, Laboratory, Field data
- Low: _______
- High: _______
### Thermal Treatment - Design

**Thermal treatment:**
- Conductive
- Electrical Resistance
- 3 phase
- 6 phase
- AC power
- DC power
- Steam
- Steam + air
- Steam + O2
- Other (describe)

**Type of Test:**
- Pilot test
- Full-scale System

**Geology of Treatment Zone:**
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- Duration:

**Hydraulic Control:**
- Yes
- No

**Thermal Test Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>Unknown</th>
<th>(  x  ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

**Temperature Profile:**

| Initial formation temperature (deg C): | Unknown |
| Maximum representative formation temperature (deg C): | Unknown |
| Time to reach maximum representative temperature (days): | Unknown |
| Duration of treatment at representative temperature (days): | Unknown |

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Formation temperature immediately post-treatment: |                     |

| Formation temperature post-treatment monitoring event 1: |                     |

| Duration of post-treatment monitoring (days): |                     |

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Comments:**

**Attachments:**

---

*Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.*
### Cost and Performance

**Remediation Goal:**

- **In Groundwater:**
- **In Soil:**

**Was the Remediation Goal Achieved:**

- **In Groundwater:**
  - Comment: ____________________________________________________________________________
  - ____________________________________________________________________________________
  - ____________________________________________________________________________________

- **In Soil:**

**General comments on the thermal application:**

- Removed 99.9% of the VOCs

**Lessons Learned**

- ____________________________________________________________________________________
  - ____________________________________________________________________________________
  - ____________________________________________________________________________________
  - ____________________________________________________________________________________
  - ____________________________________________________________________________________
  - ____________________________________________________________________________________

**Energy**

- **Total Energy Used:** 215 kWhr
- **Total energy applied to treatment zone:**
  - kWhr/m³
  - kWhr/yd³
- **Other energy:**
  - kWhr/m³
  - kWhr/yd³

**Please note other energy:** ____________________________________________________________________________________

**Cost**

- **Total Project Cost:**
  - **Consultant Cost:**
  - **Thermal Vendor Cost:**
  - **Energy Cost:** m³ yd³
  - **Other Cost 1:**
  - **Other Cost 2:**
  - **Other Cost 3:**

**Please note other cost:**

- **Other Cost 1:**
- **Other Cost 2:**
- **Other Cost 3:**

---

*Cost and Performance Facility ID#: 1220*
### General Site Information

- **File Analyzed By:** JT PD
- **Date:** 11/13/2006
- **Type of treatment:**
  - X Conductive
  - Steam
  - ERH
  - Other:
- **Type of Contaminant:**
  - Chlorinated Solvents
  - X Petroleum Hydrocarbons
  - Pesticides
  - Wood Treating
  - Other:
- **Treatment Status:**
  - Active
  - X Post
- **Type of Test:**
  - X Pilot Test
  - Full Scale System
- **Start of Test:** 2/19/1999
- **End of Test:** 6/16/1999
- **Duration:** 108 d
- **Type of Site:**
  - X Non-DOD
  - DoD

### Facility Information

- **Facility Name:** CFB Calgary
- **Address:**
- **City, State, Zip Code:** Calgary, Alberta, Canada
- **OU# or Site #:**

### Primary Contact

- **Primary point of contact:** Randall Warren
- **Organization:** Shell Canada
- **Address:**
- **City, State, Zip Code:**
- **Phone #:** 403-691-2954
- **email:** gary.millard@shell.com

### Other Contacts or Vendors

- **Point of contact:** Gary Millard
- **Type:**
  - Vendor, Consultant
  - Vendor, Technical Applications
  - Other
- **Organization:** Shell Canada
- **Address:**
- **City, State, Zip Code:**
- **Phone #:** 403-216-5558
- **email:** gary.millard@shell.com

### QA/QC

- **Characteristics of Interest**
  - Good pre- and post-treatment groundwater data
  - Good pre- and post-treatment soil data
  - Good temperature profile vs. time information
  - Flux assessment
  - Groundwater elevations
  - Geologic cross-section
  - Hydraulic Conductivity information
<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>X</td>
<td>Hx</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>X</td>
<td>Jel Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>X</td>
<td>NaPhtalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>X</td>
<td>Benzene</td>
<td>0.1 mg/L</td>
<td>1 mg/kg</td>
<td>0.1 mg/L</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>X</td>
<td>Toluene</td>
<td>0.005 mg/L</td>
<td>0.05 mg/kg</td>
<td>0.001 mg/L</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>X</td>
<td>Ethylbenzene</td>
<td>0.005 mg/L</td>
<td>1 mg/kg</td>
<td>0.005 mg/L</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>X</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>X</td>
<td>o-xylene</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
<td>X</td>
<td>Xylens</td>
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<td>None</td>
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<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>X</td>
<td>TPH</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Attachments:
Hydrogeologic Conceptual Model

X Geology: Zone

Vadose Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Saturated Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Largely impermeable sediments with inter-bedded layers of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl __________ Unknown

Aquifer Characteristics:

Is more than 1 aquifer present? Yes (number): __________ Unknown (assume single aquifer)

Aquifer 1 Aquifer 2 Aquifer 3
Depth to water:
- Low value (ft bgs): __________ __________ __________
- High value (ft bgs): __________ __________ __________
- Unknown: __________ __________ __________

Flow direction: __________ __________

Horizontal hydraulic gradient (feet/foot): __________ __________ __________ Unknown
Vertical hydraulic gradient (feet/foot): __________ __________ __________ Unknown

K range (ft/day) Measured using: Slug Test Laboratory Field data
- Low: __________ __________ __________ Unknown
- High: __________ __________ __________

Transmissivity (ft²/day): Measured using: Slug Test Laboratory Field data
- Low: __________ __________ __________ Unknown
- High: __________ __________ __________

Comments: ____________________________________________________________________________

Attachments: ____________________________________________________________________________
### Thermal Treatment - Design

- **Thermal treatment:**
  - [x] Conductive
  - [x] Electrical Resistance

- **Type of Test:**
  - [x] Pilot test
  - [ ] Full-scale System

- **Geology of Treatment Zone:**
  - [x] Relatively homogeneous and permeable unconsolidated sediments
  - [ ] Relatively homogeneous and impermeable unconsolidated sediments
  - [ ] Largely permeable sediments with inter-bedded layers of lower permeability material
  - [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
  - [ ] Competent, but fractured bedrock (i.e. crystalline rock)
  - [ ] Weathered bedrock, limestone, sandstone

- **Treatment Target Zone:**
  - [ ] Saturated only
  - [ ] Vadose only
  - [ ] Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - 19-Feb-99

- **Duration:**
  - 108 d

- **Hydraulic Control:**
  - [ ] Yes
  - [x] No

- **Treatment Cell Design:**

  | Size of target zone (ft²): | 7390 | [ ] Unknown | ( ____ x ____ ft) |
  | Thickness of target zone (ft): | 9 | [ ] Unknown |
  | Depth to top of target zone (ft bgls): | 5 | [ ] Unknown |
  | Thickness of target zone below water table (ft): | [ ] Unknown |
  | Number of energy delivery points: | 6 | [ ] Unknown |
  | Number of extraction points: | 5 | [ ] Unknown |

- **Temperature Profile:**

  | Initial formation temperature (deg C): | 10 | [ ] Unknown |
  | Maximum representative formation temperature (deg C): | 60 | [ ] Unknown |
  | Time to reach maximum representative temperature (days): | 96 | [ ] Unknown |
  | Duration of treatment at representative temperature (days): | 12 | [ ] Unknown |

  | Date | Temperature (deg C) |
  |  |  |  |
  |  |  |  |
  |  |  |  |
  |  |  |  |

- **Formation temperature immediately post-treatment:**

- **Formation temperature post-treatment monitoring event 1:**

- **Duration of post-treatment monitoring (days):**

- **Mass of contaminant removed:**

  | Via liquid pumping: | 48.5 Liters + 117 Liters | ____ lb | ____ kg | [ ] Unknown |
  | In vapor stream: | 34.4 Liters | ____ lb | ____ kg | [ ] Unknown |
  | Total: | 199.9 Liters | ____ lb | ____ kg | [ ] Unknown |

- **Comments:**

  20 ft electrode spacing. Actually 7 extraction points, but only 5 could be hooked up at any one time.

- **Attachments:**

  - [ ]

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Objective: Evaluate the ability and efficiency of McMillan-McGee ETDS; determine effect of heating on desorption of petroleum hydrocarbons; evaluate conditions when ERH will be an effective tool in remediation; and evaluate effect of heating on the indigenous microorganisms.

General comments on the thermal application:

Remediation Goal: In Soil:
Benzene-1.5 mg/Kg, toluene-340 mg/Kg, ethylbenzene-400 mg/Kg, xylenes-130 mg/Kg.

In Groundwater:
Benzene-4.2 mg/L, toluene-240 mg/L, ethylbenzene-50 mg/L, xylenes-80 mg/L.

Was the Remediation Goal Achieved:

In Groundwater
Comment:

In Soil
Comment:

Total energy applied to treatment zone: 163,000 kWhr

Energy Cost: 178 kWhr/m3 kWhr/yd3

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Cost:

Total Project Cost:

Consultant Cost:

Thermal Vendor Cost:

Energy Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:
### General Site Information

- **Type of treatment:**
  - __Conductive__
  - __Steam__
  - __ERH__
  - __Other:__

- **Type of Contaminant:**
  - __Chlorinated Solvents__
  - __Petroleum Hydrocarbons__
  - __Pesticides__
  - __Wood Treating__
  - __Other:__

- **Treatment Status:**
  - __Active__
  - __Post__

- **Type of Test:**
  - __Pilot Test__
  - __Full Scale System__

- **Start of Test:**
- **End of Test:**
- **Duration:** __60 d__

### Facility Name
- **Crowchild**
- **Address:**
- **City, State, Zip Code:**
- **OU# or Site #:**

### Primary point of contact
- **Randall Warren**
- **Organization:** __Shell Canada__
- **Address:**
- **City, State, Zip Code:**
- **Phone #: 403-691-2954**
- **email:**

### Other contacts or vendors who worked on site
- **Gary Millard**
- **Type:**
  - __Vendor, Consultant__
  - __Vendor, Technical Applications__
  - __Other__
- **Organization:** __Shell Canada__
- **Address:**
- **City, State, Zip Code:**
- **Phone #: 403-216-5558**
- **email: gary.millard@shell.com**

### QA/QC

- **Characteristics of Interest**
  - __Good pre- and post-treatment groundwater data__
  - __Good pre- and post-treatment soil data__
  - __Good temperature profile vs. time information__
  - __Flux assessment__
  - __Groundwater elevations__
  - __Geologic cross-section__
  - __Hydraulic Conductivity information__
### General Site Assessment Data

**Facility ID:** 1330

<table>
<thead>
<tr>
<th>Impacted Zone: Length (parallel to flow direction) (ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Unknown:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map attachment: Impacted zone as defined by documentation:</td>
<td>Alternative method for determining size of impacted zone (See source zone definition attachments): Map attachment:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitor Wells: Number of relevant monitoring wells with groundwater data: Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Borings: Number of relevant soil borings with pre-treatment data:</th>
<th>Number of relevant soil borings with post-treatment data:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number inside treatment zone:</td>
<td>Number outside treatment zone:</td>
</tr>
</tbody>
</table>

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Heptane</td>
<td>Crossdr</td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m+p-xylene</td>
<td></td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
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<td></td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
</tr>
</tbody>
</table>

### Comments:

```
- 
- 
- 
```

### Attachments:

```
- 
- 
- 
```
## Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Saturated Zone:</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Ground surface elevation based on wells in or adjacent to treatment zone:

- amsl
- Unknown

### Aquifer Characteristics:

- Is more than 1 aquifer present?
  - No
  - Yes (number):
  - Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Depth to water:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>low (ft bgs):</td>
<td></td>
</tr>
<tr>
<td>high (ft bgs):</td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
</tr>
</tbody>
</table>

### Flow direction

-  

### Horizontal hydraulic gradient (feet/foot):  

### Vertical hydraulic gradient (feet/foot):  

### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

-  

### Attachments:

-  

---

Facility ID#: 1240
### Thermal Treatment - Design

**Facility ID#: 1240**

**Thermal treatment:**
- [X] Conductive
- [X] Electrical Resistance
- [ ] 3 phase
- [ ] 6 phase
- [ ] AC power
- [ ] DC power
- [ ] Steam
- [ ] Steam + air
- [ ] Steam + O2
- [ ] Other (describe)

**Type of Test:**
- [X] Pilot test
- [ ] Full-scale System

**Geology of Treatment Zone:**
- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded lenses of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

**Treatment Target Zone:**
- [ ] Saturated only
- [ ] Vadose only
- [ ] Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- **Duration:**

**Hydraulic Control:**
- [ ] Yes
- [ ] No

**Treatment Cell Design:**
- **Size of target zone (ft2):**
- **Thickness of target zone (ft):**
- **Depth to top of target zone (ft bgs):**
- **Thickness of target zone below water table (ft):**

**Number of energy delivery points:**
- **Number of extraction points:**
- **Unknown**

**Temperature Profile:**
- **Initial formation temperature (deg C):**
- **Maximum representative formation temperature (deg C):**
- **Time to reach maximum representative temperature (days):**
- **Duration of treatment at representative temperature (days):**

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Formation temperature immediately post-treatment:**

**Formation temperature post-treatment monitoring event 1:**

**Duration of post-treatment monitoring (days):**

**Mass of contaminant removed:**
- **Via liquid pumping:**
- **In vapor stream:**
- **Total:**

<table>
<thead>
<tr>
<th></th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
</table>

**Comments:**

**Attachments:**

*Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.*
Cost and Performance

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

___ In Soil

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

\[ \times \] Energy

Total Energy Used: ___________ kWhr/yd\(^3\) ___________ kWhr/m\(^3\) ___________ kWhr/yd\(^3\)

___ Total energy applied to treatment zone: 227 kWhr/yd\(^3\) ___________ kWhr/m\(^3\) ___________ kWhr/yd\(^3\)

___ Other energy: ___________ kWhr/yd\(^3\) ___________ kWhr/m\(^3\) ___________ kWhr/yd\(^3\)

___ Please note other energy: 

\[ \times \] Cost

Total Project Cost:

___ Consultant Cost: 

___ Thermal Vendor Cost: 

___ Energy Cost: m\(^3\) yd\(^3\)

___ Other Cost 1: 

___ Other Cost 2: 

___ Other Cost 3: 

___ Please note other cost: ___ Other Cost 1: 

___ Other Cost 2: 

___ Other Cost 3: 
Facility Name: Operating Texaco Gas Station
Address: 419 Entiat St., Suite A
City, State, Zip Code: Kennewick, WA 99336
Phone #: 509-727-4276
email: bill@cesiweb.com

Primary point of contact: Bill Heath
Organization: CES
Point of contact: None

Other contacts or vendors who worked on site
Type: Vendor, Consultant
Vendor, Technical Applications
Other

Type of Contaminant:
Chlorinated Solvents
Petroleum Hydrocarbons
Pesticides
Wood Treating

Treatment Status:
Active
Post

Type of Test:
Pilot Test
Full Scale System

Start of Test:
End of Test:
Duration:

Type of Site:
Non-DOD
DoD

Good pre- and post-treatment groundwater data
Good pre- and post-treatment soil data
Good temperature profile vs. time information
Flux assessment
Groundwater elevations
Geologic cross-section
Hydraulic Conductivity information
### General Site Assessment Data

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): __________
  - Width (ft.): __________
  - Thickness (ft.): __________
  - Unknown
  - Impacted zone as defined by documentation
  - Alternative method for determining size of impacted zone (See source zone definition attachments)
  - Map attachment

- **Monitor Wells:**
  - Number of relevant monitoring wells with groundwater data: __________
  - Pre-treatment: __________
  - Post-treatment: __________
  - None
  - Number of wells relative to treatment zone:
    - Pre-treatment: In: __________, Upgradient: __________, Downgradient: __________, Crossgradient: __________
    - Post-treatment: In: __________, Upgradient: __________, Downgradient: __________, Crossgradient: __________

- **Soil Borings:**
  - Number of relevant soil borings with pre-treatment data: __________
  - Number of relevant soil borings with post-treatment data: __________
  - Number inside treatment zone: __________
  - Number outside treatment zone: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdir</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<td>1,1-Dichloroethene</td>
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<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans,1,2-Dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
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<td>None</td>
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<tr>
<td>1,2-Dichloroethene</td>
<td>m,p-xylene</td>
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<td></td>
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<td>None</td>
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<tr>
<td>1,1,1-Trichloroethene</td>
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<tr>
<td>Vinyl Chloride</td>
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<td>None</td>
</tr>
</tbody>
</table>

### Comments:


### Attachments:


**Hydrogeologic Conceptual Model**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>____ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>____ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>____ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>____ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

| Ground surface elevation based on wells in or adjacent to treatment zone: | ft amsl | Unknown |

- **Geology:**
  - [ ] Unconsolidated Sediments

- **Aquifer Characteristics:**
  - [ ] No
  - [ ] Yes (number): _____________
  - [ ] Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
</tr>
</tbody>
</table>

- **Flow direction:**

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

- **K range (ft/day):**
  - Measured using: ____ Slug Test ____ Laboratory ____ Field data
  - low: _____________
  - high: _____________

- **Transmissivity (ft²/day):**
  - Measured using: ____ Slug Test ____ Laboratory ____ Field data
  - low: _____________
  - high: _____________

**Comments:**

**Attachments:**
Thermal Treatment - Design

Thermal treatment:  
- Conductive (X)
- Electrical Resistance (X)

Type of Test:  
- Pilot test (X)
- Full-scale System

Geology of Treatment Zone:  
- Relatively homogeneous and permeable unconsolidated sediments (X)
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of higher permeability material
- Largely impermeable sediments with inter-bedded layers of lower permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:  
- Saturated only (X)
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  
Duration:  

Hydraulic Control:  
- Yes (X)
- No

Size of target zone (ft²):  
- 1615

Thickness of target zone (ft):  
- Unknown

Depth to top of target zone (ft bgs):  
- Unknown

Thickness of target zone below water table (ft):  
- Unknown

Number of energy delivery points:  
- 13

Number of extraction points:  
- Unknown

Temperature Profile:

- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C):  
- Time to reach maximum representative temperature (days):  
- Duration of treatment at representative temperature (days):  

Formation temperature immediately post-treatment:
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:

- Via liquid pumping:  
- In vapor stream:  
- Total:  

Comments:

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Facility ID#: 1250

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater:

Comment:

In Soil:

Comment:

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: ____________ kWhr ____________ kWhr/m³ ____________ kWhr/yd³

Total energy applied to treatment zone: ____________ kWhr ____________ kWhr/m³ ____________ kWhr/yd³

Other energy: ____________ kWhr ____________ kWhr/m³ ____________ kWhr/yd³

Please note other energy:

Cost

Total Project Cost:

Consultant Cost: ____________

Thermal Vendor Cost: ____________

Energy Cost: ____________ m³ ____________ yd³

Other Cost 1: ____________

Other Cost 2: ____________

Other Cost 3: ____________

Please note other cost:

Other Cost 1: ____________

Other Cost 2: ____________

Other Cost 3: ____________

Please note other:

Other Cost 1: ____________

Other Cost 2: ____________

Other Cost 3: ____________
General Site Information

File Analyzed By: JT PD ERH Date: 10/30/2006

Type of treatment: x Conductive ERH Other: ____________
Type of Contaminant: x Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Wood Treating Other: ____________

Treatment Status: ______ Active ______ Post
Type of Test: x Pilot Test Full Scale System
Start of Test: Aug-06 End of Test: Oct-06 Duration: 2 months
Type of Site: x Non-DOD DoD

Facility Name: Skuldelev
Address: Vestergade
City, State, Zip Code: Skuldelev Denmark
OU# or Site #: Denmark

Primary point of contact: Gorm Heron
Organization: TerraTherm
Address: 10 Stevens Rd
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: gheron@teratherm.com

Other contacts or vendors who worked on site ______ None
Point of contact: Niels Ploug
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: Kruger A/S
Address: ______________________
City, State, Zip Code: Gladsaxe, Denmark
Phone #: 011-45-39572061 email: NIP@kruger.dk

QA/QC

Characteristics of Interest

x Good pre- and post-treatment groundwater data x Good pre- and post-treatment soil data
x Good temperature profile vs. time information x Flux assessment
x Groundwater elevations x Geologic cross-section
x Hydraulic Conductivity information
### General Site Assessment Data

- **Impacted Zone:** Length (parallel to flow direction)(ft.): _____  Width (ft.): _____  Thickness (ft.): _____  Unknown
- **Impacted zone as defined by documentation**
- **Alternative method for determining size of impacted zone (See source zone definition attachments)**
- **Map attachment**

#### Monitor Wells

- **Number of relevant monitoring wells with groundwater data:**
  - Pre-treatment: 4  Post-treatment: 1
  - Number of wells relative to treatment zone:
    - Pre-treatment In: 1  Upgradient: 1  Downgradient: 1  Crossgradient: 1
    - Post-treatment In: 1  Upgradient: 1  Downgradient: 1  Crossgradient: 1

#### Soil Borings

- **Number of relevant soil borings with pre-treatment data:** 4
- **Number of relevant soil borings with post-treatment data:** 1
- **Number inside treatment zone:** 1  **Number outside treatment zone:** 0

#### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>1,1,2-trichloroethane</td>
<td></td>
<td>1,000 mg/L 1,000 mg/kg 10 mg/L 100 mg/kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None None None None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td></td>
<td>None None None None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None None None None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None None None None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylene</td>
<td></td>
<td>None None None None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td>None None None None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None None None None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,2,2-trichloroethane</td>
<td>Vinyl Chloride</td>
<td></td>
<td>None None None None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Vinyl Chloride</td>
<td></td>
<td>None None None None</td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Comments:

Pilot test with only 4 heater wells inside larger DNAPL area - impossible to achieve low concentrations due to inflow

Attachments:
### Hydrogeologic Conceptual Model

#### Geology:

**Vadose Zone:**
- [x] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [ ] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

**Saturated Zone:**
- [x] Relatively homogeneous and permeable unconsolidated sediments
- [ ] Relatively homogeneous and impermeable unconsolidated sediments
- [ ] Largely permeable sediments with inter-bedded lenses of lower permeability material
- [x] Largely impermeable sediments with inter-bedded layers of higher permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)
- [ ] Weathered bedrock, limestone, sandstone

#### Aquifer Characteristics:

**Is more than 1 aquifer present?**
- [x] Yes (number): _____________

**Depth to water:**
- Low value (ft bgs): _____________
- High value (ft bgs): _____________

**Flow direction:**

**Horizontal hydraulic gradient (feet/foot):** 0.01

**Vertical hydraulic gradient (feet/foot):** _____________

**K range (ft/day):**
- Low _____________
- High _____________

**Transmissivity (ft²/day):**
- Low _____________
- High _____________

#### Ground surface elevation based on wells in or adjacent to treatment zone: _____________ ft amsl

#### Facility ID#: 1260

#### Unconsolidated Sediments

**Geology:**
- Unknown

**Weathered bedrock, limestone, sandstone**

**Competent, but fractured bedrock (i.e. crystalline rock)**

**Largely impermeable sediments with inter-bedded layers of higher permeability material**

**Largely permeable sediments with inter-bedded lenses of lower permeability material**

**Relatively homogeneous and permeable unconsolidated sediments**

#### Attachments:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment: Conductive

Type of Test: Pilot test

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Relatively homogeneous and impermeable unconsolidated sediments
- Largely permeable sediments with inter-bedded layers of lower permeability material
- Largely impermeable sediments with inter-bedded lenses of higher permeability material
- Competent, but fractured bedrock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: Oct-06
Duration: 2 months

Hydraulic Control: Yes

Treatment Cell Design:
Size of target zone (ft²): 200
Thickmess of target zone (ft): 15
Depth to top of target zone (ft bgs): 2
Thickmess of target zone below water table (ft): 15
Number of energy delivery points: 4
Number of extraction points: 4

Temperature Profile:
Initial formation temperature (deg C): 10
Maximum representative formation temperature (deg C): 100
Time to reach maximum representative temperature (days): 60
Duration of treatment at representative temperature (days): 1

Formation temperature immediately post-treatment:
Date: 60
Temperature (deg C): 80-100

Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:
Via liquid pumping: 11 lb x kg, Unknown
In vapor stream: 24 lb x kg, Unknown
Total: 35 lb x kg, Unknown

Attachments:

Comments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

In Groundwater:

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

Total Energy Used: ___________________________ kWhr kWhr/m³ kWhr/yd³

Total energy applied to treatment zone: ___________________________ kWhr/m³ kWhr/yd³

Other energy: ___________________________ kWhr/m³ kWhr/yd³

Please note other energy: ___________________________________________

Cost

Total Project Cost: ___________________________________________

Consultant Cost: ___________________________________________

Thermal Vendor Cost: ___________________________________________

Energy Cost: ___________________________ m³ yd³

Other Cost 1: ___________________________________________

Other Cost 2: ___________________________________________

Other Cost 3: ___________________________________________

Please note other cost: ___________________________________________

Other Cost 1: ___________________________________________

Other Cost 2: ___________________________________________

Other Cost 3: ___________________________________________
General Site Information

File Analyzed By: JT x PD (x) Date: 10/30/2006
Type of treatment: x Conductive (x) Steam (x) ERH (x) Other: __________________________
Type of Contaminant: Chlorinated Solvents (x) Petroleum Hydrocarbons (x) Pesticides (x)
Wood Treating (x) Other: __________________________
Treatment Status: (x) Active (x) Post
Type of Test: (x) Pilot Test (x) Full Scale System
Start of Test: __________________________ End of Test: Dec-07 Duration: __________
Type of Site: (x) Non-DOD (x) DoD

Facility Name: Dyrup
Address: __________________________
City, State, Zip Code: Dyrup
OU# or Site #: Denmark

Primary point of contact: Gorm Heron
Organization: TerraTherm
Address: 10 Stevens Rd
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: gheron@terratherm.com

Other contacts or vendors who worked on site: (x) None
Point of contact: __________________________
Type: Vendor, Consultant (x) Vendor, Technical Applications (x) Other (x) Other
Organization: __________________________
Address: __________________________
City, State, Zip Code: __________________________ email: __________________________
Phone #: __________________________

QA/QC

Characteristics of Interest
(x) Good pre- and post-treatment groundwater data (x) Good pre- and post-treatment soil data
(x) Good temperature profile vs. time information (x) Flux assessment
(x) Groundwater elevations (x) Geologic cross-section
(x) Hydraulic Conductivity information
### Types of Contaminants

<table>
<thead>
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<th>Other</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
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</tr>
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<td>cis-1,2-dichloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
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</tr>
<tr>
<td>1,1,1-trichloroethane</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Monitor Wells

- Number of relevant monitoring wells with groundwater data: None
- Number of wells relative to treatment zone:
  - Pre-treatment: In: Upgradient: Downgradient: Crossgradient: None
  - Post-treatment: In: Upgradient: Downgradient: Crossgradient: None

### Soil Borings

- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number inside treatment zone:
- Number outside treatment zone:

### Comments:

- Additional comments can be provided here.

### Attachments:

- Additional attachments can be provided here.
<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td>___ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Saturated Zone:</td>
<td>___ Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Largely permeable sediments with inter-beded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X Largely impermeable sediments with inter-beded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>___ Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

___ Ground surface elevation based on wells in or adjacent to treatment zone: __________ ft amsl X Unknown

___ Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>X</th>
<th>Yes (number): ____________</th>
<th>Unknown (assume single aquifer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

___ Flow direction

___ Horizontal hydraulic gradient (feet/foot):

___ Vertical hydraulic gradient (feet/foot):

___ K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
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</tbody>
</table>

___ Transmissivity (ft²/day):

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
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Comments:

Attachments:
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 3 phase
- 6 phase
- AC power
- DC power

- Steam
- Steam + air
- Steam + O2
- Other (describe)

Type of Test: 
- Pilot test
- Full-scale System

Geology of Treatment Zone:
- Relatively homogeneous and permeable unconsolidated sediments
- Largely permeable sediments with inter-bedded lenses of lower permeability material
- Weathered bedrock, limestone, sandstone

Treatment Target Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 
Duration: 

Hydraulic Control: 
- Yes
- No

Treatment Cell Design:
- Size of target zone (ft²): 500
- Thickness of target zone (ft): 20
- Depth to top of target zone (ft bgs): 20
- Thickness of target zone below water table (ft): 0
- Number of energy delivery points: 6
- Number of extraction points: 

Temperature Profile:
- Initial formation temperature (deg C): 
  Unknown
- Maximum representative formation temperature (deg C): 100
  Unknown
- Time to reach maximum representative temperature (days): 60
  Unknown
- Duration of treatment at representative temperature (days): 5
  Unknown

Formation temperature immediately post-treatment: 
Formation temperature post-treatment monitoring event 1: 
Duration of post-treatment monitoring (days): 

Mass of contaminant removed:
- Via liquid pumping: 
  Unknown
- In vapor stream: 
  Unknown
- Total: 
  Unknown

Comments:

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and Performance

Remediation Goal:

____ In Groundwater: ____________________________

____ In Soil: ____________________________

Was the Remediation Goal Achieved:

____ In Groundwater: ____________________________

____ In Soil: ____________________________

General comments on the thermal application:

_________________________________________________________________________________

_________________________________________________________________________________

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Lessons Learned

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APPENDIX D

Site Specific Demonstration Plans and Data Analysis Reports:

• Camp LeJeune
• NAS Alameda Bldg. 5
• Air Force Plant 4
• Hunter Army Airfield
• Ft. Lewis East Gate Disposal Yard Area 3
Draft Final

Site Specific Demonstration Plan
Camp LeJeune – Site 89

Critical Evaluation of the State of
In Situ Thermal Treatment Technologies
for DNAPL Source Zone Treatment

Prepared for:

Environmental Security Technology Certification Program
Arlington, VA

Prepared by:
Arizona State University
Battelle Memorial Institute
Site 89 at the Camp Geiger portion of Marine Corps Base (MCB) Camp LeJeune is located near the intersection of “G” and Eighth Streets as shown in Figure 1. Site 89 property consists of the fenced portion of the former Defense Reutilization Marketing Office (DRMO); however, the area of impact associated with Site 89 extends beyond the fence to Edwards Creek and includes the wooded area to the east and south of the DRMO as well as a portion of Camp Geiger to the west.

Until June 2000, Site 89 was used primarily as a storage yard for the DRMO. The primary function of the former DRMO was one of managing scrap and surplus metal. Rubber tires, fuel bladders (mobile fuel storage tanks), and other materials were also managed at the site. Previous to DRMO operations, Site 89 was the site of the Base Motor Pool operations through approximately 1988, when it was relocated.

Through multiple investigations beginning in 1996, Site 89 was identified as the major source of chlorinated groundwater and surface water contamination. The later investigation identified free-phase dense non-aqueous phase liquids (DNAPL) present below the water table, with the DNAPL consisting mainly of 1,1,2,2-tetrachloroethane (PCA) and trichloroethene (TCE). The DNAPL source area was determined to be about 8,900 square feet in size.

The conceptual subsurface model for Site 89 includes three underlying geological formations and surface water bordering the area. The undifferentiated formation (surficial aquifer) occurs at a depth of approximately five feet below land surface (bls). The Belgrade formation (Castle Hayne confining unit) begins at a depth of approximately 8 to 15 feet bls, and the River Bend formation (Castle Hayne aquifer) begins at a depth of approximately 14 to 20 feet bls.

Electrical resistive heating (ERH) was selected as the technology to remove the free-phase DNAPL. Installation of the pilot test ERH system began in April 2006. The system consisted of 43 deep heating electrodes installed to a depth of 26 feet bls and 48 shallow heating electrodes installed to a depth of 19 feet bls. The total treatment area, shown in Figure 2, was roughly 15,900 square feet.

An additional 23 monitoring wells were installed both inside and immediately surrounding the pilot test area. These monitoring wells were classified as shallow type II monitoring wells and deep type III monitoring wells. Both type II and III monitoring wells were constructed with 2-inch diameter stainless steel screen, riser, and end cap. The type II wells screen section was 10-feet long extending from 5 to 15 feet bls with 0.010-inch wire wrap slots. The type III wells screen section was 5-feet long extending from 20 to 25 feet bls with 0.010-inch wire wrap screen. These monitoring wells along with four existing monitoring wells (MW-16, MW16IW, MW-17, and MW-17IW) were used to assess the effectiveness of the ERH technology as well as monitoring DNAPL and any possible dissolved phase contaminant migration.

The pilot system was brought on-line in September 2003 and was operated until the beginning of May 2004. The remedial system performance was continuously monitored during operation, and an estimated 48,000 pounds of volatile organic compound (VOC) contamination were removed in recovered volatile vapors and 428 pounds of chlorinated compounds were recovered from the groundwater during the pilot.
After the shutdown of the pilot system, the monitoring well network was monitored for 1 year. After a year the electrodes were covered by digging down 1 foot and cutting off the casing then covering with soil. All the monitoring wells were left in place.

The available documentation for Camp LeJeune suggests that it is a good site for further investigation because:
- The hydrogeology of the site is reasonably well-characterized
- The aerial extent of the source zone was reasonably defined prior to treatment
- Full treatment of a source zone was attempted
- The depth to groundwater is 5 feet
- The total depth to impacted groundwater is about 38 feet
- There is access to sampling locations immediately down-gradient of the remediated source zone
- The system employed at this site represents a state-of-the-art ERH system
- Pre- and post-treatment groundwater data are available
- Direct-push technologies can be used for sampling
- The monitoring well network is still present and accessible

Consistent with the already-approved generic demonstration plan for this project, the following site-specific activities are proposed:

(1) Verification of the site geological conceptual model before any new investigative work by:
   a. Measurement of depths to groundwater in nearby wells (to determine depth to groundwater, flow direction, and hydraulic gradient). See Table 1 for details on the monitoring wells and Figure 2 for measurement location.
   b. Collection of one continuous soil core near the dissolved plume core at the down-gradient edge of the treated source zone (to qualitatively confirm the site geology and to identify depths for subsequent groundwater sampling). Additional cores will be collected if time permits. See Table 1 for details on the monitoring wells and Figure 2 for measurement location.
   c. Slug tests conducted in existing groundwater monitoring wells in the area to get estimates of hydraulic conductivity over the screened intervals of those wells (to help identify if any zones are more conductive than others). See Table 1 for details on the monitoring wells and Figure 2 for measurement location.

(2) Collection of data necessary to determine groundwater concentrations and fluxes leaving the treated source zone:
   a. Groundwater samples collected from existing groundwater monitoring wells with available historical data See Table 1 for details on the monitoring wells and Figure 2 for measurement location.
   b. Groundwater samples will be collected using direct-push tools along a transect perpendicular to the direction of groundwater flow and across the width of the original source zone. See Figure 2 for groundwater sampling locations. The boreholes will be approximately 50 feet apart and will be sampled at least every 4 feet down to a depth of 38 ft (and at least once in each distinct lithologic change
suggested by the soil core). Groundwater will be collected in 40 mL volatile organic analysis (VOA) bottles with a peristaltic pump. The samples will be analyzed via a headspace analysis on a gas chromatograph (GC) equipped with electron capture (ECD) and flame-ionization (FID) detectors. If time permits, samples will be collected at other locations as well. The specific depths and numbers of samples collected at each location may be adjusted depending on the analysis results in the field.

c. Aquifer specific-capacity tests will be conducted at each depth where a groundwater sample is collected. These tests are to be conducted using the direct-push groundwater sampler. Specific capacity tests involve the measurement of the steady flow rate achieved with a fixed drawdown; ideally, all tests will be conducted with the same fixed drawdown (usually 0.3 – 1.0 feet).
Figure 1: Site location map
Figure 2. Direct-Push Locations
Health and Safety Plan (HASP)
Camp LeJeune – Site 89
### SECTION 1: GENERAL INFORMATION AND DISCLAIMER

**CLIENT NAME:** Environmental Security Technology Certification Program (ESTCP)  
**PROJECT NAME:** ESTCP Thermal Evaluation

**PRINCIPAL INVESTIGATORS:** Bruce Alleman (Battelle) and Paul Johnson (Arizona State University)

**PROJECT LEADER:** Sam Yoon

**PREPARED BY:** Sam Yoon  
**DATE:** 09/15/2005

**NOTE:** This Site Specific Health and Safety Plan - (HASP) has been prepared for use by Battelle employees for work at this site. Battelle is not responsible for its use by others. The plan is written for the specific LEVEL D site conditions, purposes, tasks, dates and personnel specified. If these conditions change, a new plan must be utilized and reviewed by those named in Section 17.

Subcontractors shall be solely responsible for the health and safety of their employees and shall comply with all applicable laws and regulations. In accordance with 1910.120(b)(1)(iv) and (v), Battelle will inform subcontractors of the site emergency response procedures, and any potential fire, explosion, health, safety or other hazards by making this Site Specific Safety and Health Plan and site information obtained by others available during regular business hours. All contractors and subcontractors are responsible for: (1) developing their own Health and Safety Plan including a written Hazard Communication Program and any other written hazard specific programs required by federal, state and local laws and regulations; (2) providing their own personal protective equipment (PPE); (3) providing documentation that their employees have been health and safety trained in accordance with applicable federal, state and local laws and regulations; (4) providing evidence of medical surveillance and medical approvals for their employees; and (5) designating their own site safety officer (SSO) responsible for ensuring that their employees comply with their own Health and Safety Plan and taking any other additional measures required by their site activities.

### SECTION 2: PROJECT INFORMATION

#### (1) SITE INFORMATION

<table>
<thead>
<tr>
<th>Site Name</th>
<th>OU16 (Site 89) Former DRMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Camp Lejuene, North Carolina</td>
</tr>
<tr>
<td>Phone Number</td>
<td>757-322-4630</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site Safety &amp; Health Contact</th>
<th>Sam Yoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone Number</td>
<td>614-424-4569/ 614-537-5658</td>
</tr>
</tbody>
</table>

#### (2) SITE CLASSIFICATION (check or circle all that apply)

- **√ Hazardous (RCRA/CERCLA/State)**
- **□ Construction**
- **□ Landfill (Non-Hazardous)**
- **□ UST/LUST**
- **□ Manufacturing**
- **□ Active**
- **√ Inactive**
- **□ Other:** military installation

#### (3) ENTRY OBJECTIVES (check or circle all that apply)

- **√ Site Inspection (General)**
- **□ Well Drilling Observation**
- **□ Sampling, Air**
- **√ Sampling, Water**
- **√ Sampling, Soil**
- **□ Other:**

#### (4) BATTELLE/ASU TASKS

<table>
<thead>
<tr>
<th>Task Performed by Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>01. Direct push activities for gw sample collection</td>
</tr>
<tr>
<td>02. IDW disposal</td>
</tr>
<tr>
<td>03.</td>
</tr>
<tr>
<td>04.</td>
</tr>
</tbody>
</table>

#### (5) PROJECT ORGANIZATION AND COORDINATION – The following personnel are designated to carry out the stated project job functions on site. (Note: One person may carry out more than one job function.)

**PRINCIPAL INVESTIGATORS**

- Bruce Alleman/Paul Johnson

**SITE SAFETY OFFICER**

- Sam Yoon
Sam Yoon has been designated to coordinate access control and security for Battelle operations on site. A safe perimeter has been established at the work area by delineating the work area with traffic cones and/or high-visibility barrier tape.

No unauthorized person should be within this area.

The on site Command Post and staging area have been established at the former ERH treatment area at Site 89 (OU16).

The prevailing wind conditions are east. A wind direction indicator is used to determine daily wind directions. The Command Post is located upwind from the Exclusion Zone or at a sufficient distance to prevent exposure should a release occur.

Control boundaries have been established and include southern portion of OU16. These boundaries are identified in the field by: traffic cones and/or high-visibility barrier tape.

SECTION 3: PHYSICAL HAZARDS

(1) IDENTIFY POTENTIAL PHYSICAL HAZARDS TO WORKERS (check or circle all that apply)

- Confined Space
- Steep/Uneven Terrain
- Drums Handling*
- Heavy Equipment
- Heat Stress
- Noise
- Moving Parts
- Extreme Cold
- Non-Ionizing Radiation
- Heavy Lifting
- Ionizing Radiation
- Other:
- Electrical
- Traffic
- Other:
- Overhead Hazards
- Biological Hazards
- Other:
- Fall (>6; Vertical)
- Surface Water (Immersion)

Site hazards will be mitigated by:
(1) Briefing site personnel as to identified physical hazards within the work area.
(2) Identifying the “kill switch” on the drilling rig.
(3) Personal protection equipment such as ear muffs, ear plugs, winter jackets, etc. will be don to site personnel.
(4) Antiseptic ointment, solution, and bug repellent (especially for ticks) will be included in the first aid kit for insect stings.

(2) SAFETY EQUIPMENT REQUIRED FOR BATTELLE/ASU EMPLOYEES (check or circle all that apply)

- Explosimeter
- Eye Wash
- Confined Space Warning Signs
- Fall Protection Equipment
- Emergency Shower
- Communications – On Site
- Barrier Tape
- Emergency Air Horn
- Communications – Off Site
- Traffic Cones
- Lights
- Other:
- Stretcher
- Lights – emergency
- Other:
- First Aid Kit
- Ladder
- A-B-C- Fire Extinguisher
- Tick Repellant
- Flotation Device (USCG Type III)

Emergency equipment will be located in the cab of the drilling rig. See Sections 10 and 12 for communication procedures. The field crew will be equipped with cellular telephones, walkie-talkies, and emergency air horn for communication.

SECTION 4: CHEMICAL HAZARDS INFORMATION

(1) IDENTIFIED CONTAMINANTS

Known or suspected hazardous/toxic material (attached historical information, physical description, map of contamination and tabulated date, if available).

<table>
<thead>
<tr>
<th>Media</th>
<th>Substances Involved</th>
<th>Characteristics</th>
<th>Estimated Concentrations</th>
<th>PEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>Chlorinated hydrocarbons</td>
<td>VO and TO</td>
<td>As much as 18,900 µg/L during the ERH operation</td>
<td></td>
</tr>
</tbody>
</table>
**SL** Chlorinated hydrocarbons VO and TO 520 mg/kg of TCE

<table>
<thead>
<tr>
<th>Media types</th>
<th>GW (ground water), SW (surface water), WW (wastewater), AIR (air), SL (soil), SD (sediments), WL (waste, liquid), WS (waste, solid), WD (waste, sludge), WG (waste, gas) OT (other).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characterizations</td>
<td>CA (corrosive, acid) CC, (corrosive, caustic), IG (ignitable), RA (radioactive), VO (volatile), TO (toxic), RE (reactive), BIO (infectious), UN (unknown), OT (other, describe)</td>
</tr>
<tr>
<td>Material Safety Data Sheets (MSDSs) for the contaminants of concern are attached. The data sheets include information on the chemical/toxicological properties of the site contaminants and signs and symptoms of over exposure.</td>
<td></td>
</tr>
</tbody>
</table>

(2) DESCRIBE POTENTIAL FOR CONTACT WITH EACH MEDIA TYPE FOR EACH OF THE BATTELLE/ASU TASKS LISTED IN SEC 2.4:

<table>
<thead>
<tr>
<th>BATTELLE TASK #</th>
<th>ROUTE OF EXPOSURE</th>
<th>POTENTIAL FOR CONTACT</th>
<th>METHOD OF CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B2</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B3</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B4</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
</tbody>
</table>

The SSO will brief the field team on interpretation of the attached MSDSs and particularly on symptoms and signs of over exposure to chemical hazards.

SECTION 5: HAZARD COMMUNICATION PROGRAM

If chemicals are introduced to the site by Battelle (e.g., decontamination liquids, preservatives, etc.), bring a copy of the Battelle Hazardous Communication Program and associate MSDSs to the site. The SSO will review this information with all field personnel. The current list of chemicals for this site is:

1,1,2-Trichloroethane  Alcohol
1,1,2,2-Tetrachloroethane  Trichloroethene
HCl (preservative)  Tetrachloroethene
Liquinox®  1,2-dichloroethene (cis- and trans-), Vinyl chloride

SECTION 6: ENVIRONMENTAL MONITORING

(1) The following environmental monitoring instruments shall be used on site at the specified intervals for breathing zone monitoring:

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>MONITORING PERIOD</th>
<th>ACTION LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Combustible Gas</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>□ O2 Meter</td>
<td>daily/hourly/continuous/other</td>
<td></td>
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<tr>
<td>□ PID (Lamp 10.6 eV)</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>□ FID</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>□ Radiation Meter (Gamma)</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>□ Respirable Dust Meter</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>□ GC/ECD/FID</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>√ GC/FID/PID/DELCD</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
</tbody>
</table>

(2) Monitoring equipment is to be calibrated according to the manufacturers’ instructions daily prior to and after each day of use. Record calibration data and air concentration in the Health and Safety on-site logbook.

(3) Action Levels for work shutdown and excavation. These are average values. Consideration should be given to the potential for release of highly toxic compounds from the waste or from reaction by-products. Levels are for persistence (> 10 min).

<table>
<thead>
<tr>
<th>Uncharacterized Airborne Vapors or Gases</th>
<th>Action Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;Background</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Characterized Airborne Gases, Vapor, Particulates</th>
<th>Action Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;50% PEL, REL, TLV</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Oxygen</th>
<th>Action Level</th>
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<tbody>
<tr>
<td>&lt; 19.5; &gt;23.5</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Flammability</th>
<th>Action Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10% LEL</td>
<td></td>
</tr>
</tbody>
</table>

(4) Military and/or civilian personnel in charge of buildings adjacent to invasive monitoring activities will be notified via a health and safety kick-off meeting of site activities. A copy of this HASP will be provided. If any action levels are reached at the work area as described above or if discernible odors are released as a result of field activities, the personnel in charge or their designated representative will be notified immediately. Hourly perimeter monitoring (support zone) will be conducted to assess whether organic vapors or odors are leaving the work area.
SECTION 7: HEALTH AND SAFETY TRAINING/MEDICAL MONITORING PROGRAM

The project staff is included in the Battelle Health and Safety Training and Medical Monitoring Programs in conformance with 29 CFR 1910.R.

HAZWOPPER TRAINING

<table>
<thead>
<tr>
<th>NAME</th>
<th>MEDICAL (Date)</th>
<th>INITIAL (Hrs/Date)</th>
<th>REFRESHER (Date)</th>
<th>CPR/FA/ (Dates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jennifer Trippett</td>
<td></td>
<td>40 hours/June 2001</td>
<td>August 7, 2005</td>
<td></td>
</tr>
</tbody>
</table>

SECTION 8: PERSONAL MONITORING

☐ No personal exposure monitoring or heat/cold stress monitoring will take place on site. If the need for such monitoring is anticipated, this HASP will be modified as accordingly.

SECTION 9: CONFINED SPACE ENTRY

☐ No confined space and/or trench entries will take place on site. If the possibility of such entries taking place exists, this HASP will be modified accordingly.

SECTION 10: COMMUNICATION PROCEDURES

The following standard hand signals will be used in case of failure to radio communications in each contaminant reduction zone:

- Hand gripping throat
- Grip partner’s wrist and both hands around wrist
- Hands on top of head
- Thumbs up
- Thumbs down

If applicable, telephone communications to the Command Post Should be Established as soon as possible. The stationary and/or mobile phone number(s) will be available one week prior to the start of field work. The HASP will be amended when these numbers are available.

The command post telephone is 757-322-4630
The mobile phone is

SECTION 11: DECONTAMINATION PROCEDURES

Personnel and equipment leaving an exclusion zone shall be thoroughly decontaminated at the decontamination facility constructed at the command post. The SSO is responsible for monitoring adherence with this decontamination plan. A Modified Level D decontamination protocol shall be used with the following decontamination stations:

1. Equipment Drop (IF NECESSARY)
2. Boot Covers, and Glove Wash and Rinse (IF NECESSARY)
3. Outer Boot and Glove Removal (IF NECESSARY)
4. Outer Garment Removal (IF NECESSARY)
5. Inner Glove Removal (IF NECESSARY)
6. Field Hand Wash

The following decontamination equipment is required (check or circle all that apply):

- [✓] Decon Pad (Plastic Sheet)
- [☐] Dry Brushes [✓] Detergent Soap
- [✓] Trash Cans/Bags [✓] Wet Brushes [☐] Other Decontamination Solution
- [✓] Buckets [✓] Water
SECTION 12: EMERGENCY PROCEDURES

On site personnel will use the following standard emergency procedures. The SSO shall be notified of any on site emergencies and be responsible for ensuring that the procedures are followed.

**Personal Injury in the Exclusion Zone**

Upon notification of an injury in the Exclusion Zone, the designated emergency signal shall be sounded. All site personnel shall assemble at the decontamination line. The SSO or alternate should evaluate the nature of the injury, and the affected person should be decontaminated to the extent possible prior to movement to the Support Zone. The on site CPR/FA personnel shall initiate the appropriate first aid, and contact should be made for an ambulance (and other emergency services as needed) and with the designated medical facility (if required). No persons shall reenter the Exclusion Zone until the cause of the injury or symptoms is determined.

**Fire/Explosion**

Upon notification of a fire or explosion on site, the designated emergency signal shall be sounded and all site personnel assembled at the decontamination line. The fire department shall be alerted and all personnel moved to a safe distance from the involved area.

**Equipment Failure**

If any other equipment (i.e., air monitoring) on site fails to operate properly, the Field Team Leader and SSO shall be notified and then determine the effect of this failure on continuing operations on site. If the failure affects the safety of personnel or prevents completion of the Work Plan tasks, all personnel shall leave the Exclusion Zone until the situation is evaluated and appropriate actions taken.

Emergency escape routes are designated for use in those situations where egress from the Exclusion Zone cannot occur through the decontamination line.

In all situations, when an on site emergency results in evacuation of the Exclusion Zone, personnel shall not reenter until:

1. The conditions resulting in the emergency have been corrected.
2. The hazards have been reassessed by the SSO.
3. The Site Safety Plan has been reviewed by the SSO and Corporate Health and Safety Manager.

SECTION 13: SPILL CONTROL PROCEDURES

No containers of liquid or solids exist on site, and no spill control plan is necessary. If the possibility of such conditions exist on site, this HASP will be modified accordingly.

SECTION 14: EMERGENCY INFORMATION

**LOCAL RESOURCES**

<table>
<thead>
<tr>
<th>Ambulance (name):</th>
<th>Onslow Memorial Hospital</th>
<th>Phone: 911</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital (name):</td>
<td>Onslow Memorial Hospital</td>
<td>Phone: 911 or (910) 577-2345</td>
</tr>
<tr>
<td>Police (local or state):</td>
<td>MC Camp Lejeune Police</td>
<td>Phone: 911</td>
</tr>
<tr>
<td>Fire (name):</td>
<td>MC Camp Lejeune</td>
<td>Phone: 911</td>
</tr>
<tr>
<td>HAZ MAT Responder:</td>
<td>National Response Center, Toxic Chemicals and Oil Spills</td>
<td>Phone: 911</td>
</tr>
</tbody>
</table>

| On-Site CPR/FA(s): | Sam Yoon | Phone: 614-537-5658 |

* For life-threatening emergencies or emergency trauma care. The above hospital is approximately 10 miles from the furthest work area and the ambulance response time is approximately 15 minutes.

** For non-life threatening medical care. The above hospital is approximately 30 minutes from the furthest work area. Injured workers will be transported here for non-emergency treatment only.

**DIRECTIONS TO NEAREST HOSPITAL – SEE ATTACHED MAP:**

**BATTELLE RESOURCES**

Manager, Corporate Health and Safety (ETE Division) Site Contact: Sam Yoon: 614-424-4569
SECTION 15: PERSONAL PROTECTIVE EQUIPMENT (check or circle all that apply)

☐ No type of respiratory protection is required on this site. If the possibility of the need for respiratory protection is anticipated, this HASP will be modified accordingly.

<table>
<thead>
<tr>
<th>CLOTHING</th>
<th>GLOVES</th>
<th>BOOTS</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Coveralls</td>
<td>☐ Cotton</td>
<td>☐ Safety</td>
<td>□ Hard Hat</td>
</tr>
<tr>
<td>☐ Tyvek</td>
<td>☑ Leather</td>
<td>☐ Fireman/Hip</td>
<td>☑ Glasses</td>
</tr>
<tr>
<td>☐ Saranex</td>
<td>☑ Nitrile</td>
<td>☐ Neoprene</td>
<td>☐ Goggles</td>
</tr>
<tr>
<td>☐ PE Tyvek</td>
<td>☐ Butyl</td>
<td>☑ Steel Toe</td>
<td>☐ Face Shield</td>
</tr>
<tr>
<td>☐ Other:</td>
<td>☐ Neoprene</td>
<td>☐ Steel Toe</td>
<td>☑ Hearing Protection</td>
</tr>
<tr>
<td>☑ Viton</td>
<td>☐ PVC</td>
<td>☐ PVA</td>
<td>☐ Latex</td>
</tr>
</tbody>
</table>

SECTION 16: SAFE WORK PRACTICES

THE FOLLOWING PRACTICES MUST BE FOLLOWED BY PERSONNEL ON SITE

1. Smoking, eating, chewing gum or tobacco, or drinking are forbidden except in clean or designated areas.
2. Ignition of flammable liquids within or through improvised heating devices (e.g., barrels) is forbidden.
3. Contact with samples, excavated materials, or other contaminated materials must be minimized.
4. Use of contact lenses is prohibited at all times.
5. Do not kneel on the ground when collecting samples.
6. If drilling equipment is involved, know where the kill switch is.
7. All electrical equipment used in outside locations, wet areas, or near water must be plugged into ground fault circuit interrupter (GFCI) protected outlets.
8. A “Buddy System” in which another worker is close enough to render immediate aid will be in effect.
9. Good housekeeping practices are to be maintained.
10. Where the eyes or body may be exposed to corrosive materials, water suitable for quick drenching or flushing shall be available for immediate use.
11. In the event of treacherous weather-related working conditions (i.e., thunderstorm, limited visibility, extreme cold or heat) the field task will be suspended until conditions improve or appropriate protection from the elements is provided.

SECTION 17: EMPLOYEE ACKNOWLEDGMENTS

PLAN REVIEWED BY:    DATE
H&S Manager:  Line Remmert
Principal Investigator  Bruce Alleman; Paul Johnson
Project Leader:  Sam Yoon
Site Safety Officer:  Sam Yoon

I acknowledge that I have read the information in this HASP form and the attached MSDSs. I understand the site hazards as described and agree to comply with the contents of the plan.

FIELD PERSONNEL (Print Name)  SIGNATURE  DATE

VISITOR (Print Name)  SIGNATURE  DATE

Organization/Agency

Organization/Agency

ER-0314  13  Appendix D
Figure 1. Directions to Onslow Memorial Hospital
Draft Final

Data Analysis Report
Camp LeJeune – Site 89

Critical Evaluation of the State of
In Situ Thermal Treatment Technologies
for DNAPL Source Zone Treatment

Prepared for:

Environmental Security Technology Certification Program
Arlington, VA

Prepared by:
Arizona State University
Battelle Memorial Institute

June 2006
The vendors and products, including the equipment, system components, and other materials identified in this report, are primarily for information purposes only. Although some of these vendors and products may have been used in the past, mention in this report does not constitute a recommendation for using these vendors or products.
Contents

Figures ..................................................................................................................................... 17
Tables ....................................................................................................................................... 18
Acronyms and Abbreviations ................................................................................................. 19

1. Introduction ....................................................................................................................... 20
2. Field Investigation ............................................................................................................. 20
3. References ....................................................................................................................... 23

Figures

FIGURE 1. SITE MAP
FIGURE 2. DIRECT-PUSH LOCATIONS
FIGURE 3. HYDRAULIC CONDUCTIVITY MEASUREMENT LOCATIONS
FIGURE 4. MONITORING WELL DEPTH-TO-WATER MEASUREMENTS AND GROUNDWATER
SAMPLING LOCATIONS
FIGURE 5. CROSS-SECTION OF DIRECT PUSH SAMPLING LOCATIONS
FIGURE 6. CHEMICAL-SPECIFIC MONITORING WELL CONCENTRATION DATA COMPARISON
FIGURE 7. 1,1-DICHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 8. CIS-1,2-DICHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 9. 1,1,2,2-TETRACHLOROETHANE DIRECT-PUSH GROUNDWATER CONCENTRATIONS
(µG/L)
FIGURE 10. 1,1,2-TRICHLOROETHANE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 11. TRICHLOROETHYLENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 12. TETRACHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 13. TRANS-1,2-DICHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS
(µG/L)
FIGURE 14. VINYL CHLORIDE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 15. HYDRAULIC CONDUCTIVITY TEST DATA (CM/S) OVERLAIN ON TRICHLOROETHYLENE
CONTOUR PLOT
Tables

TABLE 1. GEOLOGIC DESCRIPTIONS OF CONTINUOUS SOIL CORES (FEBRUARY/MARCH 2006)
TABLE 2. SAMPLING LOCATIONS AND TYPES OF TEST PERFORMED (FEBRUARY/MARCH 2006)
TABLE 3. SLUG TEST RESULTS (FEBRUARY/MARCH 2006)
TABLE 4. DEPTH-TO-GROUNDWATER FOR MONITORING WELLS (FEBRUARY/MARCH 2006)
TABLE 5. WATER QUALITY DATA FOR MONITORING WELLS (FEBRUARY/MARCH 2006)
TABLE 6. CHEMICAL CONCENTRATION DATA FOR MONITORING WELLS (FEBRUARY/MARCH 2006)
TABLE 7. CHEMICAL CONCENTRATION DATA FOR DIRECT-PUSH DOWNGRADIENT TRANSECT LOCATIONS (FEBRUARY/MARCH 2006)
TABLE 8. WATER QUALITY DATA FOR DIRECT-PUSH DOWNGRADIENT TRANSECT LOCATIONS (FEBRUARY/MARCH 2006)
TABLE 9. FIELD DATA AND RESULTS FOR CONSTANT DRAWDOWN AQUIFER TESTING IN DIRECT-PUSH DOWNGRADIENT TRANSECT LOCATIONS (FEBRUARY/MARCH 2006)
TABLE 10. MONITORING WELL CHEMICAL CONCENTRATION DATA COMPARISON
### Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>bgs</td>
<td>below ground surface</td>
</tr>
<tr>
<td>cis-1,2-DCE</td>
<td>cis-1,2-dichloroethene</td>
</tr>
<tr>
<td>DELCD</td>
<td>dry electrolytic conductivity detector</td>
</tr>
<tr>
<td>DO</td>
<td>dissolved oxygen</td>
</tr>
<tr>
<td>EC</td>
<td>electrical conductivity</td>
</tr>
<tr>
<td>ERH</td>
<td>electrical resistance heating</td>
</tr>
<tr>
<td>ESTCP</td>
<td>Environmental Security Technology Certification Program</td>
</tr>
<tr>
<td>FID</td>
<td>flame-ionization detector</td>
</tr>
<tr>
<td>ft</td>
<td>feet</td>
</tr>
<tr>
<td>GC</td>
<td>gas chromatography</td>
</tr>
<tr>
<td>kg</td>
<td>kilogram</td>
</tr>
<tr>
<td>NAPL</td>
<td>non-aqueous phase liquid</td>
</tr>
<tr>
<td>ORP</td>
<td>oxidation reduction potential</td>
</tr>
<tr>
<td>PID</td>
<td>photo-ionization detector</td>
</tr>
<tr>
<td>temp</td>
<td>temperature</td>
</tr>
<tr>
<td>TCE</td>
<td>trichloroethylene</td>
</tr>
<tr>
<td>VOA</td>
<td>volatile organic analysis</td>
</tr>
<tr>
<td>yr</td>
<td>year</td>
</tr>
</tbody>
</table>
1. Introduction

The post treatment field investigation of Camp LeJeune under ESTCP project CU-0314, *Critical Evaluation of State of In Situ Thermal Treatment Technologies*, was performed February 23 through March 3, 2006. Figure 1 identifies the extent of the previous electrical resistance heating (ERH) remediation area, which was also the specific area of interest for this particular field investigation.

Consistent with the objectives set forth under the CU-0314 Demonstration Plan, the field investigation at this site included the following:

- Verification of the site hydrogeological conceptual model
- Groundwater sampling of monitoring wells
- Depth-discrete analysis of hydraulic conductivity and dissolved petroleum hydrocarbons at temporary sampling locations downgradient of the treatment zone.

2. Field Investigations

In accordance with the approved generic demonstration plan for this project, the following site-specific activities were conducted:

(1) Verification of the site hydrogeological conceptual model:

   a. For confirmation of geology, one continuous soil core was collected at direct-push sampling locations GP1 shown in Figure 2. The continuous soil core/direct-push sampling location was located at the down-gradient edge of the treatment zone. Table 1 presents qualitative geologic descriptions from visual observations of the continuous soil core.

   b. Hydraulic conductivity slug testing was conducted in 14 monitoring wells as identified in Table 2 and in Figure 3. The slug test data were analyzed using both the Hvorslev and the Bouwer and Rice Methods; results are presented in Table 3. The Hvorslev’ expression for determining hydraulic conductivity from slug test data is:

   \[
   K = \frac{r^2 \ln(L_c/R)}{2L_c t_{37}}
   \]

   Where
   - \( K \) = hydraulic conductivity (L/T)
   - \( r \) = radius of well casing (L) (0.083 ft)
   - \( R \) = radius of well screen (L) (0.50 ft)
   - \( L_c \) = length of well screen (L) (5 or 10 ft)
   - \( t_{37} \) = time for water level to rise or fall 37% of the initial change (T) (from data set)

   (Fetter, 2000).

   The Bouwer and Rice expression for determining hydraulic conductivity from slug test data is:
\[ K = (r_c^2 \ln(R/R) / (2L_e)) * ((1/t) \ln(H_o/H_t)) \]

Where  
- \( K \) = hydraulic conductivity (L/T)  
- \( r_c \) = radius of well casing (L) (0.083 ft)  
- \( R \) = radius of gravel envelope (L) (0.50 ft)  
- \( R_e \) = effective radial distance over which head is dissipated (L) (from data set)  
- \( L_e \) = length of well screen (L) (5 or 10 ft)  
- \( H_o \) = drawdown at \( t=0 \) (L) (from data set)  
- \( H_t \) = drawdown at \( t=t \) (L) (from data set)  
- \( t \) = time since \( H = H_o \) (T) (from data set)  

(Fetter, 2000).

c. Depth-to-groundwater was measured in the 14 groundwater monitoring wells identified in Table 2 and in Figure 4. Depth-to-water measurements are summarized in Table 4.

(2) Collection of water quality samples from 26 groundwater monitoring wells within the treatment zone for analysis of dissolved chlorinated hydrocarbon groundwater concentrations:

a. Table 2 identifies the groundwater monitoring wells from which samples were collected. Prior to sample collection, three well-volumes were purged. Groundwater was then collected for analysis of field parameters and stored in volatile organic analysis (VOA) vials for analysis of dissolved chlorinated hydrocarbon concentrations. General water quality field parameters including pH, electrical conductivity (EC), temperature, dissolved oxygen (DO), and oxidation reduction potential (ORP) were measured using an Horiba U-22 meter. Petroleum hydrocarbon analysis was performed on-site by heated-headspace analysis and gas chromatography (GC) using a dry electrolytic conductivity detector (DELCD), photo-ionization detector (PID) and a flame-ionization detector (FID). General water quality data for permanent groundwater monitoring well installations can be found in Table 5 and chemical concentration data can be found in Table 6. All non-detect samples are listed as less than the detection limit.

(3) Depth-discrete hydraulic conductivity and dissolved chlorinated hydrocarbon concentration data were collected on four foot intervals as possible from 3 ft below ground surface (bgs) to 40 ft bgs at all seven direct-push sampling locations.

a. Groundwater quality data were collected from depth-specific intervals at all direct-push sampling locations (See Table 2 and Figure 2). Sampling locations were spaced on approximately 50 ft centers, as possible, along a transect downgradient of the source zone and perpendicular to the direction of groundwater flow. Figure 2 presents the direct-push sampling locations. Using
percussion assisted direct-push technology and a modified Geoprobe Groundwater Profiler, groundwater samples were collected using a peristaltic pump on 4-ft intervals from 3 ft bgs to 40 ft bgs. The location of the depth-discrete groundwater samples are shown in Figure 5. Dissolved chlorinated hydrocarbon concentration analysis was conducted, as described above, and the results are summarized in Table 7. General water quality parameters (e.g. pH, EC, temp, DO, and ORP) were also collected during depth-specific sampling, and those data are presented in Table 8.

b. Aquifer specific-capacity tests were conducted at depth-specific intervals at direct push sampling locations GP1 through GP7 as indicated in Table 2 and Figure 3. Specific-capacity tests involve the measurement of the flow rate achieved under fixed drawdown and are analyzed using the Theim Equation to estimate hydraulic conductivity. The field data and results for aquifer testing are shown in Table 9. The Theim equation for hydraulic conductivity is:

\[ T = \frac{Q}{2(h_2 - h_1)} \ln\left(\frac{r_2}{r_1}\right) \]

Where   
\( T \) = transmissivity (L²/T)  
\( Q \) = pumping rate (L³/T)  
\( h_1 \) = head at distance \( r_1 \) from the pumping well (L)  
\( h_2 \) = head at distance \( r_2 \) from the pumping well (L)

and \( K = T/b \)

Where   
\( K \) = hydraulic conductivity (L/T)  
\( b \) = length of sampler or screen section (L) (0.5 ft or length of screen)

(Fetter, 2000).

The monitoring well chemical concentration data collected in February/March 2006 by the ASU/Battelle team were compared to the previous monitoring well chemical concentration data available for the site. The analytical results for each are shown in Table 10. The comparability of these results can also be seen in Figure 6 (a through g). Note that the ASU/Battelle February/March 2006 results for vinyl chloride appear higher than previous Site 89 results and low concentration values of cis-1,2-DCE also appear to be higher, but all other chemical concentrations are comparable. Also note that the analytical detection limit was used to plot Figure 6 (a through g) when an exact concentration was not provided and estimated values were used, if possible. The results of MW-20 are not provided in the monitoring well chemical concentration data because non-aqueous phase liquid (NAPL) was pumped from the well during the purging process.

Figures 7 to 14 present contour plots of the chemical concentrations for each of the eight chemicals measured at the depth-discrete direct push sampling locations. Figure 15 presents the specific capacity pump test results for each discrete-depth direct push sampling interval overlaid on the trichloroethylene (TCE) concentration plot.
A TCE mass flux calculation was performed using the Mass Flux Toolkit, Version 1.0. This program is a freeware program developed by Groundwater Services, Inc. and others under a contract funded by the Environmental Security Technology Certification Program (ESTCP). Figure 16 is a snapshot of the input screen with TCE being used to perform the mass flux analysis. A linear spatial and vertical interpolation of the data was used for the mass flux analysis. The TCE mass flux was estimated to be 3.34E+01 kg/yr.

3. References

Figures
Figure 1. Site Map
Figure 2. Direct-Push Locations
Figure 3. Hydraulic Conductivity Measurement Locations
Figure 4. Monitoring Well Depth-to-Water Measurement and Groundwater Sampling Locations
Figure 5. Cross-section of Direct Push Sampling Locations

<table>
<thead>
<tr>
<th>GP 7</th>
<th>GP 4</th>
<th>GP 3</th>
<th>GP 1</th>
<th>GP 2</th>
<th>GP 5</th>
<th>GP 6</th>
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<td>GP 1-3</td>
<td>No Water</td>
<td>GP 2-3</td>
</tr>
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<td>GP 4-6</td>
<td>GP 3-6</td>
<td>GP 1-6</td>
<td>No Water</td>
<td>GP 2-7</td>
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<td>GP 7-8/12</td>
<td>GP 4-9</td>
<td>GP 3-9</td>
<td>GP 1-9</td>
<td>GP 2-9</td>
<td>No Water</td>
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<td>GP 7-12/16</td>
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<td>GP 3-13</td>
<td>GP 1-13</td>
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<td>GP 3-25</td>
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<td>GP 5-25</td>
<td>GP 6-25</td>
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<td>GP 4-29</td>
<td>GP 3-29</td>
<td>GP 1-27</td>
<td>GP 2-29</td>
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<td>GP 3-37</td>
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<td>GP 1-39</td>
<td>GP 2-40</td>
<td>GP 5-40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scale

1 inch = 28 feet
VE = 1/4
1,1-DCE Comparison

Figure 6(a)

cis-1,2-DCE Comparison

Figure 6(b)
Appendix D

Figure 6(c) 1,1,2,2-PCA Comparison

Figure 6(d) PCE Comparison
Figure 6(e) - 1,1,2-TCA Comparison

Figure 6(f) - TCE Comparison
Figure 6. Chemical-Specific Monitoring Well Concentration Data Comparison
Figure 7. 1,1-Dichloroethene Direct-Push Groundwater Concentrations (µg/L)
Figure 8. cis-1,2-Dichloroethene Direct-Push Groundwater Concentrations (μg/L)
Figure 9. 1,1,2,2-Tetrachloroethane Direct-Push Groundwater Concentrations (μg/L)
Figure 10. 1,1,2-Trichloroethane Direct-Push Groundwater Concentrations (μg/L)
Figure 11. Trichloroethylene Direct-Push Groundwater Concentrations (µg/L)
Figure 12. Tetrachloroethene Direct-Push Groundwater Concentrations (μg/L)
Figure 13. trans-1,2-Dichloroethene Direct-Push Groundwater Concentrations (μg/L)
Figure 14. Vinyl Chloride Direct-Push Groundwater Concentrations (µg/L)
Figure 15. Hydraulic Conductivity Test Data (cm/s) Overlain on Trichloroethylene Contour Plot
Figure 16. Mass Flux Toolkit Inputs
Tables
## Table 1. Geologic Descriptions of Continuous Soil Cores (February/March 2006)

<table>
<thead>
<tr>
<th>Boring Depth (ft)</th>
<th>Subsurface Features</th>
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<td><strong>Continuous Soil Core GP 1</strong></td>
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<tr>
<td>0-2</td>
<td>Silty fine sand with some clay</td>
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<tr>
<td>4-5</td>
<td>Fine sandy silt with some clay</td>
</tr>
<tr>
<td>6-7</td>
<td>Clayey silt with some fine sands</td>
</tr>
<tr>
<td>8</td>
<td>Silty fine sand</td>
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<tr>
<td>9</td>
<td>Clayey silt with some fine sands</td>
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<td>10</td>
<td>Fine sand</td>
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<td>11-13</td>
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</tr>
<tr>
<td>14</td>
<td>Silt</td>
</tr>
<tr>
<td>15</td>
<td>Sand and gravel with traces of clay</td>
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<tr>
<td>16-20</td>
<td>Sandy clay with fine to medium sand</td>
</tr>
<tr>
<td>22</td>
<td>Clay sands and gravels</td>
</tr>
<tr>
<td>24</td>
<td>Sands and gravels with some clay</td>
</tr>
<tr>
<td>26</td>
<td>Clayey sands with some gravel</td>
</tr>
<tr>
<td>28</td>
<td>Course sand with some clay</td>
</tr>
<tr>
<td>32</td>
<td>Sands and gravels with trace silts and clay</td>
</tr>
<tr>
<td>34</td>
<td>Clayey sands and gravel</td>
</tr>
<tr>
<td>36-40</td>
<td>Silty fine sands with some clay</td>
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Table 2. Sampling Locations and Types of Test Performed (February/March 2006)

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<th>Physical Assessment</th>
<th>Water Quality Assessment</th>
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<td>Depth-To-Water Measurement</td>
<td>Slug Testing</td>
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<tr>
<td>MW-16</td>
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<td>MW-16IW</td>
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<td>Yes</td>
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<td>Yes</td>
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<td>MW-17IW</td>
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<td>Yes</td>
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<td>GP-6*</td>
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<td>Yes</td>
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<td>GP-7*</td>
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<td>Yes</td>
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\(^a\) Water quality assessments and constant drawdown tests at direct-push locations were performed on 4-ft intervals from the phreatic surface (~3’ bgs) to 40’ bgs.

\(^b\) Depth to water measurements are approximate and not intended for groundwater elevation calculations.

\(^c\) Field parameters include: pH, electrical conductivity, temperature, dissolved oxygen, and oxidation reduction potential.
Table 3. Slug Test Results (February/March 2006)

<table>
<thead>
<tr>
<th>Monitoring Well</th>
<th>Well Screen (ft)</th>
<th>Hvorslev K (cm/s)</th>
<th>Hvorslev K (ft/d)</th>
<th>Bouwer and Rice K (cm/s)</th>
<th>Bouwer and Rice K (ft/d)</th>
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<tbody>
<tr>
<td>MW-16</td>
<td>5-15</td>
<td>2.76E-03</td>
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<td>7.74E-04</td>
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<td>4.59E-04</td>
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<td>3.75E-03</td>
<td>10.63</td>
<td>7.56E-04</td>
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<tr>
<td>MW-21</td>
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<td>2.05E-03</td>
<td>5.80</td>
<td>1.12E-04</td>
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<td>MW-21IW</td>
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<td>7.89</td>
<td>4.50E-04</td>
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<td>5-15</td>
<td>3.16E-05</td>
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<td>8.75E-06</td>
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<td>1.20E-04</td>
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Table 4. Depth-to-Groundwater for Monitoring Wells (February/March 2006)

<table>
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<tr>
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<th>DTW (m BTOC)</th>
<th>DTW (ft BTOC)</th>
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<tbody>
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</tr>
<tr>
<td>MW-17</td>
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<td>5.00</td>
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</tr>
<tr>
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<td>5.43</td>
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<td>3.64</td>
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<td>4.46</td>
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<tr>
<td>MW-27IW</td>
<td>1.11</td>
<td>3.65</td>
</tr>
<tr>
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</tr>
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</tr>
<tr>
<td>MW-30</td>
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<td>1.80</td>
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</table>

DTW - Depth-to-water  
BTOC - Below top of casing
Table 5. Water Quality Data for Monitoring Wells (February/March 2006)

<table>
<thead>
<tr>
<th>Monitoring Well</th>
<th>pH</th>
<th>EC (mS)</th>
<th>Temperature (°C)</th>
<th>DO (mg/L)</th>
<th>ORP (mV)</th>
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</thead>
<tbody>
<tr>
<td>MW-16</td>
<td>6.9</td>
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<td>3.24</td>
<td>18.2</td>
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<td>2</td>
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<td>-56</td>
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<td>1.80</td>
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<td>-123</td>
</tr>
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</table>

*a All measurements were made with a Horiba U-22 meter.
EC = electrical conductivity
DO = dissolved oxygen
ORP = oxidation-reduction potential
### Table 6. Chemical Concentration Data for Monitoring Wells (February/March 2006)

<table>
<thead>
<tr>
<th>Monitoring Well</th>
<th>Date Analyzed</th>
<th>Vinyl Chloride</th>
<th>1,1-DCE</th>
<th>trans-1,2-DCE</th>
<th>cis-1,2-DCE</th>
<th>TCE</th>
<th>1,1,2-TCA</th>
<th>PCE</th>
<th>1,1,2,2-PCA</th>
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</thead>
<tbody>
<tr>
<td>MW-16</td>
<td>2/26/06</td>
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<td>110</td>
<td>330</td>
<td>16000</td>
<td>360</td>
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<td>ND &lt;1</td>
<td>110</td>
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<td>3/3/06</td>
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<td>370</td>
<td>19000</td>
<td>16</td>
<td>ND &lt;1</td>
<td>ND &lt;1</td>
<td>ND &lt;1</td>
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<td>ND &lt;1</td>
<td>ND &lt;1</td>
<td>ND &lt;1</td>
<td>ND &lt;1</td>
<td>ND &lt;1</td>
<td>ND &lt;1</td>
<td>ND &lt;1</td>
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<td>ND &lt;1</td>
<td>ND &lt;1</td>
</tr>
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<td>59</td>
<td>3000</td>
<td>16000</td>
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<td>6000</td>
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<td>200</td>
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<td>9700</td>
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<td>74000</td>
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<td>1200</td>
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<td>11000</td>
<td>200</td>
<td>2</td>
<td>1800</td>
</tr>
</tbody>
</table>

**DUP** - Duplicate sample

**REP** - Quality control sample (second analysis of same water sample)

**ND** – non detect at the limit of 1 ug/L
Table 7. Chemical Concentration Data for Direct-Push Downgradient Transect Locations (February/March 2006)

<table>
<thead>
<tr>
<th>Sampling Location*</th>
<th>Vinyl Chloride</th>
<th>1.1 DCE</th>
<th>1.2 DCE</th>
<th>cis-1,2 DCE</th>
<th>TCE</th>
<th>1,1,2 TCA</th>
<th>PCE</th>
<th>1,1,2,2 PCA</th>
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</thead>
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<td>180</td>
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<td>ND&lt;1</td>
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<td>GP 1-15</td>
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<td>190</td>
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<td>46</td>
<td>1200</td>
<td>620</td>
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<td>110</td>
<td>68</td>
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DUP - Duplicate sample
REP - Quality control sample (second analysis of same water sample)
ND – non detect at the limit of 1 ug/L
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a All measurements were made with a Horiba U-22 meter.
--- No water quality data taken
EC = electrical conductivity
DO = dissolved oxygen
ORP = oxidation-reduction potential
Table 9. Field Data And Results for Constant Drawdown Aquifer Testing in Direct-push Downgradient Transect Locations
(February/March 2006)

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* See Figure 2

** BSWS – Below estimated static water surface
Table 10. Monitoring Well Chemical Concentration Data Comparison

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N/A – No Data Available, Dup – Duplicate Sample, REP – Quality Control Sample (second analysis of same sample), ND – Non-Detect (detection limit not available)
**Table 10. Monitoring Well Chemical Concentration Data Comparison (cont.)**

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<td>MW-27IW DUP</td>
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</tr>
</tbody>
</table>

N/A – No Data Available, Dup – Duplicate Sample, REP – Quality Control Sample (second analysis of same sample), ND – Non-Detect (detection limit not available)
Draft Final

Site Specific Demonstration Plan
NAS Alameda – Site 5

Critical Evaluation of the State of
In Situ Thermal Treatment Technologies
for DNAPL Source Zone Treatment

Prepared for:

Environmental Security Technology Certification Program
Arlington, VA

Prepared by:
Arizona State University
Battelle Memorial Institute
Site 5 at the Naval Air Station (NAS), Alameda Point is located in Alameda, California. The site consists of more than 18 acres of land located in the central portion of Alameda Point (Figure 1) and includes Building 5, the largest building at Alameda Point which covers approximately 12.5 acres.

Building 5 housed specialty shops for aircraft component repair and maintenance from 1942 until the base was closed in April 1997. Building 5 also housed a plating shop and a “selective” plating shop where small parts were plated by hand. These shops were closed in 1990 and 1993. A wastewater treatment facility for industrial wastewater was located near the southwestern corner of Building 5. A hazardous water storage area at Site 5 was closed in mid-1988. This area was located outside of Building 5 in the southeastern corner of the site. Access to this area is fenced and access is restricted. Additional activities at site 5 included a lead-acid and nickel-cadmium batteries service area.

Chemical contaminants from the various industrial processes inside Building 5 are believed to have been released directly to the subsurface beneath certain operational areas. Solvents are believed to have been released as spills and as leakage from a solvent tank in the hazardous waste storage area outside the southeast corner of Building 5. Solvent releases are also believed to have occurred from a solvent tank located on the eastern side of Building 5, and solvents and metals are believed to have been released from the plating shop via floor drains.

Multiple investigations have shown plume 5-1 and 5-3 to be known dense non-aqueous phase liquid (DNAPL) plumes. Plume 5-1 is located on the eastern side of Building 5 and plume 5-3 is located within Building 5 as shown in Figure 2. Plume 5-1 investigations showed the DNAPL consisted mainly of trichloroethylene (TCE) and trichloroethane (TCA) and the degradation products from these compounds. The DNAPL plume area was determined to be about 1/3 of an acre. A pilot scale six phase heating (SPH) application was performed in plume 5-1 in June of 2002. Based on the results of the pilot, full-scale SPH applications were performed at plume 5-1 and will be performed at plume 5-3.

The conceptual subsurface model for Site 5 includes five geologic units. The Lower San Antonio Unite, or Yerba Buena Mud, is a clay that extends from a depth of approximately 125 feet (ft) below ground surface (bgs) to 170 to 200 ft bgs. The Upper San Antonio Unite overlies the Yerba Buena Mud and extends from 100 ft bgs to about 125 ft bgs. It consists of interbedded very fine-grained, silty sand and green-grey silty clay. The Merritt Sand Formation overlies the San Antonio Formation and extends from 35 ft bgs to about 100 ft bgs and contains 3 sediment types: 1) yellow-brown clayey sand, with approximately 5 percent clay, 2) moist, silty sand, and 3) fine-grained, well-sorted sand with some shell fragments. The Bay Sediment Unit (BSU) overlies the Merritt Sand formation and extends from 15 ft bgs to about 35 ft bgs and is composed of three sediment types: 1) a stiff, moist, dark olive clay, 2) sand and clay with a number of shell fragments, and 3) silty sand with interbedded layers of fine-grained sand. Artificial fill overlies the BSU and is composed of olive brown, unconsolidated fine to medium-grained sand with lenses of silty sand, gravelly sand, or sandy gravel. Groundwater is encountered in the artificial fill between 4 and 7 ft bgs. The BSU separates the first (FWBZ) and second water-bearing zones (SWBZ) with low-permeability sediments. The FWBZ is located in the artificial fill and upper part of the BSU. The FWBZ general flow direction is to the
northeast. The SWBZ is situated within the lower part of the BSU, the Merritt Sand, and the Upper San Antonio Unit. The SWBZ general flow direction is to the south.

Installation for full-scale six-phase heating at began in 2004. The system consisted of 7 electrodes installed to a depth of 19 ft bgs and 28 electrodes installed to a depth of 14 ft bgs and 1 electrode installed to 15 ft bgs. The total treatment area was approximately 1/3 acre (Figure 3).

In addition, 2 monitoring wells were installed inside the treatment area. These two monitoring wells were used along with 12 monitoring wells installed during the pilot scale SPH application. Table 1 shows the screened intervals of the wells along with their diameter.

The full-scale system was brought on-line in July 2004 and was operated until November 2004. The remedial system performance was continuously monitored during operation, and an estimated 3,000 pounds of volatile organic compound (VOC) contamination were removed in recovered volatile vapors and groundwater.

After shutdown, monitoring wells were monitored for four months. All monitoring wells and electrodes were left in place for possible use at a later time.

The available documentation for NAS Alameda, Site 5 suggests that it is a good site for further investigation because:
- The hydrogeology of the site is reasonably well-characterized
- The aerial extent of the source zone was reasonably defined prior to treatment
- Full treatment of a source zone was performed
- The depth to groundwater is 4 to 7 feet
- The total depth of impacted groundwater is about 30 feet
- There is access to sampling locations immediately down-gradient of the remediated source zone
- The system employed at this site represents a state-of-the-art ERH system
- Pre- and post-treatment groundwater data are available
- Direct-push technologies can be used for sampling
- The monitoring well network is still present and accessible

Consistent with the already-approved generic demonstration plan for this project, the following site-specific activities are proposed:

(1) Verification of the site geological conceptual model before any new investigative work by:
   a. Measurement of depths to groundwater in nearby wells (to determine depth to groundwater, flow direction, and hydraulic gradient). See Table 1 for monitoring well details and Figure 4 for measurement locations.
   b. Collection of one continuous soil core at the down-gradient edge of the treated source zone (to qualitatively confirm the site geology and to identify depths for subsequent groundwater vertical profile sampling). One or two additional cores will be collected if time permits. See Figure 4 for sampling location.
c. Slug tests conducted in existing groundwater monitoring wells in the area to get estimates of hydraulic conductivity over the screened intervals for those wells (to help identify if any zones are more conductive than others). See Table 1 for details on the monitoring wells and Figure 4 for measurement location.

(2) Collection of data necessary to determine groundwater concentrations and fluxes leaving the treated source zone:

a. Groundwater samples collected from existing groundwater monitoring wells with available historical data. See Table 1 for details on the monitoring wells and Figure 4 for their locations.

b. Groundwater samples will be collected using direct-push tools along a transect perpendicular to the direction of groundwater flow at the down-gradient edge of the original source zone. See Figure 4 for groundwater sampling locations. Sampling locations will be approximately 40 feet apart, and at each location samples will be collected, as possible, at least every 4 feet down to a maximum depth of 30 ft (and at least once in each distinct lithologic change suggested by the soil core). The samples will be analyzed via a headspace analysis on a gas chromatograph (GC) equipped with dry electrolytic conductivity detector (DELCD), photo-ionization detector (PID), and flame-ionization (FID) detectors. If time permits, samples will be collected at additional locations as well. The specific depths and numbers of samples collected at each location may be adjusted depending on the analytical results in the field.

c. Aquifer specific-capacity tests will be conducted at each depth where a groundwater sample is collected. These tests will be conducted using the direct-push groundwater sampler and will involve the measurement of the steady flow rate achieved with a fixed drawdown; ideally, all tests will be conducted with the same fixed drawdown (usually 0.3 – 1.0 feet).
Health and Safety Plan (HASP)
NAS Alameda – Site 5
SECTION 1: GENERAL INFORMATION AND DISCLAIMER

NOTE: This Site Specific Health and Safety Plan - (HASP) has been prepared for use by Battelle employees for work at this site. Battelle is not responsible for its use by others. The plan is written for the specific LEVEL D site conditions, purposes, tasks, dates and personnel specified. If these conditions change, a new plan must be utilized and reviewed by those named in Section 17.

Subcontractors shall be solely responsible for the health and safety of their employees and shall comply with all applicable laws and regulations. In accordance with 1910.120(b)(1)(iv) and (v), Battelle will inform subcontractors of the site emergency response procedures, and any potential fire, explosion, health, safety or other hazards by making this Site Specific Safety and Health Plan and site information obtained by others available during regular business hours. All contractors and subcontractors are responsible for: (1) developing a written Health and Safety Plan including a written Hazard Communication Program and any other written hazard specific programs required by federal, state and local laws and regulations; (2) providing their own personal protective equipment (PPE); (3) providing documentation that their employees have been health and safety trained in accordance with applicable federal, state and local laws and regulations; (4) providing evidence of medical surveillance and medical approvals for their employees; and (5) designating their own site safety officer (SSO) responsible for ensuring that their employees comply with their own Health and Safety Plan and taking any other additional measures required by their site activities.

SECTION 2: PROJECT INFORMATION

(1) SITE INFORMATION

<table>
<thead>
<tr>
<th>Site Name:</th>
<th>ERH Pilot Test Site near BLDG 5</th>
</tr>
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<tbody>
<tr>
<td>Address:</td>
<td>Former Naval Air Station Alameda</td>
</tr>
<tr>
<td></td>
<td>Alameda Point, CA 92101</td>
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</tbody>
</table>

| Site Project Contact: | Glenna Clark |
| Phone Number:        | 619-532-0951 |

| Site Safety & Health Contact: | Sam Yoon |
| Phone Number: | 614-424-4569/ C: 614-218-0627 |

(2) SITE CLASSIFICATION (check or circle all that apply)

| √ Hazardous (RCRA/CERCLA/State) |
| □ Construction |
| □ Landfill (Non-Hazardous) |
| □ UST/LUST |
| □ Manufacturing |
| □ Active |
| □ Inactive |
| □ Other: military installation |

| ENTRY OBJECTIVES (check or circle all that apply) |
| √ Site Inspection (General) |
| □ Well Drilling Observation |
| □ Sampling, Air |
| □ Sampling, Water |
| □ Sampling, Soil |
| □ Other: |

DATE(S) OF FIELD VISIT(S):

(4) BATTELLE/ASU TASKS

<table>
<thead>
<tr>
<th>Groundwater Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1. Groundwater sampling</td>
</tr>
<tr>
<td>B2. Water level survey and slug tests</td>
</tr>
<tr>
<td>B3. Analytical activities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TASK PERFORMED BY OTHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct push activities for gw sample collection</td>
</tr>
<tr>
<td>IDW disposal</td>
</tr>
</tbody>
</table>

(5) PROJECT ORGANIZATION AND COORDINATION – The following personnel are designated to carry out the stated project job functions on site. (Note: One person may carry out more than one job function.)
Appendix D

PRINCIPAL INVESTIGATORS
Bruce Alleman/Paul Johnson

SITE SAFETY OFFICER
Sam Yoon

ALTERNATIVE SITE SAFETY OFFICER(S)
Jennifer Triplett/Paul Dahlen

PUBLIC INFORMATION OFFICER
N/A

SITE RECORD KEEPER
Sam Yoon/Jennifer Triplett

SITE PERSONNEL WITH CPR/FA
Sam Yoon

FIELD TEAM LEADER(S)
Sam Yoon

OTHER FIELD TEAM MANAGERS

(6) ON SITE CONTROL
Sam Yoon has been designated to coordinate access control and security for Battelle operations on site. A safe perimeter has been established at the work area by delineating the work area with traffic cones and/or high-visibility barrier tape.

No unauthorized person should be within this area.

The on site Command Post and staging area have been established at the pilot ERH test area near Building 5 at IR Site 5.

The prevailing wind conditions are west. A wind direction indicator is used to determine daily wind directions. The Command Post is located upwind from the Exclusion Zone or at a sufficient distance to prevent exposure should a release occur.

Control boundaries have been established and include West of the ERH test area. These boundaries are identified in the field by traffic cones and/or high-visibility barrier tape.

SECTION 3: PHYSICAL HAZARDS

(1) IDENTIFY POTENTIAL PHYSICAL HAZARDS TO WORKERS (check or circle all that apply)

<table>
<thead>
<tr>
<th>Confined Space</th>
<th>Steep/Uneven Terrain</th>
<th>Drums Handling*</th>
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<table>
<thead>
<tr>
<th>Heavy Equipment</th>
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<th>Noise</th>
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<table>
<thead>
<tr>
<th>Moving Parts</th>
<th>Extreme Cold</th>
<th>Non-Ionizing Radiation</th>
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<table>
<thead>
<tr>
<th>Heavy Lifting</th>
<th>Ionizing Radiation</th>
<th>Other:</th>
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<tr>
<th>Electrical</th>
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<thead>
<tr>
<th>Overhead Hazards</th>
<th>Biological Hazards</th>
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<thead>
<tr>
<th>Fall (&gt;6; Vertical)</th>
<th>Surface Water (Immersion)</th>
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</table>

Site hazards will be mitigated by:

(5) Briefing site personnel as to identified physical hazards within the work area.

(6) Identifying the “kill switch” on the drilling rig.

(7) Personal protection equipment such as ear muffs, ear plugs, winter jakets, etc. will be don to site personnel.

(8) Antiseptic ointment, solution, and bug repellent (especially for ticks) will be included in the first aid kit for insect stings.

(2) SAFETY EQUIPMENT REQUIRED FOR BATTELLE/ASU EMPLOYEES (check or circle all that apply)

<table>
<thead>
<tr>
<th>Explosimeter</th>
<th>Eye Wash</th>
<th>Confined Space Warning Signs</th>
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<table>
<thead>
<tr>
<th>Fall Protection</th>
<th>Emergency Shower</th>
<th>Communications – On Site</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Barrier Tape</th>
<th>Emergency Air Horn</th>
<th>Communications – Off Site</th>
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</thead>
<tbody>
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<thead>
<tr>
<th>Traffic Cones</th>
<th>Lights</th>
<th>Other:</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Stretch</th>
<th>Lights – emergency</th>
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<table>
<thead>
<tr>
<th>First Aid Kit</th>
<th>Ladder</th>
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<table>
<thead>
<tr>
<th>A-B-C- Fire</th>
<th>Tick Repellant</th>
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<table>
<thead>
<tr>
<th>Extinguisher</th>
<th>Flotation Device (USCG Type III)</th>
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</table>

Emergency equipment will be located in the cab of the drilling rig. See Sections 10 and 12 for communication procedures. The field crew will be equipped with cellular telephones, walkie-talkies, and emergency air horn for communication.

SECTION 4: CHEMICAL HAZARDS INFORMATION

(1) IDENTIFIED CONTAMINANTS

Known or suspected hazardous/toxic material (attached historical information, physical description, map of contamination and tabulated date, if available).

<table>
<thead>
<tr>
<th>Media</th>
<th>Substances Involved</th>
<th>Characteristics</th>
<th>Estimated Concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>Chlorinated hydrocarbons (1,1-dichloroethane, VO and TO)</td>
<td>Total chlorinated VOCs up to 35,000</td>
<td></td>
</tr>
</tbody>
</table>

ER-0314 65 Appendix D
1,1-dichloroethene, 1,1,1-trichloroethane) µg/L prior to the ERH operation, recent monitoring was at 700 µg/L.

<table>
<thead>
<tr>
<th>Media types</th>
<th>Chlorinated hydrocarbons</th>
<th>VO and TO</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW (ground water), SW (surface water), WW (wastewater), AIR (air), SL (soil), SD (sediments), WL (waste, liquid), WS (waste, solid), WD (waste, sludge), WG (waste, gas) OT (other).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characterizations</td>
<td>CA (corrosive, acid) CC, (corrosive, caustic), IG (ignitable), RA (radioactive), VO (volatile), TO (toxic), RE (reactive), BIO (infectious), UN (unknown), OT (other, describe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Safety Data Sheets (MSDSs) for the contaminants of concern are attached. The data sheets include information on the chemical/toxicological properties of the site contaminants and signs and symptoms of over exposure.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

(2) DESCRIBE POTENTIAL FOR CONTACT WITH EACH MEDIA TYPE FOR EACH OF THE BATTELLE/ASU TASKS LISTED IN SEC 2.4:

<table>
<thead>
<tr>
<th>BATTELLE TASK #</th>
<th>ROUTE OF EXPOSURE</th>
<th>POTENTIAL FOR CONTACT</th>
<th>METHOD OF CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B2</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B3</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B4</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
</tbody>
</table>

The SSO will brief the field team on interpretation of the attached MSDSs and particularly on symptoms and signs of over exposure to chemical hazards.

SECTION 5: HAZARD COMMUNICATION PROGRAM

If chemicals are introduced to the site by Battelle (e.g., decontamination liquids, preservatives, etc.), bring a copy of the Battelle Hazardous Communication Program and associate MSDSs to the site. The SSO will review this information with all field personnel. The current list of chemicals for this site is:

1,1,1-Trichloroethane (TCA) 1,2-dichloroethene (cis- and trans-), Vinyl chloride
1,1,2-Trichloroethane (TCA) Trichloroethene, Tetrachloroethene
1,1-Dichloroethane, 1,2-dichloroethane (DCA) Methanol
1,1-dichloroethene (DCE) Alcohol, Liquinox®, HCL (preservative)

SECTION 6: ENVIRONMENTAL MONITORING

(1) The following environmental monitoring instruments shall be used on site at the specified intervals for breathing zone monitoring:

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>MONITORING PERIOD</th>
<th>ACTION LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustible Gas Indicator</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>O₂ Meter</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>PID (Lamp 10.6 eV)</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>FID</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>Radiation Meter (Gamma)</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>Respirable Dust Meter</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>GC/ECD/FID</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>GC/FID/PID/DELCD</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
</tbody>
</table>

(4) Monitoring equipment is to be calibrated according to the manufacturers’ instructions daily prior to and after each day of use. Record calibration data and air concentration in the Health and Safety on-site logbook.

(5) Action Levels for work shutdown and excavation. These are average values. Consideration should be given to the potential for release of highly toxic compounds from the waste or from reaction by-products. Levels are for persistence (> 10 min).

| Uncharacterized Airborne Vapors or Gases | >Background |
| Characterized Airborne Gases, Vapor, Particulates | >50% PEL, REL, TLY |
| Oxygen | < 19.5; >23.5 |
| Flammability | > 10% LEL |

(5) Military and/or civilian personnel in charge of buildings adjacent to invasive monitoring activities will be notified via a health and safety kick-off meeting of site activities. A copy of this HASP will be provided. If any action levels are reached at the work area as described above or if discernible odors are released as a result of field activities, the
personnel in charge or their designated representative will be notified immediately. Hourly perimeter monitoring (support zone) will be conducted to assess whether organic vapors or odors are leaving the work area.

SECTION 7: HEALTH AND SAFETY TRAINING/MEDICAL MONITORING PROGRAM

The project staff is included in the Battelle Health and Safety Training and Medical Monitoring Programs in conformance with 29 CFR 1910.R.

HAZWOPER TRAINING

<table>
<thead>
<tr>
<th>NAME</th>
<th>MEDICAL (Date)</th>
<th>INITIAL (Hrs/Date)</th>
<th>REFRESHER (Date)</th>
<th>CPR/FA/ (Dates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jennifer Triplett</td>
<td>40 hours/June 2001</td>
<td>August 7, 2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paul Dahlen</td>
<td>40 hours/Nov 2001</td>
<td>February 2006</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SECTION 8: PERSONAL MONITORING

☐ No personal exposure monitoring or heat/cold stress monitoring will take place on site. If the need for such monitoring is anticipated, this HASP will be modified accordingly.

SECTION 9: CONFINED SPACE ENTRY

☐ No confined space and/or trench entries will take place on site. If the possibility of such entries taking place exists, this HASP will be modified accordingly.

SECTION 10: COMMUNICATION PROCEDURES

The following standard hand signals will be used in case of failure to radio communications in each contaminant reduction zone:

- Hand gripping throat: Can’t Talk, Having difficulty breathing
- Grip partner’s wrist and both hands around wrist: Can’t Talk, Leave area immediately
- Hands on top of head: Need assistance
- Thumbs up: OK, I am all right, I understand
- Thumbs down: No, negative

If applicable, telephone communications to the Command Post Should be Established as soon as possible. The stationary and/or mobile phone number(s) will be available one week prior to the start of field work. The HASP will be amended when these numbers are available.

The command post telephone is

The mobile phone is

SECTION 11: DECONTAMINATION PROCEDURES

Personnel and equipment leaving an exclusion zone shall be thoroughly decontaminated at the decontamination facility constructed at the command post. The SSO is responsible for monitoring adherence with this decontamination plan. A Modified Level D decontamination protocol shall be used with the following decontamination stations:

- Equipment Drop (IF NECESSARY)
- Boot Covers, and Glove Wash and Rinse (IF NECESSARY)
- Outer Boot and Glove Removal (IF NECESSARY)
- Outer Garment Removal (IF NECESSARY)
- Inner Glove Removal (IF NECESSARY)
- Field Hand Wash

The following decontamination equipment is required (check or circle all that apply)

- Decon Pad (Plastic Sheet)
- Dry Brushes
- Detergent Soap
- Trash Cans/Bags
- Wet Brushes
- Other Decontamination Solution
- Buckets
- Water

SECTION 12: EMERGENCY PROCEDURES

On site personnel will use the following standard emergency procedures. The SSO shall be notified of any on site emergencies and be responsible for ensuring that the procedures are followed.

Personal Injury in the Exclusion Zone

DESIGNATED EMERGENCY SIGNAL: Air Horn

Upon notification of an injury in the Exclusion Zone, the designated emergency signal shall be sounded. All site personnel shall assemble at the decontamination line. The SSO or alternate should evaluate the nature of the injury, and the affected person should be decontaminated to the extent possible prior to movement to the Support Zone. The on site CPR/FA personnel shall initiate the appropriate first aid, and contact should be made for an ambulance (and other emergency services as needed) and with the designated medical facility (if required). No persons shall reenter the Exclusion Zone until the cause of the injury or
symptoms is determined.

**Fire/Explosion**

Upon notification of a fire or explosion on site, the designated emergency signal shall be sounded and all site personnel assembled at the decontamination line. The fire department shall be alerted and all personnel moved to a safe distance from the involved area.

**Equipment Failure**

If any other equipment (i.e., air monitoring) on site fails to operate properly, the Field Team Leader and SSO shall be notified and then determine the effect of this failure on continuing operations on site. If the failure affects the safety of personnel or prevents completion of the Work Plan tasks, all personnel shall leave the Exclusion Zone until the situation is evaluated and appropriate actions taken.

Emergency escape routes are designated for use in those situations where egress from the Exclusion Zone cannot occur through the decontamination line.

In all situations, when an on site emergency results in evacuation of the Exclusion Zone, personnel shall not reenter until:

1. The conditions resulting in the emergency have been corrected.
2. The hazards have been reassessed by the SSO.
3. The Site Safety Plan has been reviewed by the SSO and Corporate Health and Safety Manager.

### SECTION 13: SPILL CONTROL PROCEDURES

- No containers of liquid or solids exist on site, and no spill control plan is necessary. If the possibility of such conditions exist on site, this HASP will be modified accordingly.

### SECTION 14: EMERGENCY INFORMATION

**LOCAL RESOURCES**

- **Ambulance (name):** Alameda Hospital  
  **Phone:** 911
- **Hospital (name):** Alameda Hospital  
  **Phone:** 911 or (510) 522-3700
- **Police (local or state):** Alameda City Police  
  **Phone:** 911 or (510) 522-2423
- **Fire (name):** Alameda Fire Department  
  **Phone:** 911 or (510) 337-2100
- **HAZ MAT Responder:** National Response Center, Toxic Chemicals and Oil Spills  
  **Phone:** 911
- **On-Site CPR/FA(s):** Sam Yoon  
  **Phone:** 614-218-0627

* For life-threatening emergencies or emergency trauma care.
  The above hospital is approximately 10 miles from the furthest work area and the ambulance response time is approximately 15 minutes.

** For non-life threatening medical care.
  The above hospital is approximately 30 minutes from the furthest work area. Injured workers will be transported here for non-emergency treatment only.

DIRECTIONS TO NEAREST HOSPITAL – SEE ATTACHED MAP:

**Figure 1.**

**BATTELLE RESOURCES**

- **Manager, Corporate Health and Safety (ETE Division):** Sam Yoon  
  **Site Contact:** Sam Yoon: 614-424-4569

Battelle Security Office  
(614) 424-4444

### SECTION 15: PERSONAL PROTECTIVE EQUIPMENT

- No type of respiratory protection is required on this site. If the possibility of the need for respiratory protection is anticipated, this HASP will be modified accordingly.

<table>
<thead>
<tr>
<th>CLOTHING</th>
<th>GLOVES</th>
<th>BOOTS</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coveralls</td>
<td>Cotton</td>
<td>Safety</td>
<td>Hard Hat</td>
</tr>
<tr>
<td>Tyvek</td>
<td>Leather</td>
<td>Fireman/Hip</td>
<td>Glasses</td>
</tr>
<tr>
<td>Saranex</td>
<td>Nitrile</td>
<td>Neoprene</td>
<td>Goggles</td>
</tr>
<tr>
<td>PE Tyvek</td>
<td>Butyl</td>
<td>Steel Toe</td>
<td>Face Shield</td>
</tr>
<tr>
<td>Other:</td>
<td>Neoprene</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Butyl</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| | PVC | |
| | | |

| | PVA | |
| | | |

| | | Latex |

### SECTION 16: SAFE WORK PRACTICES
THE FOLLOWING PRACTICES MUST BE FOLLOWED BY PERSONNEL ON SITE

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12.</td>
<td>Smoking, eating, chewing gum or tobacco, or drinking are forbidden except in clean or designated areas.</td>
</tr>
<tr>
<td>13.</td>
<td>Ignition of flammable liquids within or through improvised heating devices (e.g., barrels) is forbidden.</td>
</tr>
<tr>
<td>14.</td>
<td>Contact with samples, excavated materials, or other contaminated materials must be minimized.</td>
</tr>
<tr>
<td>15.</td>
<td>Use of contact lenses is prohibited at all times.</td>
</tr>
<tr>
<td>16.</td>
<td>Do not kneel on the ground when collecting samples.</td>
</tr>
<tr>
<td>17.</td>
<td>If drilling equipment is involved, know where the kill switch is.</td>
</tr>
<tr>
<td>18.</td>
<td>All electrical equipment used in outside locations, wet areas, or near water must be plugged into ground fault circuit interrupter (GFCI) protected outlets.</td>
</tr>
<tr>
<td>19.</td>
<td>A “Buddy System” in which another worker is close enough to render immediate aid will be in effect.</td>
</tr>
<tr>
<td>20.</td>
<td>Good housekeeping practices are to be maintained.</td>
</tr>
<tr>
<td>21.</td>
<td>Where the eyes or body may be exposed to corrosive materials, water suitable for quick drenching or flushing shall be available for immediate use.</td>
</tr>
<tr>
<td>22.</td>
<td>In the event of treacherous weather-related working conditions (i.e., thunderstorm, limited visibility, extreme cold or heat) the field task will be suspended until conditions improve or appropriate protection from the elements is provided.</td>
</tr>
</tbody>
</table>

SECTION 17: EMPLOYEE ACKNOWLEDGMENTS

<table>
<thead>
<tr>
<th>PLAN REVIEWED BY:</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>H&amp;S Manager:</td>
<td></td>
</tr>
<tr>
<td>Project Leader:</td>
<td></td>
</tr>
<tr>
<td>Site Safety Officer:</td>
<td></td>
</tr>
</tbody>
</table>

I acknowledge that I have read the information in this HASP form and the attached MSDSs. I understand the site hazards as described and agree to comply with the contents of the plan.

<table>
<thead>
<tr>
<th>FIELD PERSONNEL (Print Name)</th>
<th>SIGNATURE</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VISITOR (Print Name)</th>
<th>SIGNATURE</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organization/Agency</th>
<th></th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Organization/Agency</th>
<th></th>
<th></th>
</tr>
</thead>
</table>
Figure 1. Directions to Alameda Hospital
Draft Final

Data Analysis Report
NAS Alameda – Site 5

Critical Evaluation of the State of
In Situ Thermal Treatment Technologies
for DNAPL Source Zone Treatment

Prepared for:

Environmental Security Technology Certification Program
Arlington, VA

Prepared by:
Arizona State University
Battelle Memorial Institute

August 2006
The vendors and products, including the equipment, system components, and other materials identified in this report, are primarily for information purposes only. Although some of these vendors and products may have been used in the past, mention in this report does not constitute a recommendation for using these vendors or products.
Appendix D

Contents

Figures.............................................................................................................................................. 73
Tables.................................................................................................................................................. 73
Acronyms and Abbreviations ........................................................................................................... 75

1. Introduction...................................................................................................................................... 76
2. Field Investigation .......................................................................................................................... 76
3. References....................................................................................................................................... 79

Figures

FIGURE 1. SITE MAP
FIGURE 2. DIRECT-PUSH LOCATIONS
FIGURE 3. HYDRAULIC CONDUCTIVITY MEASUREMENT LOCATIONS
FIGURE 4. MONITORING WELL DEPTH-TO-WATER MEASUREMENTS AND GROUNDWATER
   SAMPLING LOCATIONS
FIGURE 5. CROSS-SECTION OF DIRECT PUSH SAMPLING LOCATIONS
FIGURE 6. VINYL CHLORIDE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 7. 1,1-DICHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 8. TRANS-1,2-DICHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 9. 1,1-DICHLOROETHANE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 10. CIS-1,2-DICHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 11. 1,1,2-TRICHLOROETHANE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 12. TRICHLOROETHYLENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 13. HYDRAULIC CONDUCTIVITY TEST DATA (CM/S) OVERLAIN ON TRICHLOROETHYLENE
   CONTOUR PLOT
FIGURE 14. 1,1-DICHLOROETHANE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 15. MASS FLUX TOOLKIT INPUTS

Tables

TABLE 1. GEOLOGIC DESCRIPTIONS OF CONTINUOUS SOIL CORES (JUNE 2006)
TABLE 2. SAMPLING LOCATIONS AND TYPES OF TEST PERFORMED (JUNE 2006)
TABLE 3. SLUG TEST RESULTS (JUNE 2006)
TABLE 4. DEPTH-TO-GROUNDWATER AND GROUNDWATER ELEVATIONS FOR MONITORING WELLS
   (JUNE 2006)
TABLE 5. WATER QUALITY DATA FOR MONITORING WELLS (JUNE 2006)
TABLE 6. CHEMICAL CONCENTRATION DATA FOR MONITORING WELLS (JUNE 2006)
TABLE 7. CHEMICAL CONCENTRATION DATA FOR DIRECT-PUSH DOWNGRADIENT TRANSECT LOCATIONS (JUNE 2006)
TABLE 8. FIELD DATA AND RESULTS FOR CONSTANT DRAWDOWN AQUIFER TESTING IN DIRECT-PUSH DOWNGRADIENT TRANSECT LOCATIONS (JUNE 2006)
TABLE 9. MONITORING WELL CHEMICAL CONCENTRATION DATA COMPARISON
**Acronyms and Abbreviations**

- **bgs** below ground surface
- **cis-1,2-DCE** cis-1,2-dichloroethene
- **DELCD** dry electrolytic conductivity detector
- **DO** dissolved oxygen
- **EC** electrical conductivity
- **ERH** electrical resistance heating
- **ESTCP** Environmental Security Technology Certification Program
- **FID** flame-ionization detector
- **ft** feet
- **GC** gas chromatography
- **kg** kilogram
- **NAPL** non-aqueous phase liquid
- **ORP** oxidation reduction potential
- **PID** photo-ionization detector
- **temp** temperature
- **TCE** trichloroethylene
- **VOA** volatile organic analysis
- **yr** year
1. Introduction

The post treatment field investigation of NAS Alameda under the Environmental Security Technology Certification Program (ESTCP) project CU-0314, *Critical Evaluation of State of the In-Situ Thermal Treatment Technologies*, was performed June 1 through June 9, 2006. Figure 1 identifies the extent of the previous electrical resistance heating (ERH) remediation area, which was also the specific area of interest for this particular field investigation.

Consistent with the objectives set forth under the CU-0314 Demonstration Plan, the field investigation at this site included the following:

- Verification of the site hydrogeological conceptual model
- Groundwater sampling of monitoring wells
- Depth-discrete analysis of hydraulic conductivity and dissolved petroleum hydrocarbons at temporary sampling locations downgradient of the treatment zone.

2. Field Investigation

In accordance with the approved generic demonstration plan for this project, the following site-specific activities were conducted:

1) Verification of the site hydrogeological conceptual model:

   a. For confirmation of geology, two continuous soil cores was collected at direct-push sampling locations GP10 and GP11 shown in Figure 2. The continuous soil cores/direct-push sampling locations were located at the down-gradient edge of the treatment zone. Table 1 presents qualitative geologic descriptions from visual observations of the continuous soil core.

   b. Hydraulic conductivity slug testing was conducted in 11 monitoring wells as identified in Table 2 and in Figure 3. The slug test data were analyzed using both the Hvorslev and the Bouwer and Rice Methods; results are presented in Table 3. The Hvorslev’ expression for determining hydraulic conductivity from slug test data is:

   \[
   K = \frac{r^2 \ln(L_e/R)}{2L_e t_{37}}
   \]

   Where
   - \( K \) = hydraulic conductivity (L/T)
   - \( r \) = radius of well casing (L) (0.083 ft)
   - \( R \) = radius of well screen (L) (0.50 ft)
   - \( L_e \) = length of well screen (L) (5 or 10 ft)
   - \( t_{37} \) = time for water level to rise or fall 37% of the initial change (T) (from data set)

   (Fetter, 2000).
The Bouwer and Rice expression for determining hydraulic conductivity from slug test data is:

$$K = \left( r_c^2 \ln\left( \frac{R_e}{R} \right) / (2L_e) \right) * \left( \frac{1}{t} \ln\left( \frac{H_o}{H_t} \right) \right)$$

Where
- \( K \) = hydraulic conductivity (L/T)
- \( r_c \) = radius of well casing (L) (0.083 ft)
- \( R \) = radius of gravel envelope (L) (0.50 ft)
- \( R_e \) = effective radial distance over which head is dissipated (L) (from data set)
- \( L_e \) = length of well screen (L) (5 or 10 ft)
- \( H_o \) = drawdown at \( t=0 \) (L) (from data set)
- \( H_t \) = drawdown at \( t=t \) (L) (from data set)
- \( t \) = time since \( H = H_o \) (T) (from data set)

(Fetter, 2000).

c. Depth-to-groundwater was measured in the 15 groundwater monitoring wells identified in Table 2 and in Figure 4. Depth-to-water measurements and groundwater elevations are summarized in Table 4.

2) Collection of water quality samples from 11 groundwater monitoring wells within the treatment zone for analysis of dissolved chlorinated hydrocarbon groundwater concentrations:

a. Table 2 identifies the groundwater monitoring wells from which samples were collected. Prior to sample collection, three well-volumes were purged. Groundwater was then collected for analysis of field parameters and stored in volatile organic analysis (VOA) vials for analysis of dissolved chlorinated hydrocarbon concentrations. General water quality field parameters including pH, electrical conductivity (EC), temperature, dissolved oxygen (DO), and oxidation reduction potential (ORP) were measured using an Horiba U-22 meter. Petroleum hydrocarbon analysis was performed on-site by heated-headspace analysis and gas chromatography (GC) using a dry electrolytic conductivity detector (DELC), photo-ionization detector (PID) and a flame-ionization detector (FID). General water quality data for permanent groundwater monitoring well installations can be found in Table 5 and chemical concentration data can be found in Table 6. All non-detect samples are listed as less than the detection limit.

3) Depth-discrete hydraulic conductivity and dissolved chlorinated hydrocarbon concentration data were collected on three foot intervals as possible from 6.5 ft below ground surface (bgs) to 21 ft bgs at all seven direct-push sampling locations.
a. Groundwater quality data were collected from depth-specific intervals at all direct-push sampling locations (See Table 2 and Figure 2). Sampling locations were spaced on approximately 15 ft centers, as possible, along a transect downgradient of the source zone and perpendicular to the direction of groundwater flow. Figure 2 presents the direct-push sampling locations. Using percussion assisted direct-push technology and a modified Geoprobe Groundwater Profiler, groundwater samples were collected using a peristaltic pump on 3-ft intervals from 6.5 ft bgs to 21 ft bgs. The location of the depth-discrete groundwater samples are shown in Figure 5. Dissolved chlorinated hydrocarbon concentration analysis was conducted, as described above, and the results are summarized in Table 7.

Aquifer specific-capacity tests were conducted at depth-specific intervals at direct push sampling locations GP1 through GP6 and GP8 as indicated in Table 2. Specific-capacity tests involve the measurement of the flow rate achieved under fixed drawdown and are analyzed using the Theim Equation to estimate hydraulic conductivity. The field data and results for aquifer testing are shown in Table 9. The Theim equation for hydraulic conductivity is:

$$T = \frac{Q}{(2(h_2-h_1))}\ln(r_2/r_1)$$

Where  
$T$ = transmissivity (L$^2$/T)  
$Q$ = pumping rate (L$^3$/T)  
$h_1$ = head at distance $r_1$ from the pumping well (L)  
$h_2$ = head at distance $r_2$ from the pumping well (L)  

and $K = T/b$

Where  
$K$ = hydraulic conductivity (L/T)  
$b$ = length of sampler or screen section (L) (0.5 ft or length of screen)

(Fetter, 2000).

The monitoring well chemical concentration data collected in June 2006 by the ASU/Battelle team were compared to the previous monitoring well chemical concentration data available for the site (March 2005). The analytical results for each are shown in Table 10.

Figures 6 to 13 present contour plots of the chemical concentrations for eight of the ten chemicals measured at the depth-discrete direct push sampling locations. Two of chemicals, 1,1,2-Trichloroethane (TCA) and tetrachloroethene (PCE), were not contoured because all groundwater samples were non-detect (less than detection limit of 1 ug/L). Figure 14 presents the specific capacity pump test results for each discrete-depth direct push sampling interval overlaid on the trichloroethylene (TCE) concentration plot.
A TCE mass flux calculation was performed using the Mass Flux Toolkit, Version 1.0. The gradient was calculated using Devlin (2003) and the three wells with the greatest lateral separation with ASU depth to water measurements and grade elevations from previous work at NAS Alameda (grade elevations were not available for all monitoring wells). This program is a freeware program developed by Groundwater Services, Inc. and others under a contract funded by the Environmental Security Technology Certification Program (ESTCP). Figure 15 is a snapshot of the input screen with TCE being used to perform the mass flux analysis. A linear spatial and vertical interpolation of the data was used for the mass flux analysis. The TCE mass flux was estimated to be 2.56E-02 kg/yr.

3. References


Figures
Figure 1. Site Map

Source: Shaw (2006)
Figure 2. Direct-Push Locations

Source: Shaw (2006)
Figure 3. Hydraulic Conductivity Measurement Locations

Source: Shaw (2006)
Figure 4. Monitoring Well Depth-to-Water Measurement and Groundwater Sampling Locations

Source: Shaw (2006)
Figure 5. Cross-section of Direct Push Sampling Locations
Figure 6. Vinyl Chloride Direct-Push Groundwater Concentrations (μg/L)
Figure 7. 1,1-Dichloroethene Direct-Push Groundwater Concentrations (μg/L)
Figure 8. trans-1,2-Dichloroethene Direct-Push Groundwater Concentrations (μg/L)
Figure 9. 1,1-Dichloroethane Direct-Push Groundwater Concentrations (μg/L)
Figure 10. cis-1,2-Dichloroethene Direct-Push Groundwater Concentrations (μg/L)
Figure 11. 1,2-Dichloroethane Direct-Push Groundwater Concentrations (µg/L)
Figure 12. 1,1,2-Trichloroethane Direct-Push Groundwater Concentrations (μg/L)
Figure 13. Trichloroethylene Direct-Push Groundwater Concentrations (μg/L)
Figure 14. Hydraulic Conductivity Test Data (cm/s) Overlain on Trichloroethylene Contour Plot
Input Data and Grid

4. CHOOSE TRANSECT
   Transect 1

5. CHOOSE TIME PERIOD
   1

6. ENTER TRANSECT DATA
   6.1 Distance of Transect 1 from Source
   6.2 Darcy Velocity
   6.3 Hydraulic Conductivity Units
   6.4 Uniform Hydraulic Conductivity?
   6.5 Uniform Hydraulic Gradient?
   6.6 Sampling Interval
   6.7 Mid Point of Sampling Interval

<table>
<thead>
<tr>
<th>Monitoring Point</th>
<th>Distance of Monitoring Point from Start of Transect (ft)</th>
<th>Sampling Interval (ft bgs)</th>
<th>Plume Top (ft bgs)</th>
<th>Plume Bottom (ft bgs)</th>
<th>Hydraulic Conductivity (ft/d)</th>
<th>Hydraulic Gradient (ft/ft)</th>
<th>Concentration (mg/L)</th>
</tr>
</thead>
<tbody>
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<td>Top Bottom</td>
<td>Top Bottom</td>
<td>Top Bottom</td>
<td>Top Bottom</td>
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<td>5 7 7.5 6.51 22 19 0.04557 8</td>
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</table>

7. CHOOSE GRID (OPTIONAL)
   Number of rows: 10
   Number of columns: 9

8. SELECT CONSTITUENT FOR CALCULATIONS
   TCE
   Constituent B

Figure 15. Mass Flux Toolkit Inputs
Tables
Table 1. Geologic Descriptions of Continuous Soil Cores (June 2006)

<table>
<thead>
<tr>
<th>Boring Depth (ft)</th>
<th>Subsurface Features</th>
</tr>
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<tr>
<td><strong>Continuous Soil Core GP 10</strong></td>
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<tr>
<td>0-1</td>
<td>Sands and gravels</td>
</tr>
<tr>
<td>1-2</td>
<td>Sands</td>
</tr>
<tr>
<td>2-3</td>
<td>Fine sands</td>
</tr>
<tr>
<td>3-4</td>
<td>Fine sands</td>
</tr>
<tr>
<td>4-5</td>
<td>Gravelly sands with some silt</td>
</tr>
<tr>
<td>5-6</td>
<td>Medium to course sand with some gravel</td>
</tr>
<tr>
<td>6-7</td>
<td>Fine sands</td>
</tr>
<tr>
<td>7-8</td>
<td>Fine sands</td>
</tr>
<tr>
<td>8-9</td>
<td>Fine sands</td>
</tr>
<tr>
<td>9-10</td>
<td>Silty fine sands</td>
</tr>
<tr>
<td>10-11</td>
<td>Fine sands</td>
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<td>11-12</td>
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<tr>
<td>13-14</td>
<td>Fine sands</td>
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<tr>
<td>14-15</td>
<td>Fine sands with some silt</td>
</tr>
<tr>
<td>15-16</td>
<td>Silty clay</td>
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<tr>
<td>16-17</td>
<td>Silty clay</td>
</tr>
<tr>
<td>17-18</td>
<td>Silty clay</td>
</tr>
<tr>
<td>18-19</td>
<td>Transition from silty clay to fine sands</td>
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<tr>
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<td>Fine sands</td>
</tr>
<tr>
<td>20-21</td>
<td>Silty fine sands with some clay</td>
</tr>
<tr>
<td>21-22</td>
<td>Clay</td>
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Table 2. Sampling Locations and Types of Test Performed (June 2006)

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<th>Physical Assessment</th>
<th>Water Quality Assessment</th>
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<td>Yes</td>
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<td>MW2I</td>
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<td>MW2D</td>
<td>Yes</td>
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<tr>
<td>MW3I</td>
<td>Yes</td>
<td></td>
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<tr>
<td>MW3D</td>
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<td>Yes</td>
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<tr>
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<td>Yes</td>
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<tr>
<td>MW4D</td>
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<tr>
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<td>Yes</td>
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<td>Yes</td>
</tr>
<tr>
<td>MW6S</td>
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<td>Yes</td>
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<td>MW7S</td>
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<td>Yes</td>
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<td>GP6&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>GP8&lt;sup&gt;a&lt;/sup&gt;</td>
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<sup>a</sup> Water quality assessments and constant drawdown tests at direct-push locations were performed on 3-ft intervals from the phreatic surface (~6' bgs) to 21-22’ bgs.

<sup>b</sup> Field parameters include: pH, electrical conductivity, temperature, dissolved oxygen, and oxidation reduction potential.
Table 3. Slug Test Results (June 2006)

<table>
<thead>
<tr>
<th>Monitoring Well</th>
<th>Well Screen (ft)</th>
<th>Hvorslev K (cm/s)</th>
<th>Hvorslev K (ft/d)</th>
<th>Bouwer and Rice K (cm/s)</th>
<th>Bouwer and Rice K (ft/d)</th>
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<tr>
<td>MW1S</td>
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<td>4.43E-03</td>
<td>12.56</td>
<td>8.27E-04</td>
<td>2.35</td>
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<td>6.20E-04</td>
<td>1.76</td>
<td>6.12E-04</td>
<td>1.73</td>
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<tr>
<td>MW2S</td>
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<td>4.43E-03</td>
<td>12.56</td>
<td>2.19E-03</td>
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<td>6.20E-04</td>
<td>1.76</td>
<td>4.12E-04</td>
<td>1.17</td>
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<td>1.53E-03</td>
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<td>8.12E-03</td>
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Table 4. Depth-to-Groundwater and Groundwater Elevations for Monitoring Wells (June 2006)

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<tr>
<th>Monitoring Well</th>
<th>Grade* (m)</th>
<th>Grade* (ft)</th>
<th>DTW (m BTOC)</th>
<th>DTW (ft BTOC)</th>
<th>DTW (m BGS)</th>
<th>DTW (ft BGS)</th>
<th>Groundwater Elevation* (m)</th>
<th>Groundwater Elevation* (ft)</th>
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<td>10.88</td>
<td>1.61</td>
<td>5.28</td>
<td>1.86</td>
<td>6.11</td>
<td>1.45</td>
<td>4.77</td>
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<td>5.66</td>
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<td>6.61</td>
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<td>1.91</td>
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<td>1.99</td>
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<td>1.09</td>
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<td>1.85</td>
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<td>1.07</td>
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DTW - Depth-to-water  
BTOC - Below top of casing  
BGS - Below ground surface
Table 5. Water Quality Data for Monitoring Wells (June 2006)

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<tr>
<th>Monitoring Well</th>
<th>Water Quality Data&lt;sup&gt;a&lt;/sup&gt;</th>
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<sup>a</sup> All measurements were made with a Horiba U-22 meter.
EC = electrical conductivity
DO = dissolved oxygen
ORP = oxidation-reduction potential
### Table 6. Chemical Concentration Data for Monitoring Wells (June 2006)

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<th>cis-1,2-DCE</th>
<th>1,2-DCA</th>
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DUP - Duplicate sample  
REP - Quality control sample (second analysis of same water sample)  
VC - Vinyl chloride  
DCE - Dichloroethene  
DCA - Dichloroethane  
TCA - Trichloroethane  
TCE - Trichloroethene  
PCE - Tetrachloroethene  
ND – non detect at the limit of 1 ug/L
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Table 7. Chemical Concentration Data for Direct-Push Downgradient Transect Locations (June 2006)
Table 7. Chemical Concentration Data for Direct-Push Downgradient Transect Locations (Continued)

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</table>

DUP - Duplicate sample  
REP - Quality control sample (second analysis of same water sample)  
VC - Vinyl chloride  
DCE - Dichloroethene  
DCA - Dichloroethane  
TCA - Trichloroethane  
TCE - Trichloroethene  
PCE - Tetrachloroethene  
ND – non detect at the limit of 1 ug/L
Table 8. Field Data And Results for Constant Drawdown Aquifer Testing in Direct-push
Downgradient Transect Locations (June 2006)
Sampling
Location*

Volume
Drawdown (ΔH)
purged
(ft BSWS**)
(ml)

Time
(min)

Time
(sec)

Total
Time
(sec)

Q (ft3/s)

Q/ΔH (ft3/ft/s)

K (cm/sec)

K (ft/d)

GP 1-7

0.25

105

2

0

120

3.1E-05

1.2E-04

6.8E-03

1.9E+01

GP 1-10

2

215

1

30

90

8.4E-05

4.2E-05

2.3E-03

6.6E+00

GP 1-13

3

150

1

30

90

5.9E-05

2.0E-05

1.1E-03

3.1E+00

GP 1-16

3

10

5

0

300

1.2E-06

3.9E-07

2.2E-05

6.1E-02

GP 1-19

3

75

2

0

120

2.2E-05

7.4E-06

4.0E-04

1.1E+00

GP 1-21

3

50

3

0

180

9.8E-06

3.3E-06

1.8E-04

5.1E-01

GP 2-7

0.75

200

1

30

90

7.8E-05

1.0E-04

5.7E-03

1.6E+01

GP 2-10

1

45

3

0

180

8.8E-06

8.8E-06

4.9E-04

1.4E+00

GP 2-13

3

195

0

30

30

2.3E-04

7.7E-05

4.2E-03

1.2E+01

GP 2-17

3

50

3

0

180

9.8E-06

3.3E-06

1.8E-04

5.1E-01

GP 2-19

3

275

1

0

60

1.6E-04

5.4E-05

3.0E-03

8.4E+00

GP 2-21

3

45

5

0

300

5.3E-06

1.8E-06

9.7E-05

2.7E-01

GP 3-6.5

0.33

115

2

0

120

3.4E-05

1.0E-04

5.6E-03

1.6E+01

GP 3-9.5

2

210

1

0

60

1.2E-04

6.2E-05

3.4E-03

9.6E+00

GP 3-12.5

3

140

3

0

180

2.7E-05

9.2E-06

5.0E-04

1.4E+00

GP 3-15.5

3

115

2

0

120

3.4E-05

1.1E-05

6.2E-04

1.8E+00

GP 3-20.5

3

25

3

0

180

4.9E-06

1.6E-06

9.0E-05

2.5E-01

GP 4-6.5

0.33

105

2

0

120

3.1E-05

9.4E-05

5.1E-03

1.5E+01

GP 4-9.5

2

140

1

30

90

5.5E-05

2.7E-05

1.5E-03

4.3E+00

GP 4-12.5

3

220

1

30

90

8.6E-05

2.9E-05

1.6E-03

4.5E+00

GP 4-15.5

10

150

2

0

120

4.4E-05

4.4E-06

2.4E-04

6.9E-01

GP 4-18.5

3

135

2

0

120

4.0E-05

1.3E-05

7.3E-04

2.1E+00

GP 4-20.5

3

50

3

0

180

9.8E-06

3.3E-06

1.8E-04

5.1E-01

GP 5-6.5

0.33

100

3

0

180

2.0E-05

5.9E-05

3.3E-03

9.3E+00

GP 5-9.5

2

170

1

30

90

6.7E-05

3.3E-05

1.8E-03

5.2E+00

GP 5-12.5

3

105

3

0

180

2.1E-05

6.9E-06

3.8E-04

1.1E+00

GP 5-15.5

3

145

3

0

180

2.8E-05

9.5E-06

5.2E-04

1.5E+00

GP 5-18.5

3

215

1

30

90

8.4E-05

2.8E-05

1.5E-03

4.4E+00

GP 5-21.5

3

65

5

0

300

7.7E-06

2.6E-06

1.4E-04

4.0E-01

GP 6-6.5

0.33

170

1

0

60

1.0E-04

3.0E-04

1.7E-02

4.7E+01

GP 6-10.5

0.67

10

3

0

180

2.0E-06

2.9E-06

1.6E-04

4.6E-01

GP 6-12.5

3

195

1

30

90

7.7E-05

2.6E-05

1.4E-03

4.0E+00

GP 6-18.5

3

230

1

0

60

1.4E-04

4.5E-05

2.5E-03

7.0E+00

GP 6-20.5

2

55

5

0

300

6.5E-06

3.2E-06

1.8E-04

5.0E-01

0.583

120

1

30

90

4.7E-05

8.1E-05

4.4E-03

1.3E+01

2

70

2

0

120

2.1E-05

1.0E-05

5.7E-04

1.6E+00

GP 8-12.5

3

305

0

30

30

3.6E-04

1.2E-04

6.6E-03

1.9E+01

GP 8-18.5

3.25

60

3

0

180

1.2E-05

3.6E-06

2.0E-04

5.6E-01

GP 8-20.5

3

95

3

0

180

1.9E-05

6.2E-06

3.4E-04

9.7E-01

GP 8-7
GP 8-9.5

* See Figure 2
** BSWS – Below estimated static water surface

ER-0314

105


### Table 9. Monitoring Well Chemical Concentration Data Comparison

<table>
<thead>
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<th>Sample Locations</th>
<th>Vinyl Chloride</th>
<th>1,1-DCE</th>
<th>trans-1,2-DCE</th>
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<th>cis-1,2-DCE</th>
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<td>16</td>
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<td>NP</td>
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</table>

Dup – Duplicate Sample, REP – Quality Control Sample (second analysis of same sample), ND – Non-Detect (detection limit not available); DCE - Dichloroethene; DCA - Dichloroethane; TCA - Trichloroethane; TCE - Trichloroethylene; PCE - Tetrachloroethylene
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Dup – Duplicate Sample, REP – Quality Control Sample (second analysis of same sample), ND – Non-Detect (detection limit not available); DCE - Dichloroethene; DCA - Dichloroethane; TCA - Trichloroethane; TCE - Trichloroethylene; PCE - Tetrachloroethene
Draft

Site Specific Work Plan
Air Force Plant 4 – Building 181

Critical Evaluation of the State of
In Situ Thermal Treatment Technologies
for DNAPL Source Zone Treatment

Prepared for:

Environmental Security Technology Certification Program
Arlington, VA

Prepared by:
Arizona State University
Battelle
1.0 Introduction

Air Force Plant 4 (AFP 4) is located in Tarrant County, Texas, seven miles northwest of the City of Fort Worth. The plant is bounded by Lake Worth on the north, Naval Air Station Fort Worth (NASFW), formerly Carswell AFB to the east, the community of White Settlement on the south and west, and the City of Fort Worth on the west. The facility occupies 602 acres. The Air Force, based out of Wright Patterson AFB Ohio, is the owner of the facility, built in 1941 as part of the World War II needs for aircraft production. The mile long structure currently is operated by Lockheed Martin Aeronautics Company, where the F-16 is in production, parts of the F-22 are built, and the future home of the Joint Strike Fighter (and various other programs). Past management of waste oil, solvents, and fuels generated during the manufacturing operations have resulted in multiple separate sites of investigation, including landfills, fire training areas, underground storage tanks, and other areas.

The Air Force Installation Restoration Program (IRP) efforts began in 1983 with the Preliminary Assessment/Site Investigation. AFP 4 was placed on the National Priorities List in August of 1990. In 1995, the Final Remedial Investigation was approved and in 1996 the Record of Decision (ROD) was signed by the Environmental Protection Agency (EPA) Region VI and the Texas Natural Resources Conservation Commission (TNRCC).

The primary contaminant at AFP 4 in Building 181 is trichloroethylene (TCE) and is associated with the EPL groundwater plume. TCE source is believed to be degreaser tanks in Building 181 which have since been removed. In May 1991, a TCE vapor degreaser tank (T-534) was discovered to be leaking and an estimated 20,000 gallons of TCE was released.

Several subsequent investigations found that releases of TCE had migrated through cracks in the concrete building floor resulting in contamination in the unsaturated zone, including Terrace Alluvium and overlying fill dirt under Building 181. The contaminated unsaturated zone beneath Building 181 was thought to be a source of contamination to Terrace Alluvial groundwater. A pilot scale six phase heating (SPH) application was performed completed in the winter of 2001. Based on the results of the pilot, a full-scale SPH application was performed in Building 181 in 2002.

The conceptual subsurface model for AFP4 includes two geologic units. Tertiary age Terrace Alluvium is exposed at ground surface, or lies beneath fill material that is generally comprised of the same Terrace Alluvium. Beneath the Terrace Alluvium lie weathered and competent bedrock consisting of Cretaceous age Goodland Limestone Formation and Walnut Clay Formation, undifferentiated at the site. Drilling logs from Building 181 record the presence of weathered limestone layers at 15 to 20 ft below ground surface (bgs) in the western portion of the site, and at 30 to 35 ft bgs in the east portion of the site. In the SPH coverage area, an approximately 5-ft thick fill layer underlies the building floor and competent bedrock is at 30 to 35 ft bgs.

The SPH application targeted an interval which included the Terrace Alluvium and weathered bedrock to a depth of approximately 35 ft bgs. The depth to groundwater is approximately 25 ft bgs during the SPH application with an east-northeast hydraulic gradient of 0.008 ft/ft with a corresponding hydraulic conductivity between 13 and 132 ft/day.
2.0 System Description

Installation for the full-scale SPH system began in 2002. The system consisted of 73 electrodes installed to a depth of 32 ft bgs, including 7 electrodes from the pilot-scale test and 2 electrodes installed during operation to enhance heat generation in target areas. The total treatment area was approximately 22,000 square feet (Figure 1).

Additionally, a monitoring network of 12 wells was used during the treatment, including five pre-existing wells and 7 newly installed monitoring wells. Table 1 shows the screened intervals of the wells along with their diameter.

The full-scale system was brought on-line in May 2002 and was operated until December 2002. The remedial system performance was continuously monitored during operation, and an estimated 1,417 pounds of TCE was removed via steam and vapor extraction systems.

The available documentation for AFP4 suggests that it is a good site for further investigation because:
- The hydrogeology of the site is reasonably well-characterized
- The aerial extent of the source zone was reasonably defined prior to treatment
- Full treatment of a source zone was performed
- The total depth of impacted groundwater is about 30 feet
- There is access to sampling locations immediately down-gradient of the remediated source zone
- The system employed at this site represents a state-of-the-art ERH system
- Pre- and post-treatment groundwater data are available
- Direct-push technologies can be used for sampling
- The monitoring well network is still present and accessible

3.0 Current Investigations

Consistent with the already-approved generic demonstration plan for this project, the following site-specific activities are proposed:

(3) Verification of the site geological conceptual model before any new investigative work by:
  a. Measurement of depths to groundwater in nearby wells (to determine depth to groundwater, flow direction, and hydraulic gradient). See Table 1 for monitoring well details and Figure 1 for measurement locations.
  b. Collection of one continuous soil core at the down-gradient edge of the treated source zone (to qualitatively confirm the site geology and to identify depths for subsequent groundwater vertical profile sampling). One or two additional cores will be collected if time permits. See Figure 1 for sampling location.
  c. Slug tests conducted in existing groundwater monitoring wells in the area to get estimates of hydraulic conductivity over the screened intervals for those wells (to help identify if any zones are more conductive than others). See Table 1 for details on the monitoring wells and Figure 1 for measurement location.
(4) Collection of data necessary to determine groundwater concentrations and fluxes leaving the treated source zone:
   a. Groundwater samples collected from existing groundwater monitoring wells with available historical data. See Table 1 for details on the monitoring wells and Figure 1 for their locations. These locations may be adjusted with new information on monitoring well conditions and locations.
   b. Groundwater samples will be collected using direct-push tools along a transect perpendicular to the direction of groundwater flow at the down-gradient edge of the original source zone. See Figure 2 for groundwater sampling locations. Sampling locations will be approximately 20 feet apart, and at each location samples will be collected, as possible, on approximately 2 feet centers down to a maximum depth of 40 ft (and at least once in each distinct lithologic change suggested by the soil core). The samples will be analyzed via a headspace analysis on a gas chromatograph (GC) equipped with dry electrolytic conductivity detector (DELCD), photo-ionization detector (PID), and flame-ionization (FID) detectors. Analytes may include any or all of the following: trichloroethene, tetrachloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,1-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, and vinyl chloride. If time permits, samples will be collected at additional locations as well. The specific depths and numbers of samples collected at each location may be adjusted depending on the analytical results in the field.
   c. Aquifer specific-capacity tests will be conducted at each depth where a groundwater sample is collected. These tests will be conducted using the direct-push groundwater sampler and will involve the measurement of the steady flow rate achieved with a fixed drawdown; ideally, all tests will be conducted with the same fixed drawdown (usually 0.3 – 1.0 feet).
Table 1

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<td>28-34</td>
<td>2</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MW-13</td>
<td>30-36</td>
<td>2</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MW-14</td>
<td>29.5-35.5</td>
<td>2</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>WJETA062</td>
<td>24.9-29.9</td>
<td>4</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>WJETA065</td>
<td>24.9-29.9</td>
<td>4</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WJETA066</td>
<td>24.7-30.2</td>
<td>4</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WJETA067</td>
<td>25.5-30.5</td>
<td>4</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>MW-2</td>
<td>--</td>
<td>2</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>MW-3</td>
<td>--</td>
<td>2</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>MW-4</td>
<td>--</td>
<td>2</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MW-6</td>
<td>--</td>
<td>2</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WJET058</td>
<td>24.9-29.9</td>
<td>4</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WJET059</td>
<td>24.15-28.65</td>
<td>4</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WJET060</td>
<td>25.05-30.05</td>
<td>4</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WJET061</td>
<td>25.2-29.7</td>
<td>4</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WJET063</td>
<td>23.1-28.1</td>
<td>4</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WJET064</td>
<td>24.1-29.1</td>
<td>4</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

Note: -- Screened interval is unknown
Figure 1
Health and Safety Plan (HASP)
Air Force Plant 4 – Building 181
### SECTION 1: GENERAL INFORMATION AND DISCLAIMER

**CLIENT NAME:** Environmental Security Technology Certification Program (ESTCP)  
**PROJECT NAME:** ESTCP Thermal Evaluation  
**PRINCIPAL INVESTIGATORS:** Eric Foote (Battelle) and Paul Johnson (Arizona State University)  
**PROJECT LEADER:** Paul Dahlen  
**PREPARED BY:** Sam Yoon  
**DATE:** 10/09/2006

**NOTE:** This Site Specific Health and Safety Plan - (HASP) has been prepared for use by Battelle employees for work at this site. Battelle is not responsible for its use by others. The plan is written for the specific LEVEL D site conditions, purposes, tasks, dates and personnel specified. If these conditions change, a new plan must be utilized and reviewed by those named in Section 17.

Subcontractors shall be solely responsible for the health and safety of their employees and shall comply with all applicable laws and regulations. In accordance with 1910.120(b)(1)(iv) and (v), Battelle will inform subcontractors of the site emergency response procedures, and any potential fire, explosion, health, safety or other hazards by making this Site Specific Safety and Health Plan and site information obtained by others available during regular business hours. All contractors and subcontractors are responsible for: (1) developing their own Health and Safety Plan including a written Hazard Communication Program and any other written hazard specific programs required by federal, state and local laws and regulations; (2) providing their own personal protective equipment (PPE); (3) providing documentation that their employees have been health and safety trained in accordance with applicable federal, state and local laws and regulations; (4) providing evidence of medical surveillance and medical approvals for their employees; and (5) designating their own site safety officer (SSO) responsible for ensuring that their employees comply with their own Health and Safety Plan and taking any other additional measures required by their site activities.

### SECTION 2: PROJECT INFORMATION

**SITE INFORMATION**

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Site Project Contact</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERH Test Site at AF Plant 4</td>
<td>Richard Wice</td>
<td>412-858-3309</td>
</tr>
<tr>
<td>Address</td>
<td>Phone Number</td>
<td>Contact</td>
</tr>
<tr>
<td>Building 181</td>
<td>Site Safety &amp; Health</td>
<td>Shane Williams</td>
</tr>
<tr>
<td>Air Force Plant 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fort Worth, TX 76108</td>
<td>Phone Number</td>
<td>O: 614-424-5792/ C: 614-348-4437</td>
</tr>
</tbody>
</table>

**SITE CLASSIFICATION**

- [ ] Hazardous (RCRA/CERCLA/State)  
- [ ] Construction  
- [ ] Landfill (Non-Hazardous)  
- [ ] UST/LUST  
- [ ] Manufacturing  
- [X] Active  
- [X] Inactive  
- [ ] Other: military installation

**ENTRY OBJECTIVES**

- [X] Site Inspection (General)  
- [X] Well Drilling Observation  
- [ ] Sampling, Air  
- [X] Sampling, Water  
- [ ] Sampling, Soil  
- [ ] Other: 

**DATE(S) OF FIELD VISIT(S):**

- 

**BATTELLE/ASU TASKS**

- Groundwater Investigation  
  - Direct push activities for gw sample collection  
- Groundwater sampling  
- Water level survey and slug tests  
- Analytical activities

**TASK PERFORMED BY OTHERS**

- Direct push activities for gw sample collection  
- IDW disposal  
- Other:

**PROJECT ORGANIZATION AND COORDINATION**

The following personnel are designated to carry out the stated project job functions on site. (Note: One person may carry out more than one job function.)

**PRINCIPAL INVESTIGATORS**

- Eric Foote/Paul Johnson

**SITE SAFETY OFFICER**

- Shane Williams
ON SITE CONTROL

Shane Williams has been designated to coordinate access control and security for Battelle operations on site. A safe perimeter has been established at the work area by delineating the work area with traffic cones and/or high-visibility barrier tape.

No unauthorized person should be within this area.

The on site Command Post and staging area have been established at the ERH treatment area near Building 181 at AF Plant 4.

The prevailing wind conditions are southwest. A wind direction indicator is used to determine daily wind directions. The Command Post is located upwind from the Exclusion Zone or at a sufficient distance to prevent exposure should a release occur.

Control boundaries have been established and include south and west of the ERH test area. These boundaries are identified in the field by: traffic cones and/or high-visibility barrier tape.

SECTION 3: PHYSICAL HAZARDS

(1) IDENTIFY POTENTIAL PHYSICAL HAZARDS TO WORKERS (check or circle all that apply)

- Confined Space
- Steep/Uneven Terrain
- Heavy Equipment
- Heat Stress
- Moving Parts
- Extreme Cold
- Heavy Lifting
- Ionizing Radiation
- Electrical
- Traffic
- Overhead Hazards
- Biological Hazards
- Fall (>6; Vertical)
- Surface Water (Immersion)

Drums Handling*
Noise
Non-Ionizing Radiation
Other:

Site hazards will be mitigated by:

(9) Briefing site personnel as to identify physical hazards within the work area.

(10) Identifying the “kill switch” on the drilling rig.

(11) Personal protection equipment such as ear muffs, ear plugs, winter jackets, etc. will be don to site personnel.

(12) Antiseptic ointment, solution, and bug repellent (especially for ticks) will be included in the first aid kit for insect stings.

(2) SAFETY EQUIPMENT REQUIRED FOR BATTELLE/ASU EMPLOYEES (check or circle all that apply)

- Explosimeter
- Eye Wash
- Confined Space Warning Signs
- Fall Protection Equipment
- Emergency Shower
- Communications – On Site
- Barrier Tape
- Emergency Air Horn
- Communications – Off Site
- Traffic Cones
- Lights
- Other:
- Stretcher
- Lights – emergency
- First Aid Kit
- Ladder
- A-B-C- Fire Extinguisher
- Tick Repellant
- Flotation Device (USCG Type III)

Emergency equipment will be located in the cab of the drilling rig. See Sections 10 and 12 for communication procedures. The field crew will be equipped with cellular telephones, walkie-talkies, and emergency air horn for communication.

SECTION 4: CHEMICAL HAZARDS INFORMATION

(1) IDENTIFIED CONTAMINANTS

Known or suspected hazardous/toxic material (attached historical information, physical description, map of contamination and tabulated date, if available).

<table>
<thead>
<tr>
<th>Media</th>
<th>Substances Involved</th>
<th>Characteristics</th>
<th>Estimated Concentrations</th>
<th>PEL</th>
</tr>
</thead>
</table>

ER-0314 116 Appendix D
### GW Chlorinated hydrocarbons (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, Vinyl chloride, 1,1,1-TCA 1,1-DCE)

Total chlorinated VOCs up to 95,100 µg/L prior to the ERH operation, recent monitoring was at 4,000 µg/L.

### SL Chlorinated hydrocarbons

As much as 55,000 µg/kg prior to the ERH operation.

---

**Media types**
- GW (ground water), SW (surface water), WW (wastewater), AIR (air), SL (soil), SD (sediments), WL (waste, liquid), WS (waste, solid), WD (waste, sludge), WG (waste, gas) OT (other).

**Characterizations**
- CA (corrosive, acid), CC (corrosive, caustic), IG (ignitable), RA (radioactive), VO (volatile), TO (toxic), RE (reactive), BIO (infectious), UN (unknown), OT (other, describe).

Material Safety Data Sheets (MSDSs) for the contaminants of concern are attached. The data sheets include information on the chemical/toxicological properties of the site contaminants and signs and symptoms of over exposure.

**2) DESCRIBE POTENTIAL FOR CONTACT WITH EACH MEDIA TYPE FOR EACH OF THE BATTELLE/ASU TASKS LISTED IN SEC 2.4:**

<table>
<thead>
<tr>
<th>BATTELLE TASK #</th>
<th>ROUTE OF EXPOSURE</th>
<th>POTENTIAL FOR CONTACT</th>
<th>METHOD OF CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B2</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B3</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B4</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
</tr>
</tbody>
</table>

The SSO will brief the field team on interpretation of the attached MSDSs and particularly on symptoms and signs of over exposure to chemical hazards.

---

**SECTION 5: HAZARD COMMUNICATION PROGRAM**

If chemicals are introduced to the site by Battelle/ASU (e.g., decontamination liquids, preservatives, etc.), bring a copy of the Battelle Hazardous Communication Program and associate MSDSs to the site. The SSO will review this information with all field personnel. The current list of chemicals for this site is:

- 1,1,1-Trichloroethane (TCA)
- Alcohol
- 1,1-Dichloroethane, 1,1-dichloro ethene (DCE)
- Trichloroethene
- HCL (preservative)
- Tetrachloroethene
- Liquinox®
- 1,2-dichloroethene (cis- and trans-), Vinyl chloride

**SECTION 6: ENVIRONMENTAL MONITORING**

(1) The following environmental monitoring instruments shall be used on site at the specified intervals for breathing zone monitoring:

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>MONITORING PERIOD</th>
<th>ACTION LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustible Gas Indicator</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>O2 Meter</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>PID (Lamp 10.6 eV)</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>FID</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>Radiation Meter (Gamma)</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>Respirable Dust Meter</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>GC/ECD/FID</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>GC/FID/PID/DELCD</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
</tbody>
</table>

(6) Monitoring equipment is to be calibrated according to the manufacturers’ instructions daily prior to and after each day of use. Record calibration data and air concentration in the Health and Safety on-site logbook.

(7) Action Levels for work shutdown and excavation. These are average values. Consideration should be given to the potential for release of highly toxic compounds from the waste or from reaction by-products. Levels are for persistence (> 10 min).

<table>
<thead>
<tr>
<th>Uncharacterized Airborne Vapors or Gases</th>
<th>ACTION LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characterized Airborne Gases, Vapor, Particulates</td>
<td>&gt;50% PEL, REL, TLV</td>
</tr>
<tr>
<td>Oxygen</td>
<td>&lt; 19.5; &gt;23.5</td>
</tr>
<tr>
<td>Flammability</td>
<td>&gt; 10% LEL</td>
</tr>
</tbody>
</table>
Military and/or civilian personnel in charge of buildings adjacent to invasive monitoring activities will be notified via a health and safety kick-off meeting of site activities. A copy of this HASP will be provided. If any action levels are reached at the work area as described above or if discernible odors are released as a result of field activities, the personnel in charge or their designated representative will be notified immediately. Hourly perimeter monitoring (support zone) will be conducted to assess whether organic vapors or odors are leaving the work area.

SECTION 7: HEALTH AND SAFETY TRAINING/MEDICAL MONITORING PROGRAM
The project staff is included in the Battelle Health and Safety Training and Medical Monitoring Programs in conformance with 29 CFR 1910.61.

HAZWOPER TRAINING

<table>
<thead>
<tr>
<th>NAME</th>
<th>MEDICAL (Date)</th>
<th>INITIAL (Hrs/Date)</th>
<th>REFRESHER (Date)</th>
<th>CPR/FA/ (Dates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eric Foote</td>
<td>August 2006</td>
<td>40 hours/ 1992</td>
<td>June 2006</td>
<td>May 2004</td>
</tr>
<tr>
<td>Shane Williams</td>
<td>February 2006</td>
<td>40 hours/ April 1994</td>
<td>July 14, 2006</td>
<td>July 2006 (good for 3 years)</td>
</tr>
<tr>
<td>Jennifer Triplett</td>
<td>40 hours/June 2001</td>
<td>August 7, 2005 (Refresher sched. For Nov. 2006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paul Dahlen</td>
<td>40 hours/Nov 1992</td>
<td>February, 2006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paul Johnson</td>
<td>40 hours/ 1987</td>
<td>August 12, 2005</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SECTION 8: PERSONAL MONITORING
-No personal exposure monitoring or heat/cold stress monitoring will take place on site. If the need for such monitoring is anticipated, this HASP will be modified accordingly.

SECTION 9: CONFINED SPACE ENTRY
-No confined space and/or trench entries will take place on site. If the possibility of such entries taking place exists, this HASP will be modified accordingly.

SECTION 10: COMMUNICATION PROCEDURES
The following standard hand signals will be used in case of failure to radio communications in each contaminant reduction zone:
- Hand gripping throat
- Grip partner’s wrist and both hands around wrist
- Hands on top of head
- Thumbs up
- Thumbs down
- Can’t Talk, Having difficulty breathing
- Can’t Talk, Leave area immediately
- Need assistance
- OK, I am all right, I understand
- No, negative

If applicable, telephone communications to the Command Post Should be Established as soon as possible. The stationary and/or mobile phone number(s) will be available one week prior to the start of field work. The HASP will be amended when these numbers are available.

The command post telephone is 480-516-1422
The mobile phone is 480-516-1422

SECTION 11: DECONTAMINATION PROCEDURES
Personnel and equipment leaving an exclusion zone shall be thoroughly decontaminated at the decontamination facility constructed at the command post. The SSO is responsible for monitoring adherence with this decontamination plan. A Modified Level D decontamination protocol shall be used with the following decontamination stations:
- Equipment Drop (IF NECESSARY)
- Boot Covers, and Glove Wash and Rinse (IF NECESSARY)
- Outer Boot and Glove Removal (IF NECESSARY)
- Outer Garment Removal (IF NECESSARY)
- Inner Glove Removal (IF NECESSARY)
- Field Hand Wash

The following decontamination equipment is required (check or circle all that apply)
- Decon Pad (Plastic Sheet)
- Dry Brushes
- Detergent Soap
- Trash Cans/Bags
- Wet Brushes
- Other Decontamination Solution
- Buckets
- Water

SECTION 12: EMERGENCY PROCEDURES
On site personnel will use the following standard emergency procedures. The SSO shall be notified of any on site emergencies and be responsible for ensuring that the procedures are followed.

Personal Injury in the Exclusion Zone
- DESIGNATED EMERGENCY SIGNAL: Air Horn

ER-0314 118 Appendix D
Upon notification of an injury in the Exclusion Zone, the designated emergency signal shall be sounded. All site personnel shall assemble at the decontamination line. The SSO or alternate should evaluate the nature of the injury, and the affected person should be decontaminated to the extent possible prior to movement to the Support Zone. The on site CPR/FA personnel shall initiate the appropriate first aid, and contact should be made for an ambulance (and other emergency services as needed) and with the designated medical facility (if required). No persons shall reenter the Exclusion Zone until the cause of the injury or symptoms are determined.

**Fire/Explosion**

| DESIGNATED EMERGENCY SIGNAL: | Air Horn |

Upon notification of a fire or explosion on site, the designated emergency signal shall be sounded and all site personnel assembled at the decontamination line. The fire department shall be alerted and all personnel moved to a safe distance from the involved area.

**Equipment Failure**

If any other equipment (i.e., air monitoring) on site fails to operate properly, the Field Team Leader and SSO shall be notified and then determine the effect of this failure on continuing operations on site. If the failure affects the safety of personnel or prevents completion of the Work Plan tasks, all personnel shall leave the Exclusion Zone until the situation is evaluated and appropriate actions taken.

Emergency escape routes are designated for use in those situations where egress from the Exclusion Zone cannot occur through the decontamination line.

In all situations, when an on site emergency results in evacuation of the Exclusion Zone, personnel shall not reenter until:

1. The conditions resulting in the emergency have been corrected.
2. The hazards have been reassessed by the SSO.
3. The Site Safety Plan has been reviewed by the SSO and Corporate Health and Safety Manager.

**SECTION 13: SPILL CONTROL PROCEDURES**

- No containers of liquid or solids exist on site and no spill control plan is necessary. If the possibility of such conditions exists on site, this HASP will be modified accordingly.

**SECTION 14: EMERGENCY INFORMATION**

1. **LOCAL RESOURCES**
   - Ambulance (name): LM Aero Emergency Services
   - Hospital (name): Harris Methodist Hospital
   - Police (local or state): LM Aero Security
   - Fire (name): LM Aero Fire Department
   - HAZ MAT Responder: National Response Center, Toxic Chemicals and Oil Spills
   - On-Site CPR/FA(s): Shane Williams
   - Phone: 911 or (817) 777-3473
   - Phone: 911 or (817) 250-3333
   - Phone: 911 or (817) 777-2567
   - Phone: 911 or (817) 777-2163
   - Phone: 911 or (800)424-8802
   - Phone: 614-348-4437

* For life-threatening emergencies or emergency trauma care. The above hospital is approximately **9.4 miles** from the furthest work area and the ambulance response time is approximately **17 minutes**.

** For non-life threatening medical care. The above hospital is approximately **30 minutes** from the furthest work area. Injured workers will be transported here for non-emergency treatment only.

** DIRECTIONS TO NEAREST HOSPITAL – SEE ATTACHED MAP:**

2. **BATTELLE RESOURCES**
   - Manager, Corporate Health and Safety (ETE Division): Eric Foote; 614-424-7939
   - Gary Carlin, 614-424-4929
   - Battelle Security Office
   - (614) 424-4444

---

ER-0314  119  Appendix D
## SECTION 15: PERSONAL PROTECTIVE EQUIPMENT (check or circle all that apply)

- **√** No type of respiratory protection is required on this site. If the possibility of the need for respiratory protection is anticipated, this HASP will be modified accordingly.

<table>
<thead>
<tr>
<th>CLOTHING</th>
<th>GLOVES</th>
<th>BOOTS</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coveralls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tyvek</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saranex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE Tyvek</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Cotton
- | Safety
- | Hard Hat
- Leather
- | Fireman/Hip
- | Glasses
- Nitrile
- Neoprene
- | Goggles
- Butyl
- Steel Toe
- | Face Shield
- Neoprene
- | Steel Toe
- | Face Shield
- | Hard Hat
- Viton
- PVC
- | PVA
- Latex

## SECTION 16: SAFE WORK PRACTICES

THE FOLLOWING PRACTICES MUST BE FOLLOWED BY PERSONNEL ON SITE

23. Smoking, eating, chewing gum or tobacco, or drinking are forbidden except in clean or designated areas.
24. Ignition of flammable liquids within or through improvised heating devices (e.g., barrels) is forbidden.
25. Contact with samples, excavated materials, or other contaminated materials must be minimized.
26. Use of contact lenses is prohibited at all times.
27. Do not kneel on the ground when collecting samples.
28. If drilling equipment is involved, know where the kill switch is.
29. All electrical equipment used in outside locations, wet areas, or near water must be plugged into ground fault circuit interrupter (GFCI) protected outlets.
30. A “Buddy System” in which another worker is close enough to render immediate aid will be in effect.
31. Good housekeeping practices are to be maintained.
32. Where the eyes or body may be exposed to corrosive materials, water suitable for quick drenching or flushing shall be available for immediate use.
33. In the event of treacherous weather-related working conditions (i.e., thunderstorm, limited visibility, extreme cold or heat) the field task will be suspended until conditions improve or appropriate protection from the elements is provided.

## SECTION 17: EMPLOYEE ACKNOWLEDGMENTS

PLAN REVIEWED BY: DATE

- H&S Manager: Linc Remmert
- Principal Investigator: Eric Foote; Paul Johnson
- Project Leader: Paul Dahlen
- Site Safety Officer: Shane Williams

I acknowledge that I have read the information in this HASP form and the attached MSDSs. I understand the site hazards as described and agree to comply with the contents of the plan.

FIELD PERSONNEL (Print Name) SIGNATURE DATE

VISITOR (Print Name) SIGNATURE DATE

Organization/Agency

Organization/Agency
1. Start at 1 S GRANTS LN, FORT WORTH on S Grants Ln going toward Wyatt Dr - go 0.2 mi
2. Bear Left on Ramp - go 0.1 mi
3. Continue on S Spur 341 - go 1.1 mi
4. S Spur 341 becomes Ramp - go 0.4 mi
5. Bear Right on Interstate 30 W - go 0.2 mi
6. Take Left ramp onto I-30 - go 5.2 mi
7. Take the Summit Ave/Henderson St exit onto Ramp - go 0.5 mi
8. Take ramp onto Ramp - go 0.2 mi
9. Turn Right on S Henderson St - go 0.2 mi
10. Turn Right on Pennsylvania Ave - go 0.1 mi
11. Arrive at 1301 PENNSYLVANIA AVE, FORT WORTH, on the Left

**Figure 1.** Directions to a nearest clinic
The vendors and products, including the equipment, system components, and other materials identified in this report, are primarily for information purposes only. Although some of these vendors and products may have been used in the past, mention in this report does not constitute a recommendation for using these vendors or products.
Contents
Figures............................................................................................................................. 124
Tables.............................................................................................................................. 124
Acronyms and Abbreviations ......................................................................................... 126

1. Introduction............................................................................................................... Error! Bookmark not defined.
2. Field Investigation ..................................................................................................... 127
3. References.................................................................................................................. 131

Figures
FIGURE 1. SITE MAP
FIGURE 2. DIRECT-PUSH LOCATIONS
FIGURE 3. HYDRAULIC CONDUCTIVITY MEASUREMENT LOCATIONS
FIGURE 4. MONITORING WELL DEPTH-TO-WATER MEASUREMENTS AND GROUNDWATER SAMPLING LOCATIONS
FIGURE 5. CROSS-SECTION OF DIRECT PUSH SAMPLING LOCATIONS
FIGURE 6. VINYL CHLORIDE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 7. 1,1-DICHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 8. TRANS-1,2-DICHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 9. 1,1-DICHLOROETHANE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 10. CIS-1,2-DICHLOROETHENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 11. 1,2-DICHLOROETHANE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 12. 1,1,2-TRICHLOROETHANE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 13. TRICHLOROETHYLENE DIRECT-PUSH GROUNDWATER CONCENTRATIONS (µG/L)
FIGURE 14. HYDRAULIC CONDUCTIVITY TEST DATA (CM/S) OVERLAIN ON TRICHLOROETHYLENE CONTOUR PLOT
FIGURE 15. MASS FLUX TOOLKIT INPUTS

Tables
TABLE 1. GEOLOGIC DESCRIPTIONS OF CONTINUOUS SOIL CORES
TABLE 2. SAMPLING LOCATIONS AND TYPES OF TEST PERFORMED
TABLE 3. SLUG TEST FIELD RESULTS
TABLE 4. DEPTH-TO-GROUNDWATER MEASUREMENTS FOR MONITORING WELLS
TABLE 5. WATER QUALITY DATA FOR MONITORING WELLS
TABLE 6. CHEMICAL CONCENTRATION DATA FOR MONITORING WELLS
TABLE 7. SURVEY DATA FOR DIRECT PUSH DOWNGRADE TRANSECT LOCATIONS
TABLE 8. CHEMICAL CONCENTRATION DATA FOR DIRECT PUSH DOWNGRADE TRANSECT LOCATIONS
TABLE 9. WATER QUALITY DATA FOR DIRECT PUSH DOWNGRADIENT TRANSECT LOCATIONS
TABLE 10. FIELD DATA RESULTS FOR PNEUMATIC SLUG TESTING
TABLE 11. MONITORING WELL CHEMICAL CONCENTRATION DATA COMPARISON
TABLE 12. MASS FLUX ANALYSIS
## Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AFP</td>
<td>Air Force Plant</td>
</tr>
<tr>
<td>bgs</td>
<td>below ground surface</td>
</tr>
<tr>
<td>DCA</td>
<td>1,1-dichloroethane</td>
</tr>
<tr>
<td>DCE</td>
<td>1,2-dichloroethene</td>
</tr>
<tr>
<td>DNAPL</td>
<td>dense non-aqueous phase liquid</td>
</tr>
<tr>
<td>DO</td>
<td>dissolved oxygen</td>
</tr>
<tr>
<td>DELCD</td>
<td>dry electrolytic conductivity detector</td>
</tr>
<tr>
<td>EC</td>
<td>electrical conductivity</td>
</tr>
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<td>ERH</td>
<td>electrical resistance heating</td>
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<tr>
<td>ESTCP</td>
<td>Environmental Security Technology Certification Program</td>
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<td>FID</td>
<td>flame-ionization detector</td>
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<td>gas chromatography</td>
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<tr>
<td>ORP</td>
<td>oxidation reduction potential</td>
</tr>
<tr>
<td>PID</td>
<td>photo-ionization detector</td>
</tr>
<tr>
<td>TCA</td>
<td>trichloroethane</td>
</tr>
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<td>TCE</td>
<td>trichloroethylene</td>
</tr>
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<td>VOA</td>
<td>volatile organic analysis</td>
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1. Introduction

The post-treatment field investigation of Air Force Plant 4 (AFP4) – Building 181, under the Environmental Security Technology Certification Program (ESTCP) project CU-0314, Critical Evaluation of State of the In-Situ Thermal Treatment Technologies, was performed December 4 through December 14, 2006. Figure 1 is a site map that identifies the extent of the previous electrical resistance heating (ERH) remediation area, which was the specific area of interest for this particular field investigation.

Consistent with the objectives set forth under the CU-0314 Demonstration Plan, the field investigation at this site included the following:
- Verification of site hydrogeological conceptual model
- Groundwater sampling of monitoring wells
- Depth-discrete analysis of hydraulic conductivity and dissolved chlorinated hydrocarbons at temporary sampling locations downgradient of the treatment zone.

2. Field Investigations

In accordance with the approved generic demonstration plan for this project, the following site-specific activities were conducted:

(3) Verification of the site hydrogeological conceptual model:

b. For confirmation of geology, three continuous soil cores were collected at direct-push sampling locations GP1, GP3 and GP6. The continuous soil cores/ direct-push sampling locations were located at the down-gradient edge of the treatment zone. Figure 2 shows the location of each direct-push location. Table 1 presents qualitative geologic descriptions from visual observations of the three continuous soil cores.

c. Hydraulic conductivity slug tests were conducted in the nine monitoring wells identified in Table 2 and illustrated in Figure 3. The slug test data was analyzed using both the Hvorslev and the Bouwer and Rice Methods; results are presented in Table 3. Hvorslev’s expression for hydraulic conductivity is:

\[ K = \frac{r^2 \ln(L_c/R)}{(2L_c t_{37})} \]

Where
- \( K \) = hydraulic conductivity (L/T)
- \( r \) = radius of well casing (L) (0.083 or 0.1667 ft)
- \( R \) = radius of well screen (L) (0.50 ft)
- \( L_c \) = length of well screen (L) (4.5, 5, 6, 10 ft or the saturated thickness if well screen was not completely covered)
- \( t_{37} \) = time for water level to rise or fall 37% of the initial change (T)

(from data set)

(Fetter, 2000).
The Bouwer and Rice expression for hydraulic conductivity is:

\[
K = \frac{r_c^2 \ln(R_e/R)}{(2L_e)} \ast \left(\frac{1}{t} \ln(H_0/H_t)\right)
\]

Where \( K \) = hydraulic conductivity (L/T)
\( r_c \) = radius of well casing (L) (0.083 or 0.1667 ft)
\( R \) = radius of gravel envelope (L) (0.50 ft)
\( R_e \) = effective radial distance over which head is dissipated (L)
(from data set)
\( L_e \) = length of well screen (L) (4.5, 5, 6, 10 ft or the saturated thickness if well screen was not completely covered)
\( H_0 \) = drawdown at t=0 (L) (from data set)
\( H_t \) = drawdown at t=t (L) (from data set)
\( t \) = time since \( H = H_0 \) (T) (from data set)

(Fetter, 2000).

It should be noted that two of the slug test locations, monitoring well WJETA062 and WJETA067, were partially-penetrating wells having only partially-submerged screens and about 1.5 ft of water in each. In contrast, two other slug test locations, monitoring well MW-7 and MW-12, were fully-penetrating wells with partially submerged screens. Corrections were made in the Bouwer and Rice analysis for these two types of wells:

i. For the partially-penetrating wells, the approach discussed in Bouwer (1989) was used, and

ii. For MW-7 and MW-12, the fully-penetrating wells with only partially-submerged screens, a correction to the porosity was made by replacing it with the specific yield as suggested by Binkhorst and Robbins (1998).

The Bouwer and Rice expression modified for partially-submerged screens is:

\[
K = \frac{r_{ce}^2 \ln(R_e/R)}{(2L_e)} \ast \left(\frac{1}{t} \ln(H_0/H_t)\right)
\]

Where
\( r_{ce}^2 = r_c^2 + \frac{S_y}{R^2-r_c^2} \)
\( S_y = \frac{V_{wc}/V_s}{(H_{oc}-H_i)} = r_c^2 \frac{(H_{oc}-H_i)}{((R^2-r_c^2)H_i)} \)
\( V_{wc} = \pi r_c^2 (H_{oc}-H_i) \)
\( V_s = \pi (R^2-r_c^2)H_i \)
\( H_{oc} = \frac{V_{sr}}{\pi r_c^2} \)

Where \( K \) = hydraulic conductivity (L/T)
\( H_i \) = length of desaturated sand column (L) (from data set)
\( H_{oc} \) = calculated initial head difference (L)
\( V_{sr} \) = volume of slug removed (L³)
\( V_s \) = volume of sand (L³)
V_{wc} = \text{volume drained into casing (L}^3\text{)}

S_y = \text{specific yield}

r_{ce} = \text{effective casing radius (L)}

r_c = \text{radius of well casing (L) (0.083 or 0.1667 ft)}

R = \text{radius of gravel envelope (L) (0.50 ft)}

R_e = \text{effective radial distance over which head is dissipated (L)}

\text{(from data set)}

L_c = \text{length of well screen (L) (saturated thickness of screened interval)}

H_o = \text{drawdown at } t=0 \text{ (L) (from data set)}

H_t = \text{drawdown at } t=t \text{ (L) (from data set)}

t = \text{time since } H = H_o \text{ (T) (from data set)}

\text{(Binkhorst and Robbins. 1998).}

d. Depth-to-groundwater was measured in the 18 groundwater monitoring wells identified in Table 2 and illustrated in Figure 4. Depth-to-water measurements, groundwater elevations, and survey coordinates are summarized in Table 4. An interpolated groundwater elevation map is presented in Figure 5.

(4) Collection of water quality samples from 15 groundwater monitoring wells within the treatment zone and 3 monitoring wells downgradient of the treatment zone for analysis of chlorinated hydrocarbon groundwater concentrations:

a. Table 2 identifies the groundwater monitoring wells from which samples were collected. Prior to sample collection, three well-volumes were purged. Groundwater was then collected for analysis of field parameters and stored in volatile organic analysis (VOA) vials for analysis of dissolved chlorinated hydrocarbon concentrations. General water quality field parameters including pH, electrical conductivity (EC), temperature, dissolved oxygen (DO), and oxidation reduction potential (ORP) were measured using an Horiba U-22 meter. Chlorinated hydrocarbon analysis was performed on-site by heated-headspace analysis and gas chromatography (GC) using a dry electrolytic conductivity detector (DELCD), a photo-ionization detector (PID), and a flame-ionization detector (FID). General water quality data for permanent groundwater monitoring well installations can be found in Table 5 and chemical concentration data can be found in Table 6. All non-detect samples are listed as less than the detection limit.

(5) Depth-discrete hydraulic conductivity and dissolved chlorinated hydrocarbon concentration data were collected on one foot intervals as possible from 29 ft below ground surface (bgs) to refusal (<35 ft bgs) at four of the 11 direct-push sampling locations, many of which produced no water. Depth-discrete intervals at 7 of the 11 sampling locations produced no water at any interval tested. Additionally, 10 composite samples were collected from the borehole open to approximately 35 ft bgs at 10 of the 11 direct-push sampling locations.
a. Groundwater quality data were collected from depth-specific intervals at direct-push sampling locations GP3, GP4, GP6, and GP7 and open-borehole, composite samples were collected at GP1 through GP9 and GP11 (See Table 2 and Figure 2). GP10 was not sampled because there was no groundwater recovery in the borehole. Sampling locations were spaced on approximately 30 ft centers, as possible, along a transect downgradient of the source zone and perpendicular to the direction of groundwater flow. Figures 2, 6, and 7 illustrate the location of the direct-push sampling locations. Sample locations were also placed along an east/west transect at the southern border of the treatment zone because previous work by others suggested the presence of a paleo channel and chlorinated solvent migration in that direction. Using percussion assisted direct-push technology and a modified Geoprobe Groundwater Profiler, groundwater samples were collected as possible using a check valve on 1-ft intervals from 29 ft bgs to refusal (less than 35 ft bgs). The location of the depth-discrete groundwater samples are illustrated in Figures 6 and 7. Table 7 provides survey data for the direct-push locations. Chlorinated hydrocarbon concentration analysis was conducted, as described above, and the results are summarized in Table 8. General water quality parameters (e.g. pH, EC, temp, DO, and ORP) were also collected during depth-specific sampling, and those data are presented in Table 9.

b. Pneumatic slug tests were conducted at depth-specific intervals at locations GP3, GP4, GP6, GP7 and GP11 using a Geoprobe Pneumatic Slug Test Kit. Slug test data were analyzed using both the Hvorslev and the Bouwer and Rice Methods, and the results are shown in Table 10. A comparison of the hydraulic conductivities derived from direct-push pneumatic slug test and monitoring well slug tests reveals that direct-push aquifer test data suggest less variable and higher hydraulic conductivity values than those derived from the monitoring well data. It is possible that this is an artifact of the direct-push pneumatic test method, which displaces much smaller volumes of water than the monitoring well tests.

Additional field work included soil conductivity measurements at GP1 and GP6 using a Geoprobe Direct Image Electrical Conductivity Probe (Wenner array). Results of the soil conductivity tests are shown in Figure 8.

The monitoring well chemical concentration data collected in December 2006 by the ASU/Battelle team were compared to the previous monitoring well chemical concentration data available for the site. The results for each are compared in Table 11.

Figures 9 through 13 show vertical chemical concentration contour plots in a transect perpendicular to the dominant groundwater flow direction for five of the ten analytes measured in depth-discrete direct-push samples. Vinyl chloride, trans-1,2-dichloroethene (DCE), 1,1-dichloroethane (DCA), 1,2-DCA, and 1,1,2-Trichloroethane (TCA) were not contoured because all groundwater samples were non-detect (<1 μg/L) for these constituents. Vertical contouring did not include locations GP1, GP2 or GP9 along the southern border of the treatment zone since no depth specific samples could be collected from these locations and chemical and hydrogeologic data suggested that the dominant flow direction for this site was to the east.
northeast. Figure 14 presents the hydraulic conductivity data from the pneumatic slug testing for each depth-discrete direct-push sampling interval overlaid on the trichloroethylene (TCE) chemical concentration contour plot.

Plan view contour plots of the chemical concentrations for 8 of 10 analytes measured in 15 monitoring wells and at direct-push sampling locations GP1 through GP9 and GP11 are shown in Figures 15 through 22. Vinyl chloride and 1,1,2-TCA were not contoured because all groundwater samples were non-detect (<1 μg/L) for these constituents.

Using the TCE groundwater concentration data, the hydraulic conductivity estimates calculated from the depth-discrete direct-push sampling and monitoring well slug tests, and a calculated gradient, a TCE mass flux calculation was performed using the Mass Flux Toolkit, Version 1.0. The gradient was calculated using Devlin (2003) and was based on current depth-to-water measurements and available historical top-of-casing elevations for all monitoring wells except MW-9 and MW-10. Depth-to-water data in MW-9 and MW-10 showed a steep gradient across that portion of the site, suggesting a localized hydrogeologic environment that was incongruent with that associated with the remainder of the monitoring wells. The Mass Flux Toolkit is a freeware program developed by Groundwater Services, Inc. and others under a contract funded by ESTCP. A linear spatial and vertical interpolation of the concentration, hydraulic conductivity, hydraulic gradient, and mass flux data was used for the analysis. For intervals with no groundwater production, a hydraulic conductivity value of 10⁻⁶ cm/s (average value, MW-9 and MW-10, the least conductive wells). The analysis was completed four times to include all data taken at the site. The first analysis used the Bouwer and Rice Method hydraulic conductivity values with monitoring wells, MW-11, MW-12, and MW-7. The second analysis used the Bouwer and Rice Method results for the direct-push locations only (no monitoring well results). The same two analyses were performed again using the Hvorslev Method hydraulic conductivity values. Table 12 presents the mass flux results for TCE in each of the four analyses. For these four calculations, the estimated TCE mass flux ranged from 4.92E+00 kg/yr to 1.09E+01 kg/yr. The highest value corresponds to the case where the monitoring well data is used, and it is dominated by the large hydraulic conductivity calculated by the Bouwer (1989) approach using MW-12 slug test data.

3. References


Figures
Figure 1. Site Map
Figure 2. Direct-Push Locations
Figure 3. Slug Test Locations
Figure 4. Sampling Locations
Figure 5. Interpolated Groundwater Elevation Map
Figure 6. North/South Cross-Section of Direct-Push Sampling Locations
(East of the Electrical Resistance Heating Application)
Figure 7. East/West Cross-Section of Direct-Push Sampling Locations
(South of the Electrical Resistance Heating Application)
(a) Electrical Conductivity results for GP1

(b) Electrical Conductivity results for GP6

Figure 8. Electrical Conductivity Results
Appendix D

Note:
* Composite sample of the open borehole

Figure 9. 1,1-DCE Direct-Push Groundwater Concentrations (μg/L)
<table>
<thead>
<tr>
<th>GP 8</th>
<th>GP 3</th>
<th>GP 7</th>
<th>GP 4</th>
<th>GP 11</th>
<th>GP 6</th>
<th>GP 5</th>
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</tbody>
</table>

Note:
* Composite sample of the open borehole

**Figure 10. cis-1,2-DCE Direct-Push Groundwater Concentrations (µg/L)**
Note:
* Composite sample of the open borehole

Figure 11. 1,1,1-TCA Direct-Push Groundwater Concentrations (μg/L)
Note:
* Composite sample of the open borehole

Figure 12. TCE Direct-Push Groundwater Concentrations (µg/L)
Note:
* Composite sample of the open borehole

Figure 13. PCE Direct-Push Groundwater Concentrations (μg/L)
Note:
* Composite sample of the open borehole

Figure 14. Hydraulic Conductivity Pneumatic Slug Test Data (cm/s) Overlain on TCE Contour Plot
Figure 15. Aerial Contour Map of 1,1-DCE Groundwater Concentrations (µg/L) for Monitoring Wells and Composite Direct-Push Sampling Locations
Figure 16. Aerial Contour Map of trans-1,2-DCE Groundwater Concentrations (μg/L) for Monitoring Wells and Composite Direct-Push Sampling Locations
Figure 17. Aerial Contour Map of 1,1-DCA Groundwater Concentrations (μg/L) for Monitoring Wells and Composite Direct-Push Sampling Locations
Figure 18. Aerial Contour Map of cis-1,2-DCE Groundwater Concentrations (μg/L) for Monitoring Wells and Composite Direct-Push Sampling Locations
Figure 19. Aerial Contour Map of 1,2-DCA Groundwater Concentrations (µg/L) for Monitoring Wells and Composite Direct-Push Sampling Locations
Figure 20. Aerial Contour Map of 1,1,1-TCA Groundwater Concentrations (μg/L) for Monitoring Wells and Composite Direct-Push Sampling Locations
Figure 21. Aerial Contour Map of TCE Groundwater Concentrations (μg/L) for Monitoring Wells and Composite Direct-Push Sampling Locations
Figure 22. Aerial Contour Map of PCE Groundwater Concentrations (μg/L) for Monitoring Wells and Composite Direct-Push Sampling Locations
Table 1. Geologic Descriptions of Continuous Soil Cores (December 2006)

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<tr>
<th>Boring Depth (ft)</th>
<th>Subsurface Features</th>
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<td></td>
<td><strong>Continuous Soil Core GP1</strong></td>
</tr>
<tr>
<td>26-31.5</td>
<td>Silty clay</td>
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<tr>
<td>31.5-32.5</td>
<td>Silty sandy clay</td>
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<tr>
<td>32.5-33.5</td>
<td>Silty sandy clay transitioning to limestone</td>
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<tr>
<td>33.5-35</td>
<td>Limestone</td>
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<td></td>
<td><strong>Continuous Soil Core GP3</strong></td>
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<td>25-30.5</td>
<td>Silty clay</td>
</tr>
<tr>
<td>30.5-33.5</td>
<td>Silty clay with gravels</td>
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<td></td>
<td><strong>Continuous Soil Core GP6</strong></td>
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<tr>
<td>25-26.5</td>
<td>Silty clay</td>
</tr>
<tr>
<td>26.5-27.5</td>
<td>Silty clay with sands and gravels</td>
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<td>27.5-30.5</td>
<td>Silty clay</td>
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<td>30.5-33.5</td>
<td>Silty sandy clay transitioning to limestone</td>
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<td>33.5-34</td>
<td>Limestone</td>
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Table 2. Sampling Locations and Types of Test Performed (December 2006)

<table>
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<tr>
<th>Groundwater Monitoring Well or Direct-push Sampling Location</th>
<th>Physical Assessment</th>
<th>Water Quality Assessment</th>
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<tr>
<td></td>
<td>Depth-To-Water Measurement</td>
<td>Hydraulic Slug Test</td>
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<td>MW-7</td>
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<td>GP-11(^b)</td>
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\(^a\) Monitoring well was dry.

\(^b\) Water quality assessments and pneumatic slug testing at direct-push locations were performed on 1-ft intervals from the phreatic surface (~28' bgs) to the point of drilling refusal (33-35' bgs).

\(^c\) Depth to water measurements are approximate and not intended for groundwater elevation calculations.

\(^d\) Field parameters include: pH, electrical conductivity, temperature, dissolved oxygen, and oxidation reduction potential.
Table 3. Slug Test Field Results (December 2006)

<table>
<thead>
<tr>
<th>Monitoring Well</th>
<th>Well Screen (ft)</th>
<th>Hvorslev K (cm/s)</th>
<th>Hvorslev K (ft/d)</th>
<th>Bouwer and Rice K (cm/s)</th>
<th>Bouwer and Rice K (ft/d)</th>
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Table 4. Depth-to-Groundwater Measurements for Monitoring Wells (December 2006)

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DTW - Depth-to-water  
BTOC - Below top of casing  
BGS - Below ground surface  
N/A - Data not available  
MSL - mean sea level  
--- No data available  
NAD83 – North American Datum of 1983
Table 5. Water Quality Data for Monitoring Wells (December 2006)

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-- indicates no water quality parameters were taken due to lack of water.

a Monitoring well was dry
b All measurements were made with a Horiba U-22 meter.
EC = electrical conductivity
D.O. = dissolved oxygen
ORP = oxidation-reduction potential
### Table 6. Chemical Concentration Data for Monitoring Wells (December 2006)

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<th>Date</th>
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**Notes:**
- DUP - Duplicate sample
- REP - Quality control sample (second analysis of same water sample)
- TCA – Trichloroethane
- DCE – Dichloroethene
- PCE - Tetrachloroethene
- TCE - Trichloroethene
- DCA – Dichloroethane
Table 7. Survey Data for Direct-Push Downgradient Transect Locations

<table>
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<tr>
<th>Sampling Location</th>
<th>Elevation from Ground Surface (ft MSL)</th>
<th>NAD83 Coordinates</th>
<th>Borehole Depth (ft BGS)</th>
<th>Water Sample Collected</th>
<th>WQ Data Collected</th>
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\* No water recovery in open borehole for water sampling

BGS = below ground surface
MSL = Mean Sea Level
COMP = Composite Sample
NAD83 = North American Datum of 1983
Table 8. Chemical Concentration Data for Direct-Push Downgradient Transect Locations (December 2006)

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* Minimal groundwater recovery in borehole GP9. Distilled water was added to the borehole to provide enough water for sampling. Based on an estimated volume of groundwater in the borehole, distilled water was added to create a 1:10 dilution.

DUP = Duplicate sample, REP = Quality control sample (second analysis of same water sample), COMP = Composite sample of the open borehole
DCE = Dichloroethene, DCA = Dichloroethane, TCE = Trichloroethene, TCA = Trichloroethane, PCE = Tetrachloroethene
Table 9. Water Quality Data for Direct-Push Downgradient Transect Locations (December 2006)

<table>
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<tr>
<th>Sampling Location</th>
<th>Borehole Depth (ft BGS)</th>
<th>Water Sample Collected</th>
<th>WQ Data Collected</th>
<th>pH</th>
<th>EC (mS)</th>
<th>Temperature (°C)</th>
<th>DO (mg/L)</th>
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--- indicates no water quality parameters were taken due to lack of water.
NAD83 = North American Datum of 1983
(2) = second sample from the same location
a No water recovery in open borehole for water sampling
b Measurements were made with a Horiba U-22 meter.

EC = electrical conductivity
D.O. = dissolved oxygen
ORP = oxidation-reduction potential
BGS = below ground surface
COMP = composite sample
MSL = Mean Sea Level
Table 10. Field Data Results for Pneumatic Slug Testing (December 2006)

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<th>Sampling Location*</th>
<th>Well Screen (ft)</th>
<th>Hvorslev K (cm/s)</th>
<th>Hvorslev K (ft/d)</th>
<th>Bouwer and Rice K (cm/s)</th>
<th>Bouwer and Rice K (ft/d)</th>
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Table 11. Monitoring Well Chemical Concentration Data Comparison

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N/A – No Data Available, Dup – Duplicate Sample, REP – Quality Control Sample (second analysis of same sample), DCE – Dichloroethene, DCA – Dichloroethane, TCE – Trichloroethene, TCA – Trichloroethane, PCE - Tetrachloroethene, ND – Non-Detect (detection limit not available).

“(1)” and “(2)” was used in the sample location nomenclature, by ASU, when more than one sample was collected from the same location.

The analytical results for 1,1-DCA and 1,1,2-TCA were not included in the comparison table, because historical data not available.

* Monitoring wells were installed 2-weeks prior to the December 2006 field investigation, therefore historical analytical data was not available.

ER-0314 166 Appendix D
### Table 11. Monitoring Well Chemical Concentration Data Comparison Continued

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<td>&lt;1 N/A -</td>
<td>6000 1100 Nov '02</td>
<td>1 N/A -</td>
<td>WJETA066 (1)</td>
</tr>
<tr>
<td>WJETA066 (2)</td>
<td>&lt;1 N/A -</td>
<td>&lt;1 N/A -</td>
<td>7100 N/A -</td>
<td>1 N/A -</td>
<td>WJETA066 (2)</td>
<td>&lt;1 N/A -</td>
<td>&lt;1 N/A -</td>
<td>7100 N/A -</td>
<td>1 N/A -</td>
<td>WJETA066 (2)</td>
</tr>
<tr>
<td>WJETA067</td>
<td>&lt;1 N/A -</td>
<td>&lt;1 N/A -</td>
<td>37000 334 Nov '04</td>
<td>&lt;1 N/A -</td>
<td>WJETA067</td>
<td>&lt;1 N/A -</td>
<td>&lt;1 N/A -</td>
<td>37000 334 Nov '04</td>
<td>&lt;1 N/A -</td>
<td>WJETA067</td>
</tr>
<tr>
<td>WJETA067 DUP</td>
<td>1 N/A -</td>
<td>&lt;1 N/A -</td>
<td>38000 N/A -</td>
<td>5 N/A -</td>
<td>WJETA067 DUP</td>
<td>1 N/A -</td>
<td>&lt;1 N/A -</td>
<td>38000 N/A -</td>
<td>5 N/A -</td>
<td>WJETA067 DUP</td>
</tr>
</tbody>
</table>

N/A – No Data Available, Dup – Duplicate Sample, REP – Quality Control Sample (second analysis of same sample), DCE – Dichloroethylene, DCA – Dichloroethane, TCE – Trichloroethylene, TCA – Trichloroethene, PCE - Tetrachloroethene, ND – Non-Detect (detection limit not available). “(1)” and “(2)” was used in the sample location nomenclature, by ASU, when more than one sample was collected from the same location.

The analytical results for 1,1-DCA and 1,1,2-TCA were not included in the comparison table, because historical data not available.

\(^a\) Monitoring wells were installed 2-weeks prior to the December 2006 field investigation, therefore historical analytical data was no
Table 12. Mass Flux Analysis for TCE

<table>
<thead>
<tr>
<th>Hydraulic Conductivity Method</th>
<th>Sampling Locations Included</th>
<th>Discharge (kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bouwer and Rice Method</td>
<td>Discrete-depth Samples and Monitoring Wells</td>
<td>1.09E+01</td>
</tr>
<tr>
<td>Bouwer and Rice Method</td>
<td>Discrete-depth Samples only</td>
<td>4.92E+00</td>
</tr>
<tr>
<td>Horslev Method</td>
<td>Discrete-depth Samples and Monitoring Wells</td>
<td>5.55E+00</td>
</tr>
<tr>
<td>Horslev Method</td>
<td>Discrete-depth Samples only</td>
<td>4.57E+00</td>
</tr>
</tbody>
</table>
Draft

Site Specific Work Plan
Former Pumphouse #2
Hunter Army Airfield (HAAF)
Savannah, Georgia

Critical Evaluation of the State of
In Situ Thermal Treatment Technologies
for DNAPL Source Zone Treatment

Prepared for:

Environmental Security Technology Certification Program
Arlington, VA

Prepared by:
Arizona State University
Battelle

February 27, 2007
1.0 Site Description

Former Pumphouse #2 at Hunter Army Airfield (HAAF) is located in Savannah, Georgia, near former Building 8065, and lies along the east-west taxiway of HAAF (See Figure 1).

Former Pumphouse #2 was an aviation-gas fuel island that was used from 1953 until the early 1970s. The site consisted of ten 25,000-gallon (gal) underground storage tanks (USTs). The pumphouse was inactive from the 1970s to 1995 when eight of the 25,000-gal USTs were removed. Two 25,000-gal tanks remained in-place because they were partially under the pumphouse structure.

During previous investigations at the Former Pumphouse #2, petroleum contaminants were identified in the soil and groundwater, including benzene, toluene, ethylbenzene, and xylenes (BTEX), as well as polynuclear aromatic hydrocarbon (PAH) constituents. The extent of the plume was identified during these investigations to cover an area of approximately 85,800 square feet (ft²). The groundwater is migrating towards the drainage ditch, which is located to the east and south of the site. Previous investigations established that the groundwater plume had not migrated past the drainage ditch.

During the previous investigations, free product was identified. It was recommended that electrical resistance heating (ERH) be implemented to remove the free product, reduce the benzene concentration in groundwater below the alternate concentration limit (ACL) of 469 micrograms per liter (ug/L), and reduce the benzene and indeno (1,2,3-cd)pyrene concentrations in soil to below the proposed alternate threshold limits (ATLs) of 0.44 and 0.66 milligrams per kilogram (mg/kg), respectively.

Interim corrective actions consisted of free product recovery using absorbent socks. The free product in the wells increased, so product delineation piezometers were installed in 200 locations to determine the horizontal extent of the free product. The product covered an area of approximately 3,825 ft² (45 by 85 ft) around monitoring well, P2-MW27. In August 2001, the free product was shown to cover an area of 4,900 ft² and by the baseline sampling for the ERH application the free product covered an area of 11,500 ft².

The conceptual subsurface model for the Former Pumphouse #2 includes two aquifer systems. The lower aquifer is the principal artesian aquifer (Floridan) and it is approximately 800 ft in total thickness and is confined by a layer of phosphatic clay from the Hawthorn Group. This water is used primarily for drinking water. The second aquifer is the surficial aquifer, which was treated during the ERH.

The surficial aquifer overlies the Hawthorn confining unit and supplies water primarily for domestic lawn and agricultural irrigation. The top of the water table ranges from 9 to 16 ft bgs (specifically at Former Pumphouse #2). The groundwater in the surficial aquifer is typically unconfined with locally, thin clay beds creating confined and semiconfined conditions. The surficial aquifer at the Former Pumphouse #2 site’s flow direction is driven by a nearby drainage ditch forcing groundwater to flow to the east and south into the drainage ditch.
2.0 System Description

A full-scale (completely covering the source area) ERH system was started in March 2002 and operated for four months. The system consisted of 111 electrodes at a spacing of 18 feet. The electrodes were spaced to treat and area of 30,000 ft², as seen in Figure 2. The electrodes were installed in unconsolidated material to a depth of 16 ft below ground surface (bgs) with the conductive interval set from 8 to 16 ft bgs. Eighteen of the electrodes were installed as a combination of electrode and dual vapor extraction (DVE) wells. Twenty-three vapor recovery wells (VRWs) were installed at a spacing of 40 ft. Additionally, 15 temporary piezometers were installed for groundwater samples. Table 1 lists the screened intervals of the wells along with their diameter. After shutdown, the temporary piezometers were left in place and are still being sampled semi-annually.

3.0 Current Investigations

The available documentation for HAAF, Former Pumphouse #2 suggests that it is a good site for further investigation because:

- The hydrogeology of the site is reasonably well-characterized
- The aerial extent of the source zone was reasonably defined prior to treatment
- Full treatment of a source zone was performed
- The depth to groundwater is approximately 9 feet.
- The total depth of impacted groundwater is about 20 feet
- There is access to sampling locations immediately down-gradient of the remediated source zone
- The system employed at this site represents a state-of-the-art ERH system
- Pre- and post-treatment groundwater data are available
- Direct-push technologies can be used for sampling
- The monitoring well network is still present and accessible

Consistent with the already-approved generic demonstration plan for this project, the following site-specific activities are proposed:

(5) Verification of the site geological conceptual model before any new investigative work by:

a. Measurement of depths to groundwater in nearby wells (to determine depth to groundwater, flow direction, and hydraulic gradient). See Table 1 for monitoring well details and Figure 3 for measurement locations.

b. Collection of one continuous soil core at the down-gradient edge of the treated source zone (to qualitatively confirm the site geology and to identify depths for subsequent groundwater vertical profile sampling). One or two additional cores will be collected if time permits. See Figure 3 for sampling locations.

c. Slug tests or aquifer specific-capacity tests will be conducted in existing groundwater monitoring wells and temperature monitoring points in the area to get estimates of hydraulic conductivity over the screened intervals for those wells (to help identify if any zones are more conductive than others). See
Table 1 for details on the monitoring wells and Figure 3 for measurement location. Aquifer specific-capacity tests will involve the measurement of the steady flow rate achieved with a fixed drawdown; ideally, all tests will be conducted with the same fixed drawdown (usually 0.3 – 1.0 feet).

(6) Collection of data necessary to determine groundwater concentrations and fluxes leaving the treated source zone:

- Groundwater samples collected from existing groundwater monitoring wells and temperature monitoring points with available historical data and analyzed for benzene, toluene, ethylbenzene, m-, p-, and o-xylene and naphthalene (BTEXN). See Table 1 for details on the monitoring wells and Figure 3 for their locations.

- Groundwater samples will be collected using direct-push tools along a transect perpendicular to the direction of groundwater flow at the down-gradient edge of the original source zone. See Aquifer specific-capacity tests for groundwater sampling locations. Sampling locations will be approximately 60ft apart, and at each location samples will be collected, as possible, at least every 2 feet down to a maximum depth of 20 ft (and at least once in each distinct lithologic change suggested by the soil core). The samples will be analyzed via a headspace analysis on a gas chromatograph (GC) equipped with photo-ionization detector (PID) and flame-ionization (FID) detectors. If time permits, samples will be collected at additional locations as well. The specific depths and numbers of samples collected at each location may be adjusted depending on the analytical results in the field.

- Aquifer specific-capacity tests will be conducted at each depth where a groundwater sample is collected. These tests will be conducted using the direct-push groundwater sampler and will involve the measurement of the steady flow rate achieved with a fixed drawdown; ideally, all tests will be conducted with the same fixed drawdown (usually 0.3 – 1.0 feet).

4.0 References


Figure 1. Site Map
Figure 2. Electrical Resistance Heating Layout and Configuration
Figure 3. Sampling Locations

Source: EPA (2005)
Table 1. Monitoring Well Details

<table>
<thead>
<tr>
<th>Existing Monitoring Well</th>
<th>Screened Interval (ft bgs)</th>
<th>Well Diameter (in)</th>
<th>Water Level Measurement</th>
<th>Slug Test / Aquifer Specific-Capacity Test</th>
<th>Groundwater Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMP-01</td>
<td>3-16</td>
<td>0.75</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TMP-02</td>
<td>3-16</td>
<td>0.75</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TMP-03</td>
<td>3-16</td>
<td>0.75</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TMP-04R</td>
<td>4.8-14.8</td>
<td>N/A</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TMP-05</td>
<td>3-16</td>
<td>0.75</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TMP-07</td>
<td>3-16</td>
<td>0.75</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TMP-09R</td>
<td>4.4-14</td>
<td>N/A</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TMP-10</td>
<td>3-16</td>
<td>0.75</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TMP-11</td>
<td>3-16</td>
<td>0.75</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TMP-12</td>
<td>3-16</td>
<td>0.75</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P2-MW28</td>
<td>3-16</td>
<td>0.75</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

N/A – Not Available  
bgs – below ground surface
Health and Safety Plan (HASP)
Former Pumphouse #2
Hunter Army Airfield (HAAF)
SECTION 1: GENERAL INFORMATION AND DISCLAIMER

CLIENT NAME: Environmental Security Technology Certification Program (ESTCP)  PROJECT NAME: ESTCP Thermal Evaluation

PRINCIPAL INVESTIGATORS: Eric Foote (Battelle) and Paul Johnson (Arizona State University)

PROJECT LEADER: Paul Dahlam

PREPARED BY: Shana Williams  DATE: 03/12/2007

NOTE: This Site Specific Health and Safety Plan (HASP) has been prepared for use by Battelle employees for work at this site. Battelle is not responsible for its use by others. The plan is written for the specific LEVEL D site conditions, purposes, tasks, dates and personnel specified. If these conditions change, a new plan must be utilized and reviewed by those named in Section 17.

Subcontractors shall be solely responsible for the health and safety of their employees and shall comply with all applicable laws and regulations. In accordance with 1910.120(b)(1)(iv) and (v), Battelle will inform its subcontractors of the site emergency response procedures, and any potential fire, explosion, health, safety, or other hazards by making this Site Specific Safety and Health Plan and site information obtained by others available during regular business hours. All contractors and subcontractors are responsible for: (1) developing their own Health and Safety Plan including a written Hazard Communication Program and any other written hazard specific programs required by federal, state and local laws and regulations; (2) providing their own personal protective equipment (PPE); (3) providing documentation that their employees have been health and safety trained in accordance with applicable federal, state and local laws and regulations; (4) providing evidence of medical surveillance and medical approvals for their employees; and (5) designating their own site safety officer (SSO) responsible for ensuring that their employees comply with their own Health and Safety Plan and taking any other additional measures required by their site activities.

SECTION 2: PROJECT INFORMATION

(1) SITE INFORMATION

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Site Project Contact</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter Army Airfield</td>
<td>Alpazza Stevenson</td>
<td>912-315-4226</td>
</tr>
<tr>
<td>Savannah, Georgia</td>
<td>Site Safety &amp; Health Contact: Shana Williams</td>
<td>Site Phone Number: 614-446-7792</td>
</tr>
</tbody>
</table>

(2) SITE CLASSIFICATION (check or circle all that apply)

- [ ] Hazardous (RCRA/CERCLA/State)
- [ ] Construction
- [ ] Landfill (Non-Hazardous)
- [ ] Manufacturing
- [ ] Active
- [ ] Inactive
- [ ] Other: military installation

(3) ENTRY OBJECTIVES (check or circle all that apply)

- [ ] Site Inspection (General)
- [ ] Well Drilling Observation
- [ ] Sampling, Air
- [ ] Sampling, Water
- [ ] Sampling, Soil
- [ ] Other:

DATE(S) OF FIELD VISIT(S):

(4) BATTELLE/ASU TASKS

<table>
<thead>
<tr>
<th>BATTELLE/ASU TASKS</th>
<th>TASK PERFORMED BY OTHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1: Groundwater Investigation</td>
<td>01. Direct push activities for gw sample collection</td>
</tr>
<tr>
<td>B2: Groundwater sampling</td>
<td>02. IDW disposal</td>
</tr>
<tr>
<td>B3: Water level survey and ring tests</td>
<td>03.</td>
</tr>
<tr>
<td>B4: Analytical activities</td>
<td>04.</td>
</tr>
</tbody>
</table>

(5) PROJECT ORGANIZATION AND COORDINATION – The following personnel are designated to carry out the stated project job functions on site. (Note: One person may carry out more than one job function.)

<table>
<thead>
<tr>
<th>PRINCIPAL INVESTIGATORS</th>
<th>Site Safety Officer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eric Foote, Paul Johnson</td>
<td>Shana Williams</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ALTERNATIVE SITE SAFETY OFFICER(S)</th>
<th>PUBLIC INFORMATION OFFICER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jennifer Triplett/Paul Dahlam</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SITE RECORD KEEPER</th>
<th>SITE PERSONNEL WITH CPR/FA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paul Dahlam</td>
<td>Shana Williams</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIELD TEAM LEADER(S)</th>
<th>OTHER FIELD TEAM MANAGERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paul Dahlam</td>
<td>Shana Williams</td>
</tr>
</tbody>
</table>

ER-0314  178  Appendix D
(6) **ON SITE CONTROL**

*Shane Williams* has been designated to coordinate access control and security for Battle's operations on site. A safe perimeter has been established at the work area by delineating the work area with traffic cones and/or high-visibility barrier tape.

No unauthorized person should be within this area.

The on site Command Post and staging area has been established at the previous EPR treatment area.

The prevailing wind conditions are **West**. A wind direction indicator is used to determine daily wind directions. The Command Post is located upwind from the Exclusion Zone or at a sufficient distance to prevent exposure should a release occur.

Control boundaries have been established and include **South and East of the EPR footprint area**. These boundaries are identified in the field by: traffic cones and/or high-visibility barrier tape.

**SECTION 3: PHYSICAL HAZARDS**

(1) **IDENTIFY POTENTIAL PHYSICAL HAZARDS TO WORKERS** (check or circle all that apply)

- Confined Space
- Steep Uneven Terrain
- Heat Stress
- Noise
- Moving Parts
- Extreme Cold
- Ionizing Radiation
- Non-Ionizing Radiation
- Heavy Lifting
- Electrical
- Traffic
- Overhead Hazards
- Biological Hazards
- Fall (>6, Vertical)
- Surface Water (Immersion)

Site hazards will be mitigated by:

1. Briefing site personnel as to identify physical hazards within the work area.
2. Identifying the "kill switch" on the drilling rig.
3. Personal protective equipment such as ear muffs, ear plugs, winter jackets, etc. will be donned by site personnel.

(2) **SAFETY EQUIPMENT REQUIRED FOR BATTELLE/ASU EMPLOYEES** (check or circle all that apply)

- Explosimeter
- Eye Wash
- Confined Space Warning Signs
- Fall Protection Equipment
- Emergency Shower
- Communications - On Site
- Barrier Taps
- Emergency Air Horn
- Communications - Off Site
- Traffic Cones
- Lights
- Other:
- Stretcher
- Lights - emergency
- Other:
- First Aid Kit
- Ladder
- Tick Repellent
- A-B-C-Fire Extinguisher
- Snake Bite Kit
- Flooding Device (USCG Type III)

Emergency equipment will be located in the cab of the drilling rig. See Sections 10 and 12 for communication procedures. The field crew will be equipped with cellular telephones and an emergency air horn for communication.

**SECTION 4: CHEMICAL HAZARDS INFORMATION**

(1) **IDENTIFIED CONTAMINANTS**

Known or suspected hazardous/toxic material (attached historical information, physical description, map of contamination and tabulated data, if available).

<table>
<thead>
<tr>
<th>Media</th>
<th>Substances Involved</th>
<th>Characteristics</th>
<th>Estimated Concentrations</th>
<th>PEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>BTX (benzene, toluene, styrene), polycyclic aromatic hydrocarbons (PAHs)</td>
<td>VO and TO</td>
<td>Not Available</td>
<td></td>
</tr>
<tr>
<td>SL</td>
<td>BTX and PAH's</td>
<td>VO and TO</td>
<td>Not Available</td>
<td></td>
</tr>
</tbody>
</table>

Media types

- GW (ground water), SW (surface water), WW (wastewater), AIR (air), SL (soil), SD (sediments), WL (waste, liquid), WS (waste, solid), WD (waste, sludge), WG (waste, gas) OT (other).

Characterizations

- CA (corrosive, acid) CC (corrosive, caustic), IG (ignitable), RA (radioactive), VO (volatile), TO (toxic), RE (reactive), EIO (infectious), UN (unknown), OT (other, describe)

Material Safety Data Sheets (MSDSs) for the contaminants of concern are attached. The data sheets include information on the chemical/toxicological properties of the site contaminates and signs and symptoms of over exposure.
### Section 5: Hazard Communication Program

If chemicals are introduced to the site by Battelle/ASU (e.g., decontamination liquids, preservatives, equipment calibration standards, etc.), bring a copy of the Battelle Hazardous Communication Program and associate MSDSs to the site. The SSO will review this information with all field personnel. The current list of chemicals for this site is:

- BTEX
- PAHs
- HCL (preservative)
- Alcohol
- Liquinex®

### Section 6: Environmental Monitoring

1. The following environmental monitoring instruments shall be used on site at the specified intervals for breathing zone monitoring:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Monitoring Period</th>
<th>Action Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustible Gas Indicator</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>O$_2$ Meter</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>PID (Lamp 10.6 eV)</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>FID</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>Radiation Meter (Gammma)</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>Respirable Dust Meter</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>GC/ECD/FID</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
<tr>
<td>GC/FID/FID/FID/DELCID</td>
<td>daily/hourly/continuous/other</td>
<td></td>
</tr>
</tbody>
</table>

2. Monitoring equipment is to be calibrated according to the manufacturers’ instructions daily prior to and after each day of use. Record calibration data and air concentration in the Health and Safety on-site logbook.

3. Action Levels for work shutdown and excavation. These are average values. Consideration should be given to the potential for release of highly toxic compounds from the waste or from reaction by-products. Levels are for persistence (> 10 min). Refer to the attached MSDSs for the TLVs.

   **Action Level**
   - Uncharacterized Airborne Gases or Vapors
   - Characterized Airborne Gases, Vapor, Particulates
   - Oxygen
   - Flammability

4. Military and/or civilian personnel in charge of buildings adjacent to invasive monitoring activities will be notified via a health and safety kick-off meeting of site activities. A copy of this HASP will be provided. If any action levels are reached at the work area as described above or of discernible odors are released as a result of field activities, the personnel in charge or their designated representative will be notified immediately. Perimeter monitoring (support zone) will be conducted, at a minimum of 3 times per day, to assess whether organic vapors or odors are leaving the work area.
SECTION 7: HEALTH AND SAFETY TRAINING/MEDICAL MONITORING PROGRAM

The project staff is included in the Battelle Health and Safety Training and Medical Monitoring Programs in conformance with 29 CFR 1910.128.

HAZWOPER TRAINING

<table>
<thead>
<tr>
<th>NAME</th>
<th>MEDICAL (Date)</th>
<th>INITIAL (Hrs/Date)</th>
<th>REFRESHER (Date)</th>
<th>CPR/RFA (Date)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eric Foose</td>
<td>August 2006</td>
<td>40 hours/1992</td>
<td>June 2006</td>
<td>May 2004 (good for 3 years)</td>
</tr>
<tr>
<td>Shana Williams</td>
<td>February 2006</td>
<td>40 hours/April 1994</td>
<td>July 14, 2006</td>
<td></td>
</tr>
<tr>
<td>Jennifer Triplatt</td>
<td></td>
<td>40 hours/June 2001</td>
<td>August 7, 2005</td>
<td></td>
</tr>
<tr>
<td>Paul Johnson</td>
<td>40 hours/1987</td>
<td>40 hours/1987</td>
<td>August 12, 2005</td>
<td></td>
</tr>
</tbody>
</table>

SECTION 8: PERSONAL MONITORING

✓ No personal exposure monitoring or heat/cold stress monitoring will take place on site. If the need for such monitoring is anticipated, this HASP will be modified accordingly.

SECTION 9: CONFINED SPACE ENTRY

✓ No confined space and/or trench entries will take place on site. If the possibility of such entries taking place exists, this HASP will be modified accordingly.

SECTION 10: COMMUNICATION PROCEDURES

The following standard hand signals will be used in case of failure to radio communications in each contaminant reduction zone:

- Hand gripping throat = Can’t Talk, Having difficulty breathing
- Grip partner’s wrist and both hands around wrist = Can’t Talk, Leave area immediately
- Hands on top of head = Need assistance
- Thumbs up = OK, I am all right. I understand
- Thumbs down = No, negative

If applicable, telephone communications to the Command Post Should be Established as soon as possible. The stationary and/or mobile phone number(s) will be available one week prior to the start of field work. The HASP will be amended when these numbers are available.

The command post telephone is 480-516-1422
The mobile phone is 480-516-1422

SECTION 11: DECONTAMINATION PROCEDURES

Personal and equipment leaving an exclusion zone shall be thoroughly decontaminated at the decontamination facility constructed at the command post. The SSO is responsible for monitoring adherence with this decontamination plan. A Modified Level D decontamination protocol shall be used with the following decontamination stations:

1. Equipment Drop (IF NECESSARY)
2. Boot Covers and Glove Wash and Rinse (IF NECESSARY)
3. Outer Boot and Glove Removal (IF NECESSARY)
4. Outer Garment Removal (IF NECESSARY)
5. Inner Garment Removal (IF NECESSARY)
6. Field Hand Wash

The following decontamination equipment is required (check or circle all that apply):

- Detergent Soap
- Other Decontamination Solution
- Water

ER-0314 181 Appendix D
SECTION 12: EMERGENCY PROCEDURES

On site personnel will use the following standard emergency procedures. The SSO shall be notified of any on site emergencies and be responsible for ensuring that the procedures are followed.

**Personal Injury in the Exclusion Zone**

**DESIGNATED EMERGENCY SIGNAL:** Air Horn

Upon notification of an injury in the Exclusion Zone, the designated emergency signal shall be sounded. All site personnel shall assemble at the decontamination line. The SSO or alternate should evaluate the nature of the injury, and the affected person should be decontaminated to the extent possible prior to movement to the Support Zone. The on site CPR/FA personnel shall initiate the appropriate first aid, and contact should be made for an ambulance (and other emergency services as needed) and with the designated medical facility (if required). No persons shall reenter the Exclusion Zone until the cause of the injury and symptoms are determined.

**Fire/Explosion**

**DESIGNATED EMERGENCY SIGNAL:** Air Horn

Upon notification of a fire or explosion on site, the designated emergency signal shall be sounded and all site personnel assembled at the decontamination line. The fire department shall be alerted and all personnel moved to a safe distance from the involved area.

**Equipment Failure**

If any equipment (i.e., air monitoring) on site fails to operate properly, the Field Team Leader and SSO shall be notified and then determine the extent of this failure on continuing operations on site. If the failure affects the safety of personnel or prevents completion of the Work Plan tasks, all personnel shall leave the Exclusion Zone until the situation is evaluated and appropriate actions taken.

Emergency escape routes are designated for use in those situations where access from the Exclusion Zone cannot occur through the decontamination line.

In all situations, when an on site emergency results in evacuation of the Exclusion Zone, personnel shall not reenter until:

1. The conditions resulting in the emergency have been corrected.
2. The hazards have been reassessed by the SSO.
3. The Site Safety Plan has been reviewed by the SSO and Corporate Health and Safety Manager.

SECTION 13: SPILL CONTROL PROCEDURES

✓ No containers of liquid or solids exist on site and no spill control plan is necessary. If the possibility of such conditions exists on site, this HASP will be modified accordingly.

SECTION 14: EMERGENCY INFORMATION

(1) LOCAL RESOURCES

<table>
<thead>
<tr>
<th>Service</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambulance (name):</td>
<td>Phone: 911</td>
</tr>
<tr>
<td>Hospital (name):</td>
<td>Phone: 911 or (912) 819-6000</td>
</tr>
<tr>
<td>Police (local or state):</td>
<td>Phone: 911 or (912) 232-4241</td>
</tr>
<tr>
<td>Fire (name):</td>
<td>Phone: 911 or (912) 651-6758</td>
</tr>
<tr>
<td>HAZ MAT Responder:</td>
<td>Phone: 911 or (912) 651-6758</td>
</tr>
<tr>
<td>On-Site CPR/FA(s):</td>
<td>Phone: 614-348-4437</td>
</tr>
</tbody>
</table>

* For life-threatening emergencies or emergency trauma care.
  The above hospital is approximately 4.8 miles from the furthest work area and the ambulance response time is approximately 13 minutes.

** For non-life threatening medical care.
  The above hospital is approximately 13 minutes from the furthest work area. Injured workers will be transported here for non-emergency treatment only.

(2) DIRECTIONS TO NEAREST HOSPITAL – SEE ATTACHED MAP:

Figure 1.

(3) BATTISTE RESOURCES

Health and Safety Representative (BSTI)
Stephanie Halpern, CSP,
614-424-7365

Site Contact: Eric Feot: 614-374-2729

Battelle Security Office
(614) 424-4444
SECTION 15: PERSONAL PROTECTIVE EQUIPMENT (check or circle all that apply)

✓ No type of respiratory protection is required on this site. If the possibility of the need for respiratory protection is anticipated, this HASP will be modified accordingly.

<table>
<thead>
<tr>
<th>CLOTHING</th>
<th>GLOVES</th>
<th>BOOTS</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coveralls</td>
<td>Cotton</td>
<td>Safety</td>
<td>Hard Hat</td>
</tr>
<tr>
<td>Terylene</td>
<td>Leather</td>
<td>Fireman/HiPP</td>
<td>Safety Glasses</td>
</tr>
<tr>
<td>Item 3</td>
<td>Nitrile</td>
<td>Neoprene</td>
<td>Face Shield</td>
</tr>
<tr>
<td>PE Terylene</td>
<td>Butyl</td>
<td>Steel Toe</td>
<td>Goggles</td>
</tr>
<tr>
<td>Other</td>
<td>Neoprene</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Viton</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Latex</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SECTION 16: SAFE WORK PRACTICES

THE FOLLOWING PRACTICES MUST BE FOLLOWED BY PERSONNEL ON SITE

1. Smoking, eating, chewing gum or tobacco, or drinking are forbidden except in clean or designated areas.
2. Ignition of flammable liquids within or through improvised heating devices (e.g., barrels) is forbidden.
3. Contact with samples, excavated materials, or other contaminated materials must be minimized.
4. Do not kneel on the ground when collecting samples.
5. If drilling equipment is involved, know where the kill switch is.
6. All electrical equipment used in outside locations, wet areas, or near water must be plugged into ground fault circuit interrupter (GFCI) protected outlets.
7. A “Buddy System” in which another worker is close enough to render immediate aid will be in effect.
8. Good housekeeping practices are to be maintained.
9. Where eyes or body may be exposed to corrosive materials, water suitable for quick drenching or flushing shall be available for immediate use.
10. In the event of hazardous weather-related working conditions (i.e., thunderstorm, limited visibility, extreme cold or heat) the field task will be suspended until conditions improve or appropriate protection from the elements is provided.

SECTION 17: EMPLOYEE ACKNOWLEDGMENTS

PLAN REVIEWED BY: ___________________________ DATE: ___________________________

H&S Representative: Stephanie Halseman, CSP
Principal Investigator: Eric Fosse, Paul Johnson
Project Leader: Paul Dahlen
Site Safety Officer: Shana Williams

I acknowledge that I have read the information in this HASP form and the attached MSDSs. I understand the site hazards as described and agree to comply with the contents of this plan.

FIELD PERSONNEL (Print Name) ___________________________ SIGNATURE ___________________________ DATE: ___________________________

____________________________________
____________________________________
____________________________________

VISITOR (Print Name) ___________________________ SIGNATURE ___________________________ DATE: ___________________________

____________________________________

Organization/Agency

____________________________________

Organization/Agency
From: Hunter Army Airfield
Drive: 4.8 miles (about 13 minutes) to St. Joseph’s/ Candler Hospital
1) Head northeast on S Perimeter Road toward Stephen Douglas Street: 3.5 mi.
2) Turn left at Duncan Drive: 190 ft.
3) Continue on Montgomery Street: 0.4 mi.
4) Turn right at W. Derenne Avenue/ GA-21 S: 0.8 mi.
5) Turn left at Reynolds Street: 486 ft.
Arrive: St. Joseph/Candler Hospital, 5356 Reynolds St., Savannah, GA 31419
Draft Final

Data Analysis Report of
Hunter Army Airfield – Former Pumphouse #2

Critical Evaluation of the State of
In Situ Thermal Treatment Technologies
for DNAPL Source Zone Treatment

Prepared for:

Environmental Security Technology Certification Program
Arlington, VA

Prepared by:

Arizona State University
Battelle

June 2007
The vendors and products, including the equipment, system components, and other materials identified in this report, are primarily for information purposes only. Although some of these vendors and products may have been used in the past, mention in this report does not constitute a recommendation for using these vendors or products.
Contents

FIGURES ....................................................................................................................... 187

TABLES ......................................................................................................................... 188

ACRONYMS AND ABBREVIATIONS ..................................................................... 189

1. INTRODUCTION .................................................................................................... 190

2. FIELD INVESTIGATION .......................................................................................... 190

3. REFERENCES ......................................................................................................... 193

Figures

Figure 1. Site Map
Figure 2. Direct Push Locations
Figure 3. Hydraulic Conductivity Measurement Locations
Figure 4. Monitoring Well Depth-to-Water Measurements and Groundwater Sampling Locations
Figure 5. Interpolated Groundwater Elevation Map
Figure 6. Cross-section of Direct Push Sampling Locations
Figure 7. Electrical Conductivity Results
Figure 8. Benzene Direct-Push Groundwater Concentrations (µg/L)
Figure 9. Toluene Direct-Push Groundwater Concentrations (µg/L)
Figure 10. Ethylbenzene Direct-Push Groundwater Concentrations (µg/L)
Figure 11. m/p-Xylene Direct-Push Groundwater Concentrations (µg/L)
Figure 12. o-Xylene Direct-Push Groundwater Concentrations (µg/L)
Figure 13. Naphthalene Direct-Push Groundwater Concentrations (µg/L)
Figure 14. Hydraulic Conductivity Test Data (cm/s) Overlain on Benzene Contour Plot
Figure 15. Benzene Contour Plot
Figure 16. Toluene Contour Plot
Figure 17. Ethylbenzene Contour Plot
Figure 18. m/p Xylenes Contour Plot
Figure 19. o Xylenes Contour Plot
Figure 20. Naphthalene Contour Plot
Figure 21. Mass Flux Analysis of Benzene Data
Figure 22. Interpolated Benzene Concentration Grid
Figure 23. Interpolated Hydraulic Conductivity Grid
Figure 24. Benzene Mass Flux Results

Tables
Table 1. Geologic Descriptions of Continuous Soil Cores
Table 2. Sampling Locations and Types of Test Performed
Table 3. Slug Test Results
Table 4. Field Data and Results for Constant Drawdown Aquifer Testing in Monitoring Wells
Table 5. Depth-to-Groundwater and Groundwater Elevations for Monitoring Wells
Table 6. Water Quality Data for Monitoring Wells
Table 7. Chemical Concentration Data for Monitoring Wells
Table 8. Chemical Concentration Data for Direct Push Downgradient Transect Locations
Table 9. Water Quality Data for Direct Push Downgradient Transect Locations
Table 10. Field Data and Results for Constant Drawdown Aquifer Testing in Direct-Push Downgradient Transect Locations
Table 11. Monitoring Well Chemical Concentration Data Comparison
### Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>bgs</td>
<td>below ground surface</td>
</tr>
<tr>
<td>DO</td>
<td>dissolved oxygen</td>
</tr>
<tr>
<td>EC</td>
<td>electrical conductivity</td>
</tr>
<tr>
<td>ERH</td>
<td>electrical resistance heating</td>
</tr>
<tr>
<td>ESTCP</td>
<td>Environmental Security Technology Certification Program</td>
</tr>
<tr>
<td>FID</td>
<td>flame-ionization detector</td>
</tr>
<tr>
<td>ft</td>
<td>feet</td>
</tr>
<tr>
<td>GC</td>
<td>gas chromatography</td>
</tr>
<tr>
<td>kg</td>
<td>kilogram</td>
</tr>
<tr>
<td>ORP</td>
<td>oxidation reduction potential</td>
</tr>
<tr>
<td>PID</td>
<td>photo-ionization detector</td>
</tr>
<tr>
<td>temp</td>
<td>temperature</td>
</tr>
<tr>
<td>VOA</td>
<td>volatile organic analysis</td>
</tr>
<tr>
<td>yr</td>
<td>year</td>
</tr>
</tbody>
</table>
1. Introduction

The post-treatment field investigation of Hunter Army Airfield – Former Pumphouse #2, under the Environmental Security Technology Certification Program (ESTCP) project ER-0314, Critical Evaluation of State of the In-Situ Thermal Treatment Technologies, was performed March 26 through April 2, 2007. Figure 1 is a site map that identifies the extent of the previous electrical resistance heating (ERH) remediation area, which was also the specific area of interest for this particular field investigation.

Consistent with the objectives set forth under the ER-0314 Demonstration Plan, the field investigation at this site included the following:

- Verification of the site hydrogeological conceptual model
- Groundwater sampling of monitoring wells
- Depth-discrete analysis of hydraulic conductivity and dissolved petroleum hydrocarbons at temporary sampling locations downgradient of the treatment zone.

2. Field Investigations

In accordance with the approved generic demonstration plan for this project, the following site-specific activities were conducted:

(6) Verification of the site hydrogeological conceptual model:

c. For confirmation of geology, two continuous soil cores were collected at direct-push sampling locations GP3 and GP6 shown in Figure 2. The continuous soil cores/direct-push sampling locations were located at the down-gradient edge of the treatment zone. Table 1 presents qualitative geologic descriptions from visual observations of the two continuous soil cores.

d. Hydraulic conductivity slug testing was conducted in monitoring well, P2-MW28 identified in Table 2 and in Figure 3. The slug test data were analyzed using both the Hvorslev and the Bouwer and Rice Methods; results are presented in Table 3. The Hvorslev’ expression for determining hydraulic conductivity from slug test data is:

\[ K = \frac{r^2 \ln(L_c/R)}{2L_c t_{37}} \]

Where
- \( K \) = hydraulic conductivity (L/T)
- \( r \) = radius of well casing (L) (0.083 ft)
- \( R \) = radius of well screen (L) (0.50 ft)
- \( L_c \) = length of well screen (L) (10 ft or the saturated thickness if well screen was not completely covered)
- \( t_{37} \) = time for water level to rise or fall 37% of the initial change (T) (from data set)

(Fetter, 2000).
The Bouwer and Rice expression for determining hydraulic conductivity from slug test data is:

\[ K = \left( r_c^2 \ln \left( \frac{R_e}{R} \right) / (2L_e) \right) \times \left( \frac{1}{t} \ln \left( \frac{H_o}{H_t} \right) \right) \]

Where  
- \( K \) = hydraulic conductivity (L/T)
- \( r_c \) = radius of well casing (L) (0.083 ft)
- \( R \) = radius of gravel envelope (L) (0.50 ft)
- \( R_e \) = effective radial distance over which head is dissipated (L) (from data set)
- \( L_e \) = length of well screen (L) (10 ft or the saturated thickness if well screen was not completely covered)
- \( H_o \) = drawdown at \( t=0 \) (L) (from data set)
- \( H_t \) = drawdown at \( t=t \) (L) (from data set)
- \( t \) = time since \( H = H_o \) (T) (from data set)

(Fetter, 2000).

In addition, aquifer specific-capacity tests were conducted on 11 monitoring wells, which were unsuitable for performing slug tests. Nine (9) of the eleven (11) monitoring wells were unsuitable due to insufficient casing diameter (1-inch). The remaining two (2) monitoring wells had sufficient casing diameters (2-inch), however the water column measured in the wells were of insufficient depth for performing slug tests. Specific-capacity tests involve measurements of the flow rate achieved under fixed drawdown and are analyzed using the Theim Equation to estimate hydraulic conductivity. The results are presented in Table 4. The Theim equation for hydraulic conductivity is:

\[ T = \frac{Q}{(2(h_2-h_1))}\ln\left(\frac{r_2}{r_1}\right) \]

Where  
- \( T \) = transmissivity (L²/T)
- \( Q \) = pumping rate (L³/T)
- \( h_1 \) = head at distance \( r_1 \) from the pumping well (L)
- \( h_2 \) = head at distance \( r_2 \) from the pumping well (L)

\[ K = \frac{T}{b} \]

Where  
- \( K \) = hydraulic conductivity (L/T)
- \( b \) = length of sampler or screen section (L) (0.5 ft or length of screen)

(Fetter, 2000).

e. Depth-to-groundwater was measured in the 12 groundwater monitoring wells identified in Table 2 and in Figure 4. Depth-to-water measurements, groundwater elevations, and survey coordinates are summarized in Table 5. An interpolated groundwater elevation map is presented in Figure 5.

(7) Collection of water quality samples from 11 groundwater monitoring wells within the treatment zone and one monitoring well cross-gradient of the treatment zone for analysis of dissolved petroleum hydrocarbon groundwater concentrations:
f. Table 2 identifies the groundwater monitoring wells from which samples were collected. Prior to sample collection, three well-volumes were purged. Groundwater was then collected for analysis of field parameters and stored in volatile organic analysis (VOA) vials for analysis of dissolved petroleum hydrocarbon concentrations. General water quality field parameters including pH, electrical conductivity (EC), temperature, dissolved oxygen (DO), and oxidation reduction potential (ORP) were measured using an Horiba U-22 meter. Petroleum hydrocarbon analysis was performed on-site by heated-headspace analysis and gas chromatography (GC) using a photo-ionization detector (PID) and a flame-ionization detector (FID). General water quality data for permanent groundwater monitoring well installations can be found in Table 6 and chemical concentration data can be found in Table 7. All non-detect samples are listed as less than the detection limit.

(8) Depth-discrete hydraulic conductivity and dissolved petroleum hydrocarbon concentration data were collected on one or two foot intervals as possible from 12 ft below ground surface (bgs) to ~22 ft bgs at all 10 direct-push sampling locations.

g. Groundwater quality data were collected from depth-specific intervals at all direct-push sampling locations (See Table 2 and Figure 2). Sampling locations were spaced on approximately 50 ft centers, as possible, along a transect downgradient of the source zone and perpendicular to the direction of groundwater flow. Figure 2 presents the direct-push sampling locations. Sample locations were placed around the treatment zone because previous work by others suggested the drainage ditch surrounding the site caused radial flow and dissolved petroleum hydrocarbon migration could be radially outward. Using percussion assisted direct-push technology and a modified Geoprobe Groundwater Profiler, groundwater samples were collected using a peristaltic pump on 2-ft intervals from 13 ft bgs to ~22 ft bgs. The location of the depth-discrete groundwater samples are shown in Figure 6. Dissolved petroleum hydrocarbon concentration analysis was conducted, as described above, and the results are summarized in Table 8. General water quality parameters (e.g. pH, EC, temp, DO, and ORP) were also collected during depth-specific sampling, and those data are presented in Table 9.

h. Aquifer specific-capacity tests were conducted at depth-specific intervals at all direct push sampling locations, as indicated in Table 2. Specific-capacity tests involve the measurement of the flow rate achieved under fixed drawdown and are analyzed using the Theim Equation to estimate hydraulic conductivity. The field data and results for aquifer testing are shown in Table 10.

Additional field work included soil conductivity measurements at GP3 and GP6 using a Geoprobe Direct Image Electrical Conductivity Probe (Wenner array). Results of the soil conductivity tests are shown in Figure 7.
The monitoring well chemical concentration data collected in March/April 2007 by the ASU/Battelle team were compared to the previous monitoring well chemical concentration data available for the site. The analytical results for each are shown in Table 11.

Figures 8 through 13 show vertical chemical concentration contour plots in a transect perpendicular to the dominant groundwater flow direction for seven analytes measured in depth-discrete direct-push samples. Figure 14 presents the hydraulic conductivity data from the aquifer specific-capacity tests for each depth-discrete direct-push sampling interval overlaid on the Benzene chemical concentration contour plot.

Plan view contour plots of the chemical concentrations for the analytes (benzene, toluene, ethylbenzene, m/p-xylene, o-xylene, and naphthalene) are shown in Figures 15 through 20. These contour plots were constructed using the concentration data from 11 monitoring wells and the highest discrete-depth concentration from each direct-push sampling location. Using the benzene groundwater concentration data, the hydraulic conductivity estimates (Table 10) calculated from the depth-discrete direct-push sampling and an average calculated gradient, a benzene mass flux calculation was performed using the Mass Flux Toolkit, Version 1.0. The average gradient of 0.01 ft/ft was chosen because each individual direct-push sampling location had a hydraulic gradient of approximately 0.01 ft/ft based on an extrapolated groundwater elevation map. The groundwater elevation map was used because the treatment zone had a surface elevation that varied significantly and the depth-to-water measurements were thus, unusable because no survey data was available for the temporary sampling locations. The Mass Flux Toolkit is a freeware program developed by Groundwater Services, Inc. and others under a contract funded by ESTCP. Figure 21 is a snapshot of the Benzene inputs used to perform the mass flux analysis. Linear spatial and vertical interpolation of the concentration, hydraulic conductivity, hydraulic gradient, and mass flux data were used for the analysis. Figures 22 and 23 show the interpolated concentration grid and the interpolated hydraulic conductivity grid, respectively. Finally, Figure 24 shows the mass flux result for Benzene, which is estimated to be 3.75E-02 kg/yr.

3. References

Figures
Figure 1. Site Map
Figure 2. Direct-Push Locations
Figure 3. Hydraulic Conductivity Measurement Locations
Figure 4. Monitoring Well Depth-to-Water Measurements and Groundwater Sampling Locations

Legend:
- P2: Abandoned Monitoring Wells
- P2: Monitoring Wells
- E91: Electrodes
- E32: Dual Vapor Extraction Electrodes
- SV16: Dual vapor/Soil Vapor Wells
- TMP: Temperature Monitoring Points
- Collection of depth-to-water
- Direct Push Sampling Location
- Soil core and Direct Push Sampling Location

Source: EPA
Figure 5. Interpolated Groundwater Elevation Map
Figure 6. Cross-section of Direct Push Sampling Locations
Figure 7. Electrical Conductivity Results
Figure 8. Benzene Direct-Push Groundwater Concentrations (μg/L)
Figure 9. Toluene Direct-Push Groundwater Concentrations (μg/L)
Figure 10. Ethylbenzene Direct-Push Groundwater Concentrations (μg/L)
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Figure 14. Hydraulic Conductivity Test Data (cm/s) Overlain on Benzene Contour Plot
Figure 15. Benzene Contour Plot
Figure 16. Toluene Contour Plot
Figure 17. Ethylbenzene Contour Plot
Figure 18. m/p Xylenes Contour Plot
Figure 19. O Xylenes Contour Plot
Figure 20. Naphthalene Contour Plot
Figure 21. Mass Flux Analysis of Benzene Data
Figure 22. Interpolated Benzene Concentration Grid
Figure 23. Interpolated Hydraulic Conductivity Grid
Figure 24. Benzene Mass Flux Results
Tables
Table 1. Geologic Descriptions of Continuous Soil Cores (March/April 2007)

<table>
<thead>
<tr>
<th>Boring Depth (ft)</th>
<th>Subsurface Features</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Continuous Soil Core GP 3</strong></td>
</tr>
<tr>
<td>0-20</td>
<td>Fine Sand</td>
</tr>
<tr>
<td></td>
<td><strong>Continuous Soil Core GP 6</strong></td>
</tr>
<tr>
<td>0-20</td>
<td>Fine Sand</td>
</tr>
</tbody>
</table>
**Table 2. Sampling Locations and Types of Test Performed (March/April 2007)**

<table>
<thead>
<tr>
<th>Groundwater Monitoring Well or Direct-push Sampling Location</th>
<th>Physical Assessment</th>
<th>Water Quality Assessment</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Depth-To-Water Measurement</td>
<td>Slug Testing</td>
</tr>
<tr>
<td>TMP 1</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>TMP 2</td>
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<td>Yes</td>
</tr>
<tr>
<td>TMP 3</td>
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<td>Yes</td>
</tr>
<tr>
<td>TMP 4R</td>
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<td>Yes</td>
</tr>
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<td>TMP 5</td>
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<td>Yes</td>
</tr>
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<td>Yes</td>
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<td>TMP 11</td>
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<td>TMP 12</td>
<td>Yes</td>
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<td>P2-MW28</td>
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<td>Yes</td>
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<tr>
<td>GP 2$^{(a)}$</td>
<td>Yes$^{(b)}$</td>
<td>Yes</td>
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<td>GP 3$^{(a)}$</td>
<td>Yes$^{(b)}$</td>
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<td>GP 9$^{(a)}$</td>
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</tr>
<tr>
<td>GP 55$^{(a)}$</td>
<td>Yes$^{(b)}$</td>
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</tr>
<tr>
<td>GP 65$^{(a)}$</td>
<td>Yes$^{(b)}$</td>
<td>Yes</td>
</tr>
</tbody>
</table>

(a) Water quality assessments and constant drawdown tests at direct-push locations were performed on 1 and 2-ft intervals from the phreatic surface (~13' bgs) to 20-22' bgs.

(b) Depth to water measurements are approximate and not intended for groundwater elevation calculations.

(c) Field parameters include: pH, electrical conductivity, temperature, dissolved oxygen, and oxidation reduction potential.
Table 3. Slug Test Results (March/April 2007)

<table>
<thead>
<tr>
<th>Monitoring Well</th>
<th>Well Screen (ft)</th>
<th>Hvorslev K (cm/s)</th>
<th>Hvorslev K (ft/d)</th>
<th>Bouwer and Rice K (cm/s)</th>
<th>Bouwer and Rice K (ft/d)</th>
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</thead>
<tbody>
<tr>
<td>P2-MW28</td>
<td>8-18</td>
<td>7.05E-03</td>
<td>19.34</td>
<td>1.34E-03</td>
<td>3.60</td>
</tr>
</tbody>
</table>

Note: The total depth of monitoring well P2-MW28 measured approximately 20 ft bgs, which did not correspond with the well completion specifications which reported a total depth of 18 ft bgs.
### Table 4. Field Data and Results for Constant Drawdown Aquifer Testing in Monitoring Wells (March/April 2007)

<table>
<thead>
<tr>
<th>Sampling Location*</th>
<th>Drawdown (ΔH) (ft) BSWS**</th>
<th>Volume purged (ml)</th>
<th>Time (min)</th>
<th>Time (sec)</th>
<th>Total Time (sec)</th>
<th>Q (ft³/s)</th>
<th>Q/ΔH (ft³/ft/s)</th>
<th>K (cm/sec)</th>
<th>K (ft/d)</th>
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<td>5.6E-02</td>
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* See Figure 3

** BSWS – Below estimated static water surface
Table 5. Depth-to-Groundwater and Groundwater Elevations for Monitoring Wells (March/April 2007)

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<th>Monitoring Well</th>
<th>Top of Casing Elevation (NGVD29) (ft)</th>
<th>Ground Surface Elevation (NGVD29) (ft)</th>
<th>NAD 27 Northing Coordinate (ft)</th>
<th>NAD 27 Easting Coordinate (ft)</th>
<th>DTW (m BTOC)</th>
<th>DTW (ft BTOC)</th>
<th>Groundwater Elevation (m)</th>
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DTW - Depth-to-water
BTOC - Below top of casing
BGS - Below ground surface
N/A - Data not available
NAD 27 – North American Datum of 1927
NGVD29 – National Geodetic Vertical Datum of 1929
--- Unable to take a water level reading because casing was destroyed
### Table 6. Water Quality Data for Monitoring Wells (March/April 2007)

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<th>Monitoring Well</th>
<th>pH</th>
<th>EC (mS)</th>
<th>Temperature (°C)</th>
<th>DO (mg/L)</th>
<th>ORP (mV)</th>
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(a) All measurements were made with a Horiba U-22 meter.
EC = electrical conductivity
DO = dissolved oxygen
ORP = oxidation-reduction potential
Table 7. Chemical Concentration Data for Monitoring Wells (March/April 2007)

<table>
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<th>Monitoring Well</th>
<th>Benzene (µg/L)</th>
<th>Toluene (µg/L)</th>
<th>Ethylbenzene (µg/L)</th>
<th>m/p-Xylene (µg/L)</th>
<th>o-Xylene (µg/L)</th>
<th>Naphthalene (µg/L)</th>
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DUP - Duplicate sample
REP - Quality control sample (second analysis of same water sample)
### Table 8. Chemical Concentration Data for Direct-Push Downgradient Transect Locations (March/April 2007)

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<th>m/p-Xylene</th>
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See Figure 1
DUP = Duplicate sample, REP = Quality control sample (second analysis of same water sample)
Table 9. Water Quality Data for Direct-Push Downgradient Transect Locations  
(March/April 2007)

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<th>Temperature (°C)</th>
<th>DO (mg/L)</th>
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(a) All measurements were made with a Horiba U-22 meter.
--- No water quality data taken
EC = electrical conductivity
DO = dissolved oxygen
ORP = oxidation-reduction potential
Table 10. Field Data and Results for Constant Drawdown Aquifer Testing in Direct-Push Downgradient Transect Locations (March/April 2007)

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* See Figure 2
** BSWS – Below estimated static water surface
Table 11. Monitoring Well Chemical Concentration Data Comparison

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N/A – No Data Available
Dup – Duplicate Sample
REP – Quality Control Sample (second analysis of same sample)
Critical Evaluation of the State of In Situ Thermal Treatment Technologies for DNAPL Source Zone Treatment

Prepared for:

Environmental Security Technology Certification Program
Arlington, VA

Prepared by:

Arizona State University
Battelle

January 2008
The vendors and products, including the equipment, system components, and other materials identified in this report, are primarily for information purposes only. Although some of these vendors and products may have been used in the past, mention in this report does not constitute a recommendation for using these vendors or products.
Contents

FIGURES .......................................................................................................................................... 236

TABLES ........................................................................................................................................... 236

ACRONYMS AND ABBREVIATIONS .............................................................................................. 237

1. INTRODUCTION ...................................................................................................................... 238

2. FIELD INVESTIGATION .......................................................................................................... 238

Figures

Figure 1. Site Map
Figure 2. Average Groundwater Temperature (within ERH Treatment Zone)
Figure 3. Monitoring Well C07 Data
Figure 4. Monitoring Well E03 Data
Figure 5. Monitoring Well E10 Data
Figure 6. Monitoring Well F06 Data
Figure 7. Monitoring Well FX3-1 Data
Figure 8. Monitoring Well FX3-12 Data
Figure 9. Monitoring Well FX3-13 Data
Figure 10. Monitoring Well FX3-2 Data
Figure 11. Monitoring Well FX3-4 Data
Figure 12. Monitoring Well FX3-6 Data
Figure 13. Monitoring Well H06 Data
Figure 14. Monitoring Well K02 Data
Figure 15. Monitoring Well LC-138 Data
Figure 16. Monitoring Well LC-156 Data
Figure 17. Monitoring Well LC-64A Data
Figure 18. Monitoring Well M08 Data
Figure 19. Monitoring Well P05 Data

Tables

Table 1. Groundwater Sampling Locations
Table 2. Groundwater Monitoring Well Analytical Data
Table 3. Groundwater Monitoring Well Water Temperatures
Table 4. Groundwater Treatment Zone Average Water Temperature
Table 5. Mass Flux Analysis
## Acronyms and Abbreviations

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<td>electrical resistance heating</td>
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1. Introduction

The post-treatment field investigation of Ft. Lewis, Washington – Area 3 (Area 3), under the Environmental Security Technology Certification Program (ESTCP) project CU-0314, *Critical Evaluation of State of the In-Situ Thermal Treatment Technologies*, was performed June 6, 2006 to September 25, 2007. Consistent with the objectives set forth in the CU-0314 Demonstration Plan, field investigations at this site focused on the collection of data to determine dissolved groundwater concentrations and the mass discharge immediately downgradient from the remediated source zone.

The investigation at Area 3 was different than the other field investigations performed under CU-0314; this was the only investigation that spanned the complete treatment cycle of an in-situ thermal remedial application. Since the electrical resistance heating (ERH) application at Area 3 was undergoing installation when field investigations for CU-0314 began, it was decided that pre-, active-, and post-treatment groundwater samples would be collected from existing upgradient, treatment zone, and downgradient groundwater monitoring wells. This monitoring approach provided a comprehensive set of data that allowed for pre- versus post-treatment groundwater data analysis, the ability to assess treatment temperature and groundwater concentration versus time and location, and with existing hydraulic conductivity information generated by the contractor, the ability to calculate a mass discharge from the treatment zone immediately following the application.

2. Field Investigations

In accordance with the approved generic demonstration plan for this project, the following site-specific activities were conducted:

1. Collection of groundwater samples from 5 upgradient, 8 treatment-zone, and 4 downgradient groundwater monitoring wells (see Figure 1) for analysis of dissolved chlorinated and petroleum hydrocarbon concentrations. Samples were collected and analyzed for the pre-, during-, and post-treatment thermal time periods.

   a. Table 1 identifies the groundwater monitoring wells from which samples were collected. Groundwater was collected by United States Army Corps of Engineers (USACE) personnel for analysis and stored in volatile organic analysis (VOA) vials preserved hydrochloric acid. Samples were packaged and shipped to Arizona State University where they were analyzed for dissolved chlorinated and petroleum hydrocarbon concentrations by heated-headspace analysis and gas chromatography (GC) using a photo-ionization detector (PID), a flame-ionization detector (FID), and a dry electrolytic conductivity detector (DELCD). Chemical concentration data can be found in Table 2. During the post-treatment sample analysis, 1,1-dichloroethene (DCE), was detected. Therefore, 1,1-DCE analysis was then performed on the pre- and during treatment samples, but it was not detected. All non-detect samples are listed as less than the detection limit.
All monitoring well chemical concentration data has associated sampling temperature data. Temperature data is based on either in-situ thermocouple measurements (for wells within the treatment zone) or field measurements of purge water (for wells outside of treatment zone). Table 3 presents the monitoring well sampling temperature data. An average treatment zone groundwater temperature was calculated from thermocouple data and can be found in Table 4 and Figure 2.

The dissolved chemical concentration data and average treatment zone temperature were plotted against time for each monitoring well. Figures 3 through 19 represent these data parameters.

Using the dissolved TCE groundwater concentration data and hydraulic conductivity measurements made by USACE personnel/contractors for monitoring wells around Area 3, a TCE mass flux calculation was performed\(^1\). Hydraulic conductivity measurements ranged from 38 to 120 ft/day with an average of 65 ft/day. This range of hydraulic conductivity values was used when determining the mass flux. Ft. Lewis also has a variable hydraulic gradients based on the time of year. A range of hydraulic gradient values was found based on groundwater elevation data recorded throughout 2006-2007. This range of measurements was used in determining the mass flux to provide a reasonable range of values based on the seasonal variations. Table 5 presents the mass flux discharge numbers. The mass flux results for TCE are estimated to be 1.42E-01 to 1.57E+00 kg/yr.

\(^1\) The Mass Flux Toolkit Version 1.0 was used to calculate the mass flux. The Mass Flux Toolkit is a freeware program developed by Groundwater Services, Inc. and others under a contract funded by ESTCP.
Figures
Figure 1. Site Map
Figure 2. Average Groundwater Temperature (within ERH Treatment Zone)
Figure 3. Monitoring Well C07 Data
Figure 4. Monitoring Well E03 Data
Figure 5. Monitoring Well E10 Data
Figure 6. Monitoring Well F06 Data
Figure 7. Monitoring Well FX3-1 Data
Figure 8. Monitoring Well FX3-12 Data
Figure 9. Monitoring Well FX3-13 Data
Figure 10. Monitoring Well FX3-2 Data
Figure 11. Monitoring Well FX3-4 Data
Figure 12. Monitoring Well FX3-6 Data
Figure 13. Monitoring Well H06 Data
Figure 14. Monitoring Well K02 Data
Figure 15. Monitoring Well LC-138 Data
Figure 16. Monitoring Well LC-156 Data
Figure 17. Monitoring Well LC-64A Data
Figure 18. Monitoring Well M08 Data
Figure 19. Monitoring Well P05 Data
Tables
Table 1. Groundwater Sampling Locations

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<td>Post-treatment concentration data</td>
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DUP - Duplicate sample, REP - Quality control sample (second analysis of same water sample), N/A - Contaminant not analyzed for Non-detect parameters are reported as less than the detection limit (<1 µg/L), TB - Trip blank DCE – Dichloroethene, TCE – Trichloroethene, TMB – Trimethylbenzene, PCE - Tetrachloroethene
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<tr>
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<tr>
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</tr>
<tr>
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<tr>
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<td>1/5/07</td>
<td>--</td>
</tr>
</tbody>
</table>

Note:
-- No temperature data taken
* Temperature data estimated based on background temperature because wells were not in the treatment zone
Table 3. Groundwater Monitoring Well Water Temperatures (Continued)

<table>
<thead>
<tr>
<th>Monitoring Well</th>
<th>Date Analyzed</th>
<th>Post-Treatment Temperature (ºC)</th>
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</thead>
<tbody>
<tr>
<td>C07</td>
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<td>C07</td>
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<table>
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<td>M08</td>
<td>3/1/07</td>
<td>34</td>
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<tr>
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Note:
-- No temperature data taken
* Temperature data estimated based on background temperature because wells were not in the treatment zone
Table 4. Groundwater Treatment Zone Average Water Temperature

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<th>Date</th>
<th>Temperature (°C)</th>
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<td>12/24/06</td>
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<tr>
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<td>3/15/07</td>
<td>43</td>
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<tr>
<td>4/5/07</td>
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<tr>
<td>7/16/07</td>
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<td>8/13/07</td>
<td>29</td>
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<tr>
<td>9/18/07</td>
<td>28</td>
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</table>
Table 5. Mass Flux Analysis

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<tr>
<th>Hydraulic conductivity (ft/day)</th>
<th>Hydraulic Gradient (ft/ft)</th>
<th>Hydraulic Conductivity and Gradient Measurements</th>
<th>Discharge (kg/yr)</th>
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</thead>
<tbody>
<tr>
<td>38</td>
<td>0.0012</td>
<td>Low hydraulic conductivity and gradient</td>
<td>1.42E-01</td>
</tr>
<tr>
<td>38</td>
<td>0.0027</td>
<td>Low hydraulic conductivity and average gradient</td>
<td>3.20E-01</td>
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<tr>
<td>65</td>
<td>0.0027</td>
<td>Average hydraulic conductivity and gradient</td>
<td>5.47E-01</td>
</tr>
<tr>
<td>65</td>
<td>0.0034</td>
<td>Average hydraulic conductivity and middle of average and high gradient</td>
<td>6.89E-01</td>
</tr>
<tr>
<td>120</td>
<td>0.0042</td>
<td>High hydraulic conductivity and gradient</td>
<td>1.57E+00</td>
</tr>
</tbody>
</table>
Appendix E

Quality Assurance Project Plan
(see electronic attachment)
E1.0 Purpose and Scope of Plan

This Quality Assurance Project Plan (QAPP) establishes the quality assurance guidelines to be utilized during this project. This QAPP has been developed to address the DoD requirements for precision, accuracy, representativeness, completeness, and comparability of data collected and generated during this demonstration. The QAPP also provides the quality assurance requirements for data handling, manipulation, and reporting. It has been designed to ensure the quality of the data gathered and generated, as well as the conclusions and recommendations reached from the use of the data.

E2.0 Quality Assurance Responsibilities

Dr. Paul C. Johnson will be responsible for ensuring that the data collection activities conform to this QAPP. ASU will conduct the analysis of groundwater samples in the field with a laboratory-quality GC (SRI Model 3610C or equivalent). The ASU field laboratory will establish data quality objectives similar to those outlined below.

The quality assurance activities incorporated in the project will be used to maintain the accuracy and the precision of the system demonstration and the field analytical techniques. These activities include frequent equipment calibration, field blank samples (for shipment to the analytical laboratory), and field laboratory sample blanks. The quality assurance activities are designed to trigger corrective action activities and diagnose potential sources of error.

ASU will be responsible for summarizing the laboratory data and for data reduction and technology evaluation. Dr. Paul Johnson will be responsible for reviewing analytical data, identifying any deviations from the established protocols and data quality objectives, and then deciding how the data will be used, and what corrections, if any, need to be made to the field analytical procedures.

E3.0 Project Objectives

The objectives of this demonstration are summarized below:
<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Description</th>
<th>Primary or Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data set collected provides useful supplemental post-treatment data on water quality and mass discharge</td>
<td>Data set to include aquifer characterization data and contaminant concentration along a transect perpendicular to groundwater flow.</td>
<td>Primary</td>
</tr>
</tbody>
</table>

This QAPP focuses on the in-field data collection activities.

**E4.0 Experimental Measurements**

The following section describes measurements to be made during this project; these are divided into categories focused on water quality changes and system hydraulic measurements.

**E4.1 Groundwater Quality Measurement**

Groundwater will be assessed for dissolved oxygen and concentrations of chemicals of interest (site-specific).

**General Water Quality Parameters:** General water quality parameters pH, electrical conductivity (EC), temperature, dissolved oxygen (DO), and oxidation reduction potential (ORP) will be measured using a flow-through system composed of a meter (Horiba U-22 or similar), a flow-through cell, and a variable-speed slow-flow peristaltic pump. Water quality measurements will be monitored until a stable reading is obtained and until a sufficient volume of water from the well or groundwater sampling point is purged (volume will vary depending on the depth of the depth-discrete sample).

**Dissolved Oxygen:** In lieu of more detailed general water quality assessments, DO concentrations will be measured using a flow-through system composed of a DO meter (YSI Model 550A Oxygen Probe or similar), a flow-through cell, and a variable-speed slow-flow peristaltic pump. DO concentrations will be monitored until a stable reading is obtained and until a sufficient volume of water from the well or groundwater sampling point is purged (volume will vary depending on the depth of the depth-discrete sample).

**Dissolved Chemicals of Interest:** Groundwater samples will be collected using the low-flow variable-speed peristaltic pump discussed above. After water quality parameters have been collected and an appropriate volume of water has been purged from the sampling interval, a sample will be collected in a 40-mL VOA vial with a septa-lined cap. Groundwater samples will be analyzed in the field for concentrations of chemicals of interest. Samples measured in the field will be analyzed using a headspace GC method. The GC used will be an SRI Series 8610C.
or similar equipped with a FID, PID, and/or an DELCD detectors. The GC will be calibrated to known dissolved concentrations of these analytes.

E4.2 System Hydraulics Measurements

The following measurements relate to better understanding the groundwater flow system at the time of sampling:

**Depth to groundwater:** The depth to groundwater will be measured with a standard electronic interface probe. For example, typical devices are comprised of an electronic sensor attached to the end of a 50- to 200-ft measuring tape marked with 0.01-ft increments.

**Aquifer Characterization Tests:** Specific capacity pump tests will be conducted as follows: a) an interface probe will locate the static water level in a small-diameter Geoprobe drive rod, b) tubing will be lowered so that the tubing intake is located a known distance below the static water level, c) a peristaltic pump will be operated at full speed with the hope that the pump rate is faster than the recharge rate to the well, so that the draw-down becomes the depth to the tubing intake, d) the flow rate is measured by the standard bucket-and-stopwatch approach, and e) the data is analyzed to determine hydraulic conductivity.

Slug tests will be conducted in conventional wells using a data logging pressure transducer and a slug capable of displacing about 2-ft of water. The slug is either lowered into, or pulled out of the well, and the water level response is monitored until it stabilizes at the pre-test level. The data is then analyzed by standard slug-test analysis methods.

Laboratory permeameter tests will be conducted using the constant-head technique whereby the flow through a vertical column is measured under conditions of a constant pre-set hydraulic head. The flow is measured by recording the time it takes to fill a 2-L volumetric flask and then the hydraulic conductivity is determined from the known column geometry, pre-set head, and measured flowrate.

E4.3 Sample Collection Techniques

Groundwater samples will be collected in a manner consistent with site conditions.

In most cases, groundwater samples will be collected using a variable-speed low-flow peristaltic pump and collected in a 40-mL VOA vial with a septa-lined cap. Analyses will be conducted in the field within 24-hours. In some cases it may be necessary to collect samples using bailers or down-hole pumps.

All sample collection devices will be cleaned and prepared in accordance to applicable USEPA procedures prior to each use.

E4.4 Sample Identification Procedures

Each sample will be identified with a unique sample number coded to correlate to the sampling location and depth assigned by the sample collector at the time of collection. This code will be
logged onto a master field data sheet indicating who collected the sample, where the sample was collected, and the date of sample collection.

Each sample will be logged in the Project Record Book (see section on Documentation) with the information recorded on the sample container label and a brief sample description. Any samples being shipped off-site for analysis will be logged on a chain-of-custody log sheet to be sent with the samples to document sample receipt.

**E5.0 Data Quality Parameters**

Precision will be based on the relative percent difference (RPD) of duplicate analysis of samples. Accuracy will be determined by the percentage of analyte recovered (percent recovery [%R]) from sample of known concentration. Laboratory QC will consist of analytical duplicates conducted for 10% of the total samples submitted for analysis. One laboratory control sample will be included for each 20 samples to ensure that the analytical equipment is operating properly. Laboratory controls will consist of standards of known concentrations. The calculation for each of these quantitative objectives is described in the following sections.

**Accuracy:** The percent accuracy is calculated from the general equation:

\[
\text{% Accuracy} = \frac{100 (X - X_a)}{X_a} \quad (B-1)
\]

where

- \(X\) is the parameter measured
- \(X_a\) is the parameter's known value

The accuracy claimed by each field instrument manufacturer will be compared with the percent accuracy as measured from standard samples. If the percent accuracy is less than the required accuracy then corrective action will be initiated.

**Precision:** Precision for the field laboratory analytical procedures will be assessed by the analytical laboratory on an on-going basis. ASU (Dr. Johnson) will review all analytical data to ensure that any questions concerning data validity are addressed at the earliest time possible.

**Completeness:** Percent completeness is defined by the general equation:

\[
\text{% Completeness} = 100 \frac{D_o}{D_s} \quad (B-2)
\]

where

- \(D_o = \text{quantity of data obtained}\)
- \(D_s = \text{quantity of data scheduled to be obtained}\)
Completeness in meeting the scheduled data recovery objectives will increase throughout the project as the experience base in equipment operation characteristics increases. The completeness objective for operations during this study is 90% for each test parameter.

E6.0 Calibration Checks, Quality Control Checks, and Corrective Actions

All GC-FID/PID/DELCD analyses will be conducted on a dedicated SRI Instruments Model 8610C gas chromatograph using a DB-1 type capillary column. The instrument will be calibrated each day at at least three different concentrations spanning the concentration range of interest (e.g. 10, 100, 1000 µg/L for dissolved concentrations of chemicals of interest). In addition, at least one calibration sample is re-analyzed approximately two – to four-times during the day to detect any instrument drift. If area counts from successive calibration analyses consistently deviate by more than 20%, or if retention times vary by more than 0.20 minutes, then the following routine checks are made to the equipment: a) leaking septum and b) change in gas flows. If these prove not to be the source of error, then a new standard is made and analyzed. If necessary, recalibration over the entire concentration range is repeated. Reporting levels will be established based on the calibration results. Based on experience with this instrument, reporting levels of about 1 – 5 µg/L are possible for typical chemicals of interest in groundwater.

Water quality meters are calibrated according to the manufacturer’s specification.

YSI DO meters are calibrated in air, at ambient temperature, according to the manufacturer’s specification.

The specific nature of all corrective actions and the operating limits that would trigger the need for corrective action for all aspects of the remediation system and analytical operations are to numerous to anticipate here. Most corrective actions will be empirical in nature as the following specific examples show.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem</td>
<td>Corrective Action</td>
</tr>
<tr>
<td>Analysis of standard sample indicated field GC accuracy has drifted outside established limits (calibration check every 20 samples).</td>
<td>Perform replicate standard analysis. Verify instrument parameters Recalibrate instrument.</td>
</tr>
<tr>
<td>DO/WQ meter does not calibrate properly, or is providing suspect data.</td>
<td>Recalibrate and re-test Replace membrane as applicable, recalibrate, and retest</td>
</tr>
</tbody>
</table>
E7.0 Documentation and Record-Keeping

E7.1 Quality Assurance Reports

A chronological record of all field work associated with the project will be maintained in the Project Record Book. The record book will be used to record all activities and relevant observations during the field sampling events.

E7.2 Data Format

A summary of the sampling results for each sampling event will be produced within 30 days of the sampling event. The data will be presented with the following data fields:

- Sampling date
- Sampling time
- Location designation
- Position of sampling location relative to known location
- DO
- Temperature
- Chemical concentration(s)
- Relevant notes for the collection and analysis of that sample

E7.3 Data Storage

All data and reports will be archived in both paper and electronic format. All electronic files will be backed-up on compact disks (CDs) at one-month intervals (minimum). All paper files (e.g., field log books) will be copied and archived in a project-specific file.
APPENDIX F

Uncertainty Analysis for Mass Discharge Calculations
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<th>End of Transect</th>
<th>Top of Sampling Interval</th>
<th>Bottom of Sampling Interval</th>
<th>Parameter Examined</th>
<th>Parameter Value Removed For Analysis</th>
<th>Total Mass Flux Excluding Selected Point and Interpolating (g/day)</th>
<th>Contribution of Selected Point to Total Mass Flux (%)</th>
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**RESULTS**
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<th>Total Mass Flux Excluding Selected Point and Interpolating (g/day)</th>
<th>Contribution of Selected Point to Total Mass Flux (%)</th>
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**RESULTS**
### Interpolation Error Results

**TCE Interpolation Methods**
- Hydraulic Conductivity: 1) Vertical: Linear 2) Horizontal: Linear
- Concentration: 1) Vertical: Linear 2) Horizontal: Linear
- Hydraulic Gradient: Nearest Neighbor

**Total Mass Flux Including All Points**

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Bottom of
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Parameter
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Parameter
Value
Removed For
Analysis

Parameter
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Total Mass Flux
Excluding Selected
Point and
Interpolating
(g/day)

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7.50E+02
1.20E+03
6.20E+02
5.40E+02
6.20E+02
6.80E+01
3.00E+00
2.00E+01
7.20E+01
1.10E+02
7.30E+02
5.80E+01
1.80E+05
1.50E+05
4.20E+04
4.40E+03
1.20E+03
1.10E+02
2.70E+01
3.00E+01
4.20E+02
1.10E+05
1.10E+05
9.40E+04
7.90E+04
2.80E+04
2.70E+04
1.70E+02
5.10E+02
1.90E+02
1.20E+05
9.40E+04
3.80E+03
3.60E+03
2.30E+03
5.70E+02
2.10E+03
5.20E+03
1.80E+03
1.80E+03
1.40E+02
3.20E+01
0.00E+00

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9.10E+01
9.12E+01
8.99E+01
9.10E+01
9.01E+01
9.41E+01
9.16E+01
9.60E+01
8.90E+01
8.96E+01
9.26E+01
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9.10E+01
1.10E+02
7.91E+01
9.01E+01
9.25E+01
9.13E+01
9.10E+01
9.11E+01
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9.10E+01
9.10E+01
8.97E+01
9.10E+01
9.11E+01
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9.12E+01
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9.15E+01
9.10E+01
9.10E+01
8.91E+01
9.05E+01
9.42E+01
9.10E+01
9.10E+01
9.10E+01
9.10E+01
9.10E+01
9.10E+01
9.10E+01
9.10E+01
9.10E+01
9.13E+01

Page 2 of 2

Contribution of
Selected Point to
Total Mass Flux
(%)
0.0
-0.2
1.2
0.0
1.0
-3.4
-0.7
-5.5
2.2
1.6
-1.7
-3.7
0.0
-2.7
3.4
-1.7
-0.2
0.1
-0.1
0.1
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.2
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
-21.4
13.0
1.0
-1.6
-0.4
0.0
-0.1
0.0
0.0
0.0
1.4
0.0
-0.1
1.3
-0.2
0.0
-0.5
0.0
0.0
2.1
0.5
-3.6
0.0
0.0
0.0
0.0
0.1
0.0
0.0
0.0
0.0
-0.3


## TCE Interpolation Methods

**Hydraulic Conductivity:** Uniform  
**Concentration:** 1) Vertical: Linear  2) Horizontal: Linear  
**Hydraulic Gradient:** Uniform

### Total Mass Flux Including All Points

<table>
<thead>
<tr>
<th>End of Transect</th>
<th>Top of Sampling Interval</th>
<th>Bottom of Sampling Interval</th>
<th>Parameter Examined</th>
<th>Parameter Value Removed For Analysis</th>
<th>Parameter Units</th>
<th>Total Mass Flux Excluding Selected Point and Interpolating (g/day)</th>
<th>Contribution of Selected Point to Total Mass Flux (%)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Start of Transect</td>
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TCE Interpolation Methods

Hydraulic Conductivity: Uniform
Concentration: 1) Vertical: Linear 2) Horizontal: Linear
Hydraulic Gradient: Uniform

Total Mass Flux Including All Points: 3.90E-01 (g/day)

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### TCE Interpolation Methods

- **Hydraulic Conductivity:** Uniform
- **Concentration:** 1) Vertical: Linear  2) Horizontal: Linear
- **Hydraulic Gradient:** Uniform

### Total Mass Flux Including All Points

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Removed For Analysis</th>
<th>Interpolating Total Mass Flux Including All Points (g/day)</th>
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<td><strong>Bottom of Sampling Interval</strong></td>
<td><strong>Parameterler Value Intercepting</strong></td>
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<td><strong>Total Mass Flux Excluding Selected</strong></td>
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<td></td>
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<td>(g/day)</td>
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### RESULTS
### Interpolation Error Results

#### Benzene Interpolation Methods

Hydraulic Conductivity: 1) Vertical: Linear  2) Horizontal: Linear  
Concentration: 1) Vertical: Linear  2) Horizontal: Linear  
Hydraulic Gradient: Nearest Neighbor

**Total Mass Flux Including All Points**: 1.03E-01 (g/day)

#### RESULTS

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<th>Top of Sampling Interval</th>
<th>Bottom of Sampling Interval</th>
<th>Parameter Examined</th>
<th>Parameter Value Removed For Analysis</th>
<th>Parameter Units</th>
<th>Interpolating calculated without that point using the interpolation scheme specified in the DMA input route data.</th>
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</table>

*Note: The table above shows all concentration and, if applicable, non-uniform conductivity/Darcy velocity and gradient input data. During the uncertainty analysis, each of the points in the table are removed one at a time and the mass flux calculated without that point using the interpolation scheme specified in the DMA input route data.*
<table>
<thead>
<tr>
<th>End of Transect</th>
<th>Top of Sampling Interval</th>
<th>Bottom of Sampling Interval</th>
<th>Parameter Examined</th>
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<th>Total Mass Flux Excluding Selected Point and Interpolating (g/day)</th>
<th>Contribution of Selected Point to Total Mass Flux (%)</th>
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<td>Contribution of Selected Point to Total Mass Flux (%)</td>
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**RESULTS**

- **Parameter Examined**: Concentration or Gradient
- **Parameter Value Removed For Analysis**: 0.00E+00 or 1.00E+00
- **Parameter Units**: ug/L or ft/ft
- **Total Mass Flux Excluding Selected Point and Interpolating (g/day)**
- **Contribution of Selected Point to Total Mass Flux (%)**

**End of Transect** is marked with a 1.00E+00 in the Parameter Value column.