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

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- **Thermal Conduction Heating** -
  Gorm Heron (TerraTherm)
  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.
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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<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>
<tbody>
<tr>
<td>Quantitative Performance Objectives</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collect data on in-situ thermal applications</td>
<td>Data on hydrogeologic setting, type and method of application, temperature data, and estimate of contaminant reduction</td>
<td>• Ability to obtain documentation</td>
<td>Summary table of relevant data.</td>
</tr>
<tr>
<td>Qualitative Performance Objectives</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assess Groundwater Quality and Mass Discharge</td>
<td>Groundwater concentration data and groundwater velocity</td>
<td>Ability to obtain accurate concentration data and velocity data</td>
<td>Summary tables of concentration and mass discharge data.</td>
</tr>
</tbody>
</table>

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 downgradient 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 Full-Scale Systems</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:</td>
<td>Steam Heating</td>
<td></td>
<td></td>
<td></td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>see footnotes</td>
</tr>
<tr>
<td>relatively homogeneous and permeable unconsolidated sediments (mixtures of sands, gravels and silts, etc.)</td>
<td>Resistance Heating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Other</td>
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<td></td>
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<tr>
<td>Generalized Scenario B:</td>
<td>Steam Heating</td>
<td></td>
<td></td>
<td></td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>see footnotes</td>
</tr>
<tr>
<td>relative homogeneous and permeable unconsolidated sediments (days, slurry days, etc.)</td>
<td>Resistance Heating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generalized Scenario C:</td>
<td>Steam Heating</td>
<td></td>
<td></td>
<td></td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>see footnotes</td>
</tr>
<tr>
<td>largely permeable sediments with interbedded lenses of low permeable material</td>
<td>Resistance Heating</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td>Other</td>
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<td></td>
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<tr>
<td>Generalized Scenario D:</td>
<td>Steam Heating</td>
<td></td>
<td></td>
<td></td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>see footnotes</td>
</tr>
<tr>
<td>largely impermeable sediments with interbedded layers of higher permeable material</td>
<td>Resistance Heating</td>
<td></td>
<td></td>
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<td></td>
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<td>Other</td>
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<tr>
<td>Generalized Scenario E:</td>
<td>Steam Heating</td>
<td></td>
<td></td>
<td></td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>see footnotes</td>
</tr>
<tr>
<td>competent, but fractured bedrock</td>
<td>Resistance Heating</td>
<td></td>
<td></td>
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<td>Other</td>
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<td></td>
</tr>
<tr>
<td>Generalized Scenario F:</td>
<td>Steam Heating</td>
<td></td>
<td></td>
<td></td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>see footnotes</td>
</tr>
<tr>
<td>weathered bedrock</td>
<td>Resistance Heating</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Other</td>
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<tr>
<td>Generalized Scenario G:</td>
<td>Steam Heating</td>
<td></td>
<td></td>
<td></td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>see footnotes</td>
</tr>
<tr>
<td></td>
<td>Resistance Heating</td>
<td></td>
<td></td>
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<td>Other</td>
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</tr>
</tbody>
</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

| Technology            | Site Name | Geology at This Site (Most Like Scenario?) | Year(s) Applied | Pilot Test? | Full-Scale System? | # of Energy Delivery Points (wells or electrodes) | Size of Target Treatment Area | Thickness of Target Treatment Interval | Depth to Top of Treatment Zone | Thickness of Treatment Zone Below Ground Water Table | Peak Temperature in Target Treatment Zone | Duration of Treatment at Peak Temperature | Number of Ground Water Monitoring Wells Used for Post-Treatment Monitoring | Duration of Post-Treatment Monitoring | Estimated Post-Treatment Mass Discharge | Estimated Reduction in Mass Discharge | Criteria Used to Assess Success |
|-----------------------|-----------|---------------------------------------------|----------------|-------------|--------------------|--------------------------------------------------|-------------------------------|-----------------------------------|----------------------------------|---------------------------------------------|-----------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Steam Injection       | Site #1   |                                             |                 |             |                    |                                                  |                               |                                    |                                  |                                             |                                    |                                              |                                              |                                              |                                              |                                              |
|                       | Site #2   |                                             |                 |             |                    |                                                  |                               |                                    |                                  |                                             |                                    |                                              |                                              |                                              |                                              |                                              |
|                       | Site #3   |                                             |                 |             |                    |                                                  |                               |                                    |                                  |                                             |                                    |                                              |                                              |                                              |                                              |                                              |
| Electrical Resistance Heating | Site #4    |                                             |                 |             |                    |                                                  |                               |                                    |                                  |                                             |                                    |                                              |                                              |                                              |                                              |                                              |
|                       | Site #5    |                                             |                 |             |                    |                                                  |                               |                                    |                                  |                                             |                                    |                                              |                                              |                                              |                                              |                                              |
|                       | Site #6    |                                             |                 |             |                    |                                                  |                               |                                    |                                  |                                             |                                    |                                              |                                              |                                              |                                              |                                              |
| Other Thermal Treatments | Site #7    |                                             |                 |             |                    |                                                  |                               |                                    |                                  |                                             |                                    |                                              |                                              |                                              |                                              |                                              |
|                       | Site #8    |                                             |                 |             |                    |                                                  |                               |                                    |                                  |                                             |                                    |                                              |                                              |                                              |                                              |                                              |
|                       | Site #9    |                                             |                 |             |                    |                                                  |                               |                                    |                                  |                                             |                                    |                                              |                                              |                                              |                                              |                                              |

**Scenario Descriptors (for the target treatment zone):**

A - relatively homogenous and permeable unconsolidated sediments (sands, etc.)
B - relatively homogenous and relatively impermeable unconsolidated sediments (clays)
C - largely permeable sediments with interbedded lenses of low permeable material
D - largely impervious sediments with interbedded layers of higher permeable material
E - Competent, but Fractured Bedrock
F - Weathered Bedrock

**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 Scenario</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</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>Former Pumphouse #2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Force Plant 4</td>
<td>170</td>
<td>Flow direction based on groundwater contour maps and contaminant distribution from site documentation.</td>
</tr>
<tr>
<td>Bldg 181</td>
<td></td>
<td></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</td>
<td>10</td>
<td>400</td>
<td>12 - 22</td>
<td>48</td>
<td>47</td>
</tr>
<tr>
<td>Former Pumphouse #2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Force Plant 4</td>
<td>10</td>
<td>170</td>
<td>29 - 35</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Bldg 181</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></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>

\( \text{ft} \) - Feet  
\( \text{bgs} \) – Below ground surface  
\( \text{N/A} \) – 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 (16 sampling events)</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 8. Range of Permanent Monitoring Well Pre- and Post-Treatment Concentration Data (ug/L).

<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>Hunter Army Airfield, Former Pumphouse 2</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>Air Force Plant 4, Bldg 181</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>NAS Alameda, Site 5-1, Bldg. 5</td>
<td>1,1-Dichloroethane</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>Cis-1,2-Dichloroethene</td>
<td>48,800</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>ND&lt;250</td>
<td>ND&lt;1.3</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>ND&lt;250</td>
<td>ND&lt;0.5</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Camp LeJeune, Site 89</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>16,100</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>Cis-1,2-Dichloroethene</td>
<td>48,800</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>ND&lt;250</td>
<td>ND&lt;1.3</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>ND&lt;250</td>
<td>ND&lt;0.5</td>
<td>ND&lt;0.5</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ft. Lewis EGDY Area 3</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-Tetrachloroethane</td>
<td>18,600</td>
<td>ND&lt;2</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</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></td>
<td>Vinyl Chloride</td>
<td>5,500</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>Tetrachloroethylene</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)&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Post-treatment Mass Discharge (kg/yr)&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Post-treatment Mass Discharge per Linear Foot (kg/yr/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter Army Airfield</td>
<td></td>
<td>5.2 x 10&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1.9 x 10&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>1.1 x 10&lt;sup&gt;-3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Former Pumphouse 2&lt;sup&gt;*&lt;/sup&gt;</td>
<td></td>
<td>6.0 x 10&lt;sup&gt;1&lt;/sup&gt;</td>
<td>2.1 x 10&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>1.4 x 10&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Air Force Plant 4</td>
<td></td>
<td>4.9 x 10&lt;sup&gt;1&lt;/sup&gt;</td>
<td>4.9</td>
<td>3.4 x 10&lt;sup&gt;-2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bldg 181&lt;sup&gt;**&lt;/sup&gt;</td>
<td></td>
<td>6.0 x 10&lt;sup&gt;1&lt;/sup&gt;</td>
<td>4.9</td>
<td>3.4 x 10&lt;sup&gt;-2&lt;/sup&gt;</td>
</tr>
<tr>
<td>NAS Alameda Site 5-1, Bldg. 5&lt;sup&gt;*&lt;/sup&gt;</td>
<td></td>
<td>6.8 x 10&lt;sup&gt;2&lt;/sup&gt;</td>
<td>8.2 x 10&lt;sup&gt;1&lt;/sup&gt;</td>
<td>5.5 x 10&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Camp LeJeune Site 89&lt;sup&gt;*&lt;/sup&gt;</td>
<td></td>
<td>3.2 x 10&lt;sup&gt;1&lt;/sup&gt;</td>
<td>2.1</td>
<td>1.9 x 10&lt;sup&gt;-2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ft. Lewis EGDY Area 3&lt;sup&gt;***&lt;/sup&gt;</td>
<td></td>
<td>Total Contaminant Flux</td>
<td></td>
<td></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-bedded layers of higher permeability sediments
- **Scenario C**: largely permeable sediments with inter-bedded 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 \(<4 \times 10^4 \text{ ft}^2\) \((<3716 \text{ m}^2, \text{ or about one acre})\) and roughly two-thirds of those involved treatment zones smaller than \(10^4 \text{ ft}^2\) \((<929 \text{ m}^2, \text{ or about a quarter-acre})\). 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></td>
<td>Total</td>
<td>182</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  10⁴ - 4x10⁴  &lt;4x10⁴  Unknown</td>
<td>&lt;0.25  0.25-0.50  &gt;0.5  Unknown</td>
</tr>
<tr>
<td>Steam-Based Heating</td>
<td>16     6      4      20</td>
<td>20     2      4      20</td>
</tr>
<tr>
<td>Resistance Heating</td>
<td>36     24     0      27</td>
<td>10     23     27     27</td>
</tr>
<tr>
<td>Conductive Heating</td>
<td>19     6      0      1</td>
<td>1       1      23     1</td>
</tr>
<tr>
<td>Other (including Mixing/Heating)</td>
<td>8     2      0      13</td>
<td>2       0      8      13</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 ft² (~per 10 m²), 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 ft² (~one per 40 m², or greater than 20-ft (6-m) spacings), while most conductive heating applications involved densities greater than one energy delivery point per 200 ft² (~one per 20 m², 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 13. Basic Operating Conditions Summary for all Applications Reviewed.

<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>Generalized Scenario A: relatively homogeneous and unconsolidated sediments (mixtures of sands, gravels and silts, etc.)</td>
<td>SEE</td>
<td></td>
<td></td>
<td></td>
<td>Guadalupe</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>Generalized Scenario C: largely permeable sediments with interbedded lenses of less permeable material</td>
<td>SEE</td>
<td></td>
<td></td>
<td></td>
<td>Edwards Air Force Base, Edwards Air Force Base</td>
</tr>
<tr>
<td>Generalized Scenario E: weathered bedrock</td>
<td>SEE</td>
<td></td>
<td></td>
<td></td>
<td>Edwards Air Force Base, Edwards Air Force Base</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>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</td>
</tr>
<tr>
<td>3</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td>10x</td>
<td></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></td>
</tr>
<tr>
<td>6</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td>&lt;10x</td>
<td>x</td>
</tr>
<tr>
<td>7</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td>&lt;10x</td>
<td></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></td>
</tr>
<tr>
<td>10</td>
<td>ERH</td>
<td>Generalized Scenario C</td>
<td>1000x</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>SEE</td>
<td>Generalized Scenario C</td>
<td>100x</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>SEE</td>
<td>Generalized Scenario C</td>
<td>10x</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>SEE</td>
<td>Generalized Scenario C*</td>
<td>10000x</td>
<td>x</td>
</tr>
<tr>
<td>14</td>
<td>SEE</td>
<td>Generalized Scenario D*</td>
<td>&lt;10x</td>
<td></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)</th>
<th>Post-treatment Discharge (kg/yr)</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 10^1</td>
<td>1.9 x 10^{-1}</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 10^1</td>
<td>2.1 x 10^{-1}</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^{-3}</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^{-3}</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^{-1}</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^{-2}</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^{-2}</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^{-2}</td>
<td>1.6 x 10^{-3}</td>
</tr>
<tr>
<td>14</td>
<td>SEE</td>
<td>Generalized Scenario C</td>
<td></td>
<td>4.6</td>
<td>7.3 x 10^{-2}</td>
<td>3.4 x 10^{-3}</td>
</tr>
<tr>
<td>13</td>
<td>SEE</td>
<td>Generalized Scenario C **</td>
<td></td>
<td>1.3</td>
<td>2.8</td>
<td>1.0 x 10^{-3}</td>
</tr>
<tr>
<td>14</td>
<td>SEE</td>
<td>Generalized Scenario D</td>
<td></td>
<td>1.9 x 10^{-2}</td>
<td>1.8 x 10^{-2}</td>
<td>1.2 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 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 base 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 discrete-depth sampling data only and discrete-depth sampling data with monitoring well data.
^^ 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 \(<4 \times 10^4 \text{ ft}^2\) (\(<4000 \text{ m}^2\) or an acre) and two-thirds of those were \(<10^4 \text{ ft}^2\) (\(<1000 \text{ m}^2\) 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 Address</th>
<th>Phone Fax E-mail</th>
<th>Role in Project</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Project Technical Lead</td>
</tr>
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<td>Team Member</td>
</tr>
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<td>Team Member</td>
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<td>Team Member</td>
</tr>
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<td>COR</td>
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Points of Contact

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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.

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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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<tbody>
<tr>
<td>10</td>
<td>60-80</td>
</tr>
<tr>
<td>12</td>
<td>90-120</td>
</tr>
<tr>
<td>15</td>
<td>120-180</td>
</tr>
<tr>
<td>20</td>
<td>300-400</td>
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</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).

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\textsuperscript{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\textsuperscript{3}) at temperatures below 325°C, sites are rarely heated beyond this temperature.

\textsuperscript{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 Ohio. 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 zones.
- 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

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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\textsuperscript{6}.

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\textsuperscript{7}.

2.5 \textit{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.\textsuperscript{8}.

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


\textsuperscript{7} Baker and Kuhlman, Ibid.

\textsuperscript{8} LaChance et al 2006. Ibid.
components and stabilization of the leftover NAPL phase allows treatment at the boiling point\(^9\).

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.

![Diagram of generic layout of heater borings and process equipment](image)

Figure 3. Generic layout of heater borings and process equipment for an ISTD project.

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.

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.

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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 project11, 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.

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• 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 know 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 flotation. 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.

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.

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.
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\(^\text{13}\).

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

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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.

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(^{16})</td>
</tr>
<tr>
<td>20-40</td>
<td>100-200</td>
<td>Young-Rainey STAR Center Area A(^{17})</td>
</tr>
<tr>
<td>&gt;40</td>
<td>200-400+</td>
<td>Visalia Pole Yard (Creosote)(^{18})</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


\(^{17}\) Heron et al. 2005. Ibid.

\(^{18}\) 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 Yard19, 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.
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.\textsuperscript{20}

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).

Figure 6. Effluent Treatment System.

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)

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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.\(^{24}\) 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.

![Figure 3. 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

\(^{24}\) 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 ¾ 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.**

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

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:
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>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Analyzed By</td>
<td>JT</td>
</tr>
<tr>
<td>PD</td>
<td>X</td>
</tr>
<tr>
<td>Date</td>
<td>11/10/2006</td>
</tr>
<tr>
<td>Type of treatment</td>
<td>Conductive</td>
</tr>
<tr>
<td>Steam</td>
<td>X</td>
</tr>
<tr>
<td>ERH</td>
<td>X</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Type of Contaminant</td>
<td>Chlorinated Solvents</td>
</tr>
<tr>
<td>Petroleum Hydrocarbons</td>
<td>X</td>
</tr>
<tr>
<td>Pesticides</td>
<td></td>
</tr>
<tr>
<td>Wood Treating</td>
<td>X</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Treatment Status</td>
<td>Active</td>
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<tr>
<td>Post</td>
<td>X</td>
</tr>
<tr>
<td>Type of Test</td>
<td>Pilot Test</td>
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<tr>
<td>Full Scale System</td>
<td>X</td>
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<tr>
<td>Start of Test</td>
<td>varied</td>
</tr>
<tr>
<td>End of Test</td>
<td>varied</td>
</tr>
<tr>
<td>Duration</td>
<td>42 to 47 days</td>
</tr>
<tr>
<td>Type of Site</td>
<td>Non-DOD</td>
</tr>
<tr>
<td>DoD</td>
<td>X</td>
</tr>
<tr>
<td>Facility Name</td>
<td>Ft. Richardson (Arrays 1, 2, and 3)</td>
</tr>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code</td>
<td>Ft. Richardson, Alaska</td>
</tr>
<tr>
<td>OU# or Site #</td>
<td>OU B; Poleline Rd Disposal Area (Arrays 4, 5, and 6)</td>
</tr>
<tr>
<td>Primary point of contact</td>
<td>Scott Kendell</td>
</tr>
<tr>
<td>Organization</td>
<td>US Army Corps - Alaska District</td>
</tr>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code</td>
<td></td>
</tr>
<tr>
<td>Phone #</td>
<td>907-753-5661</td>
</tr>
<tr>
<td>email</td>
<td><a href="mailto:scott.kendall@poar02.usace.army.mil">scott.kendall@poar02.usace.army.mil</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></td>
</tr>
<tr>
<td>Type</td>
<td>Vendor, Consultant</td>
</tr>
<tr>
<td>Vendor, Technical Applications</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

### 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): ___
- 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: ___
- Number of relevant monitoring wells with groundwater data:
  - 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>Trichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>10 mg/kg</td>
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<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
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<tr>
<td></td>
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<td>Toluene</td>
<td></td>
<td>None</td>
<td>10 mg/kg</td>
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<td></td>
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<tr>
<td></td>
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<td>None</td>
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<tr>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
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<td>10 mg/kg</td>
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</table>

### Comments:

### Information for ARRAY 1

### Attachments:

____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
General Site Assessment Data

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

<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></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>1,1-trichloroethane</td>
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<td></td>
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<td>0.05 mg/kg</td>
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<tr>
<td>1,2,2-trichloroethane</td>
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<td>Vinyl Chloride</td>
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<td>0.05 mg/kg</td>
</tr>
<tr>
<td>chloroform</td>
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<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>carbon tetrachloride</td>
<td></td>
<td></td>
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<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>chlorobenzene</td>
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<td></td>
<td></td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>benzene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
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</tr>
<tr>
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<td></td>
<td>None</td>
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<tr>
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<td>None</td>
<td>None</td>
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<tr>
<td>o-xylene</td>
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<td></td>
<td>None</td>
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</tr>
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<td></td>
<td></td>
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</tr>
<tr>
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</tr>
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</tr>
<tr>
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<td>None</td>
</tr>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Information for ARRAY 1

Attachments:

None
General Site Assessment Data

Impacted Zone: Length (parallel to flow direction)(ft.): 225 Width (ft): 25 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: None

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

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: 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) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
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<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross</td>
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<td>5 mg/kg</td>
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<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>None</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
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<td>trans-1,2-dichloroethene</td>
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<tr>
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<td>1,2-dichloroethene</td>
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<td>0.05 mg/kg</td>
</tr>
<tr>
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<td></td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td></td>
<td>chloroform</td>
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<td>0.05 mg/kg</td>
</tr>
<tr>
<td></td>
<td>carbon tetrachloride</td>
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<tr>
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<tr>
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<tr>
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Comments:

Information for ARRAY 1

Attachments:
### Hydrogeologic Conceptual Model

#### Facility ID: 0010

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<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

#### Aquifer Characteristics:
- Is more than 1 aquifer present? No
- Yes (number): _______ Unknown

<table>
<thead>
<tr>
<th>Aquifer</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></td>
<td>low value: 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>high value: 14</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
- 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</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Transmissivity</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
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</thead>
<tbody>
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<td></td>
<td>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:
- _______ ft amsl Unknown

#### Comments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

#### Attachments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
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: 7/11/1997  ended: 8/22/97
Duration: 42 d

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): 10 Unknown
- Duration of treatment at representative temperature (days): 32 Unknown

Mass of contaminant removed:
- Via liquid pumping: 7.6 lb 3.86 lb 393.6 lb Unknown
- In vapor stream: 7.6 lb 3.86 lb 393.6 lb Unknown

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><em>Conductive</em></th>
<th><em>Electrical Resistance</em></th>
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</thead>
<tbody>
<tr>
<td>Array 2</td>
<td><em>Steam</em></td>
<td><em>Steam + O2</em></td>
</tr>
<tr>
<td>3 phase</td>
<td><em>AC power</em></td>
<td><em>Steam + air</em></td>
</tr>
<tr>
<td>6 phase</td>
<td><em>DC power</em></td>
<td><em>Steam + O2</em></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 Zone:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 8/24/97 (ended 10/9/97)
Duration: 47 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): 18
- Maximum representative formation temperature (deg C): 100
- Time to reach maximum representative temperature (days): 27
- Duration of treatment at representative temperature (days): 20

Formation temperature immediately post-treatment: 219.7
Formation temperature post-treatment monitoring event 1: Unknown
Duration of post-treatment monitoring (days): 18

Mass of contaminant removed:
- Via liquid pumping: 2.7 lb
- In vapor stream: 217 lb
- Total: 219.7 lb

Comments:

Attachments:

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

x Thermal treatment: __ Conductive ________________________________

x Electrical Resistance Array e ________________________________

3 phase x 6 phase AC power DC power ________________________________

Steam Steam Steam + air Steam + O2 ________________________________

x Other (describe) ________________________________

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 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 ________________________________

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

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

x Hydraulic Control __ Yes __ No ________________________________

x Treatment Cell Design:

Size of target zone (ft^2): 570 Unknown (7 x 77 ft) ________________________________

Thickness of target zone (ft): 27 Unknown ________________________________

Depth to top of target zone (ft bgs): 8 Unknown ________________________________

Thickness of target zone below water table (ft): 25 Unknown ________________________________

Number of energy delivery points: 6 Unknown ________________________________

Number of extraction points: 1 Unknown ________________________________

x Temperature Profile:

Initial formation temperature (deg C): 8 Unknown ________________________________

Maximum representative formation temperature (deg C): 100 Unknown ________________________________

Time to reach maximum representative temperature (days): 17 Unknown ________________________________

Duration of treatment at representative temperature (days): 30 Unknown ________________________________

Date Temperature (deg C) ________________________________

Formation temperature immediately post-treatment: ________________________________

Formation temperature post-treatment monitoring event 1: ________________________________

Duration of post-treatment monitoring (days): ________________________________

x Mass of contaminant removed:

Via liquid pumping: 49 lbs __ kg __ Unknown ________________________________

In vapor stream: 138 lbs __ kg __ Unknown ________________________________

Total: 142.9 lbs __ kg __ Unknown ________________________________

Comments: ________________________________

Attachments: ________________________________

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

Remediation Goal:

- In Groundwater: Goals in mg/L: TCE-0.005, 1,1,2,2-tetrachloroethane (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
  - Comment:
- 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: ___________ ___________ 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: 967822
  - Consultant Cost: ___________
  - Thermal Vendor Cost: ___________
  - Energy Cost: 30000 per month ___________ 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 Date: 9/18/2006

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

Type of Site: x Non-DOD x DoD

Facility Name: Ft. Richardson (Arrays 4, 5, and 6)
Address: Ft. Richardson, Alaska
OU# or Site #: OU B; Poleline Rd Disposal Area (Arrays 4, 5, and 6)

Primary point of contact: Scott Kendell
Organization: US Army Corps - Alaska District
Address: 907-753-5661
Phone #: 907-753-5661 email: scott.kendall@poa02.useace.army.mil

Other contacts or vendors who worked on site: None
Point of contact:
Type: x Vendor, Consultant x Vendor, Technical Applications x Other: x
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

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 225
- Width (ft.): 8
- Thickness (ft.): 0
- 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: 1
- Pre-treatment: 2
- Post-treatment: 1
- Number of wells relative to treatment zone:
  - Pre-treatment: In: 1, Upgradient: ___, Downgradient: ___, Crossgradient: ___
  - Post-treatment: In: 2, Upgradient: ___, Downgradient: ___, Crossgradient: ___

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 6
- Number of relevant soil borings with post-treatment data: __
- Number inside treatment zone: 3
- 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>1,1,2-trichloroethane</td>
<td>Hexane</td>
<td>Cross</td>
<td>0.1 mg/L, None</td>
<td>0.1 mg/L, None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>0.01 mg/L, None</td>
<td>0.001 mg/L, None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Napthenol</td>
<td></td>
<td>None, None</td>
<td>None, None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>0.001 mg/L, None</td>
<td>None, None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>0.1 mg/L, None</td>
<td>0.01 mg/L, None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None, None</td>
<td>None, None</td>
</tr>
<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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<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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<td>None, None</td>
<td>None, None</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td></td>
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<td>None, None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td></td>
<td>None, None</td>
<td>None, None</td>
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<tr>
<td></td>
<td>Carbon tetrachloride</td>
<td>0.01 mg/L</td>
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<td>0.001 mg/L, None</td>
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<td></td>
<td>cis-1,2-dichloroethene</td>
<td>0.1 mg/L</td>
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<td>None, None</td>
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<td>Tetrachloroethene</td>
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<td>None, None</td>
<td>None, None</td>
</tr>
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</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? **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): 5.5</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs): 20</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
</tr>
</tbody>
</table>

### Flow direction

- **NE**

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

- __________ ft amsl
- **Unknown**

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

- __________

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

- __________

### K range (ft/day)

- Measured using: **Slug Test** **Laboratory** **Field data**
  - low: 0.05
  - high: 0.5

### Transmissivity (ft²/day)

- Measured using: **Slug Test** **Laboratory** **Field data**
  - low
  - high

### Comments:

- x-section in Tech Report on pages 30-35

### Attachments:
**Thermal Treatment - Design**

**Facility ID#: 0020**

### 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:
- 7/31/1999
- Duration: 65 days

### Hydraulic Control
- Yes
- No

### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>7500</th>
<th>Unknown</th>
<th>(110 x 50 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>12</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>8</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>20</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>3</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>2</td>
<td>Unknown</td>
<td></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): | 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>
<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>Mass (lb)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
<td>29.6</td>
<td>x</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td>628</td>
<td>x</td>
</tr>
<tr>
<td>Total:</td>
<td>658</td>
<td>x</td>
</tr>
</tbody>
</table>

**Comments:**

3 arrays

**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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General Site Information

File Analyzed By: JT x PD Date: 11/6/2006
Type of treatment: ______ Conductive ______ Steam ______ ERH x Other: RFH
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: 3/26/1998 End of Test: 5/13/1999 Duration: 413 d
Type of Site: ______ Non-DOD x DoD

x Facility Name: Ft. Wainwright
Address: CH2M Hill
City, State, Zip Code: Ft. Wainwright, Alaska
OU# or Site #: OU 5

x 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 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: __________
  - 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) 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>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>
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<td>None</td>
<td>None</td>
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<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
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<td>5 mg/kg</td>
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<td>Ethylbenzene</td>
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<td>Vinyl Chloride</td>
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<td></td>
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<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

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

**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>___ 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>___ 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>
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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

**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>14</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Flow direction: NNW

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

**K range (ft/day)**  

- Measured using:  
  - Slug Test  
  - Laboratory  
  - Field data
- low: 400  
- high: 600

**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

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:  3/26/1998  
Duration:  413 days

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

- Size of target zone (ft²): 400  
- Thickness of target zone (ft): 10  
- Depth to top of target zone (ft bgs): 6  
- Thickness of target zone below water table (ft): 0  
- Number of energy delivery points: 4  
- Number of extraction points: 1

Temperature Profile:

- Initial formation temperature (deg C): 5  
- Maximum representative formation temperature (deg C): 25  
- Time to reach maximum representative temperature (days): 139  
- Duration of treatment at representative temperature (days): 274

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:

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.

Attachments:

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

**Facility ID#: 0030**

**Performance**

**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:**

**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 ?*

**Lessons Learned**

*Text continues here*

**Energy**

**Total Energy Used:** 55600 kWhr

**Total energy applied to treatment zone:** kWhr

**Other energy:** kWhr

*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 ____
Type of treatment: _____ Conductive _____ Steam x 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: _____ Non-DOD x DoD

Facility ID#: 0040
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**

**Facility ID:** 0040

---

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

**Map attachment**

**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 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>Crossgradient</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>1,1-dichloroethene</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>
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<td>Vinyl Chloride</td>
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<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<td>DRO 10-12</td>
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<td>DRO 15-17</td>
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<td>TAqH</td>
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<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

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

**Attachments:**

---
<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>
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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>
<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>
<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>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes (number):</td>
</tr>
<tr>
<td>Unknown (assume single aquifer)</td>
</tr>
<tr>
<td>Aquifer 1</td>
</tr>
<tr>
<td>Aquifer 2</td>
</tr>
<tr>
<td>Aquifer 3</td>
</tr>
<tr>
<td>Depth to water:</td>
</tr>
<tr>
<td>low value (ft bgs): 14</td>
</tr>
<tr>
<td>high value (ft bgs): 10</td>
</tr>
<tr>
<td>Unknown:</td>
</tr>
</tbody>
</table>

- Flow direction: NNW

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

<table>
<thead>
<tr>
<th>K range (ft/day)</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>
<tr>
<td>low</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>high</td>
</tr>
<tr>
<td>600</td>
</tr>
</tbody>
</table>

- Transmissivity (ft²/day): 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
- 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: 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): 2
- 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

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:  
  - Date:  
  - Temperature (deg C):  
- In vapor stream:  
  - Date:  
  - Temperature (deg C):  
- Total:

Comments:

15 ft spacing
Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
x Performance
  Remediation Goal:
  x In Groundwater: DRO -15 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
  x 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

x Energy
  Total Energy Used: 205 016 x 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: __________________________________________

x 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: 8/24/2007

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

Address: ______________________________________________________________________________________

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: None

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:**

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

- 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: None

### Soil Borings:
- Number of relevant 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: 

### 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>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
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<td></td>
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<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
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<td></td>
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</table>

### Comments:

- 
- 
- 
- 

### Attachments:

- 
- 
### Unconsolidated Sediments

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

### 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>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water</td>
<td>low</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>ft bgs</td>
<td>ft bgs</td>
<td>ft bgs</td>
</tr>
<tr>
<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>Low (ft/day):</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>High (ft/day):</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

#### Transmissivity (ft²/day)

<table>
<thead>
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<th>Low (ft²/day):</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High (ft²/day):</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<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

### Comments:

**Remarks:**

**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:**
  - Duration: __________

- **Hydraulic Control:**
  - Yes
  - No

- **Treatment Cell Design:**

  | Size of target zone (ft²) | 858 | Unknown | (____ x ____ ft) |
  | Thickness of target zone (ft) | 22 | Unknown |
  | Depth to top of target zone (ft bgs) | 0 | Unknown |
  | Thickness of target zone below water table (ft) | 1 | Unknown |
  | Number of extraction points | 12 | Unknown |
  | Number of energy delivery points | 18 | Unknown |

- **Temperature Profile:**

  | Initial formation temperature (deg C) | Unknown |
  | Maximum representative formation temperature (deg C) | 110 | Unknown |
  | Time to reach maximum representative temperature (days) | 55 | Unknown |
  | Duration of treatment at representative temperature (days) | 20 | 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: __________ 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: ____________________________ 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: 10/29/2006

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  X Full Scale System
Start of Test: ____________  End of Test: ____________ Duration: 21 months
Type of Site: ___ Non-DOD  X DoD

Facility Name: Defense Fuel Support Point Whittier
Address: ____________
City, State, Zip Code: Whittier, AK 99693
OU# or Site #: __________________
Email: mlf@mlfa.alaska.com

Primary point of contact: Wayne Barnum (DESC Headquarters contact) Jack Appolloni (DESC Alaska contact)
Organization: Defense Energy Support Center
Address: 8725 John J. Kingman Road
City, State, Zip Code: Fort Belvoir, Virginia 22060-6222
Phone #: 4650  email: jack.appolloni@dla.mil

Other contacts or vendors who worked on site  ___ None
Point of contact: Michael Foster
Type:  X Vendor, Consultant  ___ Vendor, Technical Applications  ___ Other
Organization: Michael L. Foster and Associates
Address: 13135 Old Glenn Highway, Suite 210
City, State, Zip Code: Eagle River, Alaska 99577
Phone #: 907-696-6200  email: mlf@mlfa.alaska.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.): 200
- Width (ft.): 300
- 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 relevant soil borings with post-treatment data: 35

- In:
  - Pre-treatment: 4
  - Post-treatment: 11
  - Number of relevant monitoring wells with groundwater data: 35
  - Number of relevant soil borings with post-treatment data: 35

- Upgradient:
  - Pre-treatment: 4
  - Post-treatment: 11

- Downgradient:
  - Pre-treatment: 26
  - Post-treatment: 26

- Crossgradient:
  - Pre-treatment: 26
  - Post-treatment: 26

Soil Borings:
- Number of relevant soil borings with pre-treatment data: None
- Number of relevant soil borings with post-treatment data: 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>
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<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>BTEX</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>JP4</td>
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<tr>
<td></td>
<td>1,1-dichloroethene</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>Vinyl Chloride</td>
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<td>Jet Fuel</td>
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<td>None</td>
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<td>o-xylene</td>
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<td>None</td>
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<td>1,2-dichloroethane</td>
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<tr>
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<td>1,1-dichloroethane</td>
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<td>None</td>
</tr>
<tr>
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<td>None</td>
</tr>
<tr>
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<td>1,1,2-trichloroethane</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>
<td>None</td>
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</tbody>
</table>

Comments:

JP4 estimated loss of 100,000 gallons

Attachments:
Hydrogeologic Conceptual Model

| 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

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
</tr>
<tr>
<td></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): __________ __________ __________ __________ 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             |           |           |            |

--- Field data

--- Laboratory

--- Slug Test

Comments: __________________________________________________________________________________________

Attachments: ______________________________________________________________________________________
<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
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<tbody>
<tr>
<td>Thermal treatment</td>
<td>Conductive, Electrical Resistance, 3 phase, 6 phase, AC power, DC power</td>
</tr>
<tr>
<td>Steam</td>
<td>Steam, Steam + air, Steam + O2, Steam + air</td>
</tr>
<tr>
<td>Type of Test</td>
<td>Pilot test, Full-scale System</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>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, Vadose only, Both (Saturated and Vadose zones)</td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td>21 months</td>
</tr>
<tr>
<td>Hydraulic Control</td>
<td>Yes, No</td>
</tr>
<tr>
<td>Size of target zone (ft²)</td>
<td>Unknown, (150 x 150 ft)</td>
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<tr>
<td>Thickness of target zone (ft)</td>
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</tr>
<tr>
<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>
<td>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>Unknown</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>
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<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>Via liquid pumping: 1000 gal, 1000 lb, 1000 kg, Unknown</td>
</tr>
<tr>
<td></td>
<td>In vapor stream: 15000 gal, 1500 lb, 1500 kg, Unknown</td>
</tr>
<tr>
<td></td>
<td>Total: 16000 gal, 16000 lb, 16000 kg, Unknown</td>
</tr>
</tbody>
</table>

**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: _______________________ 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: 3,800,000

____ 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: 5/23/2005
Type of treatment: Conductive Steam ERH Other: Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Type of Contaminant: Wood Treating Other: PAH, Dioxins/Furans, PCPs
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 2/27/2003 End of Test: 9/24/2005 Duration: 836 d
Type of Site: Non-DOD DoD

Facility Name: Alhambra Pole Yard
Address: Alhambra CA 91803
OU# or Site #: AOC-2
City, State, Zip Code: Alhambra CA 91803
Phone #: 626-302-8692 email: tony.landler@sce.com
City, State, Zip Code: Rosemead CA 91770
Organization: SCE
Address: 2244 Walnut Grove Avenue
City, State, Zip Code: Rosemead CA 91770
Phone #: 626-302-8692 email: tony.landler@sce.com
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 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
- Pre-treatment: 
- Post-treatment: 
- Number of wells relative to treatment zone:
  - Pre-treatment: 
  - Post-treatment: 
- Number of relevant monitoring wells with post-treatment data: None
- Number of relevant monitoring wells with pre-treatment data: None
- Number inside treatment zone: 23
- Number outside treatment zone: 65

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 65
- Number of relevant soil borings with post-treatment data: 23
- Number inside treatment zone: 65
- Number outside treatment zone: 23

**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>Creosote</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>Benzene</td>
<td>None</td>
<td>5.000 mg/kg</td>
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<td></td>
<td>1,1-dichloroethene</td>
<td>Napthalene</td>
<td>TPH</td>
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<td>5 mg/kg</td>
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<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
<td>dioxin*</td>
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<td>1.000 mg/kg</td>
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<td>dioxin*</td>
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<td>total PAH</td>
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<td>None</td>
</tr>
</tbody>
</table>

**Notes:**
- Comments: Volume treated: 16,200 yd³ from 7 to 105 ft
- Volume concentration was actually 0.0001 mg/kg

**Attachments:**

---

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*
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:  
- 470 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): 240</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs): 270</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction:  
- SSE  

Horizontal hydraulic gradient (feet/foot):  
- 0.003  
- 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:  

Facility ID#: 0060
<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th></th>
<th>Conductive</th>
<th>Phases 1 &amp; 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td></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>Steam + air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam + O2</td>
<td>Other (describe)</td>
</tr>
</tbody>
</table>

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

<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>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</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>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>2/27/2003</th>
</tr>
</thead>
</table>

| Hydraulic Control | Yes | No |

### Total Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>22506</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>31 (average)</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>785</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>131</td>
</tr>
</tbody>
</table>

### Temperature Profile:

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th></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>

<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>

### 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>lb</td>
<td>kg</td>
</tr>
<tr>
<td>Total:</td>
<td>15,306070</td>
<td>lb</td>
<td>kg</td>
</tr>
</tbody>
</table>

### 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 (16200 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.
**Thermal Treatment - Design**

| Facility ID# | 0660 |

**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:**
- 2/27/03 (ended 2/11/04)

**Duration:**
- 350 days

**Hydraulic Control:**
- ✗ Yes
- ✗ No

**Treatment Cell Design:**

| Size of target zone (ft²): | 15278 |
| Thickness of target zone (ft): | 33 (average) |
| Depth to top of target zone (ft bgs): | 0 |
| Thickness of target zone below water table (ft): | 0 |
| Number of energy delivery points: | 15278 |
| Number of extraction points: | 33 |

**Thickness of target zone:**
- Unknown (x ft)

**Temperature Profile:**
- Initial formation temperature (deg C):
  - 23
- Maximum representative formation temperature (deg C):
  - 315
- 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:
  - Unknown
- In vapor stream:
  - Unknown
- Total:
  - Unknown

**Comments:**

Phase 1 ended in early 2004; 7 ft (2.1 M) spacing with depths ranging from 7 to 105 ft with an average of 33 ft bgs in a volume of 8,360 m³ (11,000 yd³). 419 heater-only wells and 85 heater-vacuum wells.

**Attachments:**
Thermal Treatment - Design

Thermal treatment:  
  x Conductive  Phase 2  
  __ Electrical Resistance  
  ____ 3 phase  ____ 6 phase  ____ AC power  ____ DC power  
  ____ Steam  
  ____ Steam  ____ Steam + air  ____ Steam + O2  
  ____ Other (describe)  

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 layers 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  __ Both (Saturated and Vadose zones)  

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

Duration of treatment at representative temperature (days):  
  486  

Time to reach maximum representative temperature (days):  
  Unknown  

Maximum representative formation temperature (deg C):  
  335  

Initial formation temperature (deg C):  
  20  

Number of extraction points:  
  7222  

Number of energy delivery points:  
  241  

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

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

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

Hydraulic Control:  
  x Yes  __ No  

Treatment Cell Design:  

Temperature Profile:  

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Unknown</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>Type</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</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:  

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:  

Phase 2  

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

Lessons Learned

Energy

Total Energy Used: 19,359,051 kWhr  kWhr/m³  kWhr/yd³

Cost

Total Project Cost: 17,900,000.00

Consultant Cost: 916,000

Thermal Vendor Cost: 11,263,000

Energy Cost: 2,265,000.00  m³  yd³

Other Cost 1: 687,000

Other Cost 2: 600,000

Other Cost 3: 2,169,000

Please note other cost:

Other Cost 1: Laboratory and Air Quality Testing Expenses

Other Cost 2: SCE Labor Costs

Other Cost 3: ($266,000) Waste Disposal, ($415,000) Regulatory Oversight, (1,488,000) Miscellaneous Project Costs
General Site Information

File Analyzed By: JT PD ERH Date: 10/26/2006

Type of treatment: Conductive Steam ERH Other: RFH
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 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: Bakersville, CA
City, State, Zip Code: 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
**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>None</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>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethylene</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>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</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>
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<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>

**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 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 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:**
- **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 (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 + air  
- Steam + O2

Other (describe): RFH

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  
- 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>
<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:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<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.
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: 

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: X Pilot Test Full Scale System 

Start of Test: End of Test: Duration: 

Type of Site: X Non-DOD DoD 

Facility Name: GATX Annex Terminal 

City, State, Zip Code: San Pedro, CA 

OU# or Site #: 

Primary point of contact: Paul DePercin Organization: SITE/ US EPA 

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

### 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**

### 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>Trichloroethene</td>
<td>Benzene</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>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Naphthalene</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-dichloroethene</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-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>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td><strong>Total VOCs</strong></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:
- 8925 cubic yards of contaminated soil - total
- Only treated 65 cubic yards

### Attachments:
- [Attachment 1](#)
- [Attachment 2](#)
- [Attachment 3](#)
**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:

<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*

### Flow direction

- Unknown

### 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>
</tr>
</tbody>
</table>

*Measured using:

- Slug Test
- Laboratory
- Field data

### 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>

*Measured using:

- Slug Test
- Laboratory
- Field data

### Comments:

- Unknown

### Attachments:

- Unknown
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:  

Duration: 

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 extraction points: unknown
- Number of energy delivery 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: 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, 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.
Performance

Remediation Goal:

- In Groundwater:

- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater

  Comment:

- In Soil

  Comment:

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:

- 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: 7/28/2006
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: 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 None
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 Geologic cross-section
Hydraulic Conductivity information
General Site Assessment Data

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

- Number of relevant soil borings with pre-treatment data: 10
- Number inside treatment zone: 0
- Number outside treatment zone: 11

Map for impacted zone pg 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>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>1.0 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.01 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>0.001 mg/L</td>
<td>None</td>
<td>0.001 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>0.05 mg/L</td>
<td>None</td>
<td>0.05 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>0.05 mg/L</td>
<td>None</td>
<td>0.05 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Methylbenzene</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Toluene</td>
<td>0.05 mg/L</td>
<td>None</td>
<td>0.05 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</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:

Have screen intervals on: BAI-01, 02, 04, 4S, 4D, 5S, and 5D
Have well coordinates of some wells pgs 5, 7 and hydraulic conductivity pg 6
Pre GW cons pg 7, post GW cons pg 71

Attachments:

Map for impacted zone pg 8
**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
    - 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

### Aquifer Characteristics:
- **Ground surface elevation based on wells in or adjacent to treatment zone:** 130 ft amsl
- **Is more than 1 aquifer present?** No
- **Depth to water:**
  - Low value (ft bg): 13
  - High value (ft bg): 21
  - Unknown:
- **Flow direction:** SW
- **Horizontal hydraulic gradient (feet/foot):** 0.012
- **Vertical hydraulic gradient (feet/foot):** Unknown
- **K range (ft/day):**
  - Low: 0.75
  - High: 14.3
  - Measured using: Slug Test
  - Laboratory: Known
  - Field data: Unknown
- **Transmissivity (ft²/day):**
  - Low: 0.3
  - High: 21
  - Measured using: Slug Test
  - Laboratory: Known
  - Field data: Unknown

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

### Attachments:

---

---
### Thermal Treatment - Design

**Thermal treatment:**
- Conductive
- Electrical Resistance

- 3 phase
- 6 phase
- AC power
- DC power

- Steam
- **DUS/HPO**
- 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:**
- 10/23/2002
- Duration: 29 days

**Hydraulic Control:**
- Yes
- No

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²)</th>
<th>652</th>
<th>Unknown</th>
<th>(29 x 29 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft)</td>
<td>15</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs)</td>
<td>25</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft)</td>
<td>15</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) | 21 | Unknown |
| Maximum representative formation temperature (deg C) | 100 | Unknown |
| Time to reach maximum representative temperature (days) | 22 | Unknown |
| Duration of treatment at representative temperature (days) | 2 | 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>

**Formation temperature immediately post-treatment:**
- 11/20/2002
- 100

**Formation temperature post-treatment monitoring event 1:**
- 12/2/2002
- 88

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

12/9/06 - 80C

**Attachments:**

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

Remediation Goal:
- In Groundwater:
  - 1. Destroy COCs, 2. heat up soil and groundwater by steam, and 3. maintain hydraulic control
- In Soil:

Was the Remediation Goal Achieved:
- In Groundwater
  - Comment: concentration levels from ~10,000 ug/L of VOCs to ~2,000 ug/L. Test was terminated; follow-on remedial technology applied in 2004 (ozone sparging) has reduced levels from ~2,000 ug/L to <500 ug/L; system is still operating at site.
- In Soil
  - Comment:

General comments on the thermal application:

Aquifer region immediately adjacent to extraction well dried out

Lessons Learned

Energy

Total Energy Used: ________________ 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: ________________

- Consultant Cost: 930,160
- 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  __________ Date: 10/18/2006
Type of treatment: ________ 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 ________ Full Scale System
Start of Test: ______________ End of Test: ______________ Duration: __________
Type of Site: ________ Non-DOD ________ DoD

Facility Name: Pemaco Superfund Site
Address: __________________________________________
City, State, Zip Code: Los Angeles County, CA
OU# or Site #: _______________________________________

Primary point of contact: Tim Garvey
Organization: TN & Associates
Address: __________________________________________
City, State, Zip Code: Ventura, CA 93001
Phone #: 805-585-6386 email: _______________________________________

Other contacts or vendors who worked on site ________ None
Point of contact: David Flemings
Type: x ________ Vendor, Consultant ________ Vendor, Technical Applications ________ Other ________
Organization: TRS
Address: __________________________________________
City, State, Zip Code: __________________________________
Phone #: 425-396-4266 email: dfleming@thermairs.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

**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>1</td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossgradient</td>
<td>50 mg/L</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>
<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>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td></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:**

[\(\text{Add} \text{ any} \text{ required} \text{ comments} \)]

**Attachments:**

[\(\text{Include} \text{ any} \text{ necessary} \text{ attachments} \)]
<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>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
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<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>
<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  Yes (number): _____________  Unknown (assume single aquifer)</td>
</tr>
<tr>
<td>Depth to water:</td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>60</td>
</tr>
<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 ____________ ____________ ____________

- 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

□ 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: Jun-05 □ Duration: Unspecified

□ Hydraulic Control □ Yes □ No

Treatment Cell Design:

Size of target zone (ft2): 13200
Thickness of target zone (ft): 20
Depth to top of target zone (ft bgs): 60
Thickness of target zone below water table (ft): 15
Number of energy delivery points: Unspecified
Number of extraction points: Unspecified

Temperature Profile:

Initial formation temperature (deg C): Unknown
Maximum representative formation temperature (deg C): Unknown
Time to reach maximum representative temperature (days): Unspecified
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: Unspecified lb kg Unknown
In vapor stream: Unspecified lb kg Unknown
Total: Unspecified 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: __________ 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>Facility Name:</th>
<th>Carson, CA</th>
</tr>
</thead>
<tbody>
<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>

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
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<tbody>
<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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## General Site Assessment Data

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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>
</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>Benzene</td>
<td>Hexane</td>
<td></td>
<td>10 mg/L</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>Toluene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethane</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethane</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>None</td>
<td>0.03 mg/kg</td>
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<tr>
<td>1,1-Dichloroethane</td>
<td>Ethylbenzene</td>
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<td>None</td>
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<tr>
<td>1,2-Dichloroethane</td>
<td>Mesitylene</td>
<td></td>
<td></td>
<td>5,000 mg/L</td>
<td>1,000 mg/kg</td>
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<tr>
<td>1,1,1-Trichloroethane</td>
<td>b-xylene</td>
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<tr>
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<td></td>
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<td></td>
<td>10 mg/L</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td>Total CVOCs 20 ft</td>
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<td>None</td>
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<tr>
<td>Total CVOCs 25 ft</td>
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<td>None</td>
<td>1,000 mg/kg</td>
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<tr>
<td>Total CVOCs 30 ft</td>
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<td></td>
<td>None</td>
<td>1,000 mg/kg</td>
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<tr>
<td>Total CVOCs 35 ft</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>5,000 mg/kg</td>
</tr>
</tbody>
</table>

**Comments:**

**Attachments:**
### Hydrogeologic Conceptual Model

#### Geology:

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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): _____________

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>low value (ft bgs): 20</td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>25</td>
</tr>
<tr>
<td>Aquifer 3</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### Flow direction

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>

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

- 0.002 to 0.004

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

- 0.141

#### K range (ft/day)

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

#### Transmissivity (ft²/day)

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

**Facility ID#:** 0090

### 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
Thickness of target zone (ft): 20
Depth to top of target zone (ft bgs): 17
Thickness of target zone below water table (ft): 17
Number of extraction points: 20
Number of energy delivery points: 6

Temperature Profile:

Initial formation temperature (deg C): 21
Maximum representative formation temperature (deg C): 100
Time to reach maximum representative temperature (days): 231
Duration of treatment at representative temperature (days): 253

Formation temperature immediately post-treatment: 11/8/2005 100
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: 24800 (1,2-DCA) ________ lb ________ kg Unknown

22 ft spacing between thermal wells, approximately 260 to 330 watts/ft power input to each well. Treated 3,233 yd3.

Comments:

Attachments:

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:**

*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% reduction (MW-19).

**Energy**

- **Total Energy Used:** 2085.3 kWhr
  - Comment:
- **Total energy applied to treatment zone:** kWhr/m³ kWhr/yd³
  - Comment:
- **Other energy:** kWhr/m³ kWhr/yd³
  - Comment:

**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>General Site Information</th>
<th>Facility ID#</th>
<th>0095</th>
</tr>
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</table>

- **File Analyzed By:** JT PD  
- **Date:** 10/30/2006

<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>
</tr>
<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td></td>
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<td>Type of Test:</td>
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<td>Full Scale System</td>
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</tr>
<tr>
<td>Start of Test:</td>
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<tr>
<td>Duration:</td>
<td></td>
<td></td>
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<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **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:** None  
  - **Point of contact:** James Keegan  
    - **Type:** Vendor, Consultant  
    - **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

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

- **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: __________

### 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></td>
<td>Tetrachloroethene</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>Naphtalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>Ethylbenzene</td>
<td>None</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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</tbody>
</table>

### Comments:

- ____________________________________________________________________________

### Attachments:

- ____________________________________________________________________________
### Geology:  

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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>
</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>
<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): | 15 |
| high value (ft bgs): |    |
| Unknown: |    |

<table>
<thead>
<tr>
<th>Flow direction</th>
</tr>
</thead>
</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             |            |            |            |

### Field data

**K range (ft/day)**
- Measured using: Slug Test, Laboratory, Field data
  - Low value: Unknown
  - High value: Unknown

**Transmissivity (ft²/day)**
- Measured using: Slug Test, Laboratory, Field data
  - Low value: Unknown
  - High value: 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: ____________ Duration: ____________

Hydraulic Control __ Yes __ No

Treatment Cell Design:

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

Thickness of target zone (ft): 20 __ Unknown

Depth to top of target zone (ft bgs): __8__ __ Unknown

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

Number of energy delivery points: 13 __ Unknown

Number of extraction points: 15 __ 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: ____________ ____________ ____________ ____________ ____________

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:  

- **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
Type of treatment: Conductive  Steam  ERH  Other: 
Type of Contaminant: Chlorinated Solvents  Petroleum Hydrocarbons  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: The Source Group
Address: 1962 Freeman Ave
City, State, Zip Code: Signal Hill, CA 90755
Phone #: 703-767-8318  email: paul.rogers@dlamil

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.): 300
- Width (ft.): 200
- 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: 11
- Post-treatment: 11
- Number of wells relative to treatment zone:
  - Pre-treatment:
    - In: 1
    - Upgradient: 4
    - Downgradient: 4
    - Crossgradient: 4
  - Post-treatment:
    - In: 3
    - Upgradient: 4
    - Downgradient: 4
    - Crossgradient: 4

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 11
- Number inside treatment zone: 13
- Number outside treatment zone: 0
- Number of relevant soil borings with post-treatment data: 13

### 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>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>BTEX</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td></td>
<td>None</td>
<td>None</td>
<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>
<td>1,1-dichloroethene</td>
<td>BTEX</td>
<td>0.001 mg/L</td>
<td>0.01 mg/kg</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>BTEX</td>
<td>0.001 mg/L</td>
<td>0.01 mg/kg</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>BTEX</td>
<td>0.001 mg/L</td>
<td>0.01 mg/kg</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>BTEX</td>
<td>1 mg/L</td>
<td>1,000 mg/kg</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td></td>
<td>1 mg/L</td>
<td>1,000 mg/kg</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td>Diesel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td></td>
<td>TPHi</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td></td>
<td>TPHi</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td></td>
<td>TPHi</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
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: 40 ft amsl

Aquifer Characteristics:

Is more than 1 aquifer present? Yes (number): Unknown

Depth to water:
- low value (ft bgs): 24
- high value (ft bgs): 25
- Unknown:

Flow direction: NE - E

Horizontal hydraulic gradient (feet/foot): 0.008 to 0.04

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:

aquifer DTW is 11 to 31 feet regionally and regional flow is to the NW, but different in treatment area

Attachments:
Thermal Treatment - Design

| Facility ID# | 0110 |

---

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  
- 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:  
- 3/27/1997  
- Duration: 137 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:  

Notes:  
- Total mass was 800 gallons of Diesel, etc.  
- Steam wells installed - 5  
- Recovery wells installed - 2 (1 not used)  
- 20 ft radius of influence and 20 ft columnar per injection well  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Please note other cost:

Energy Cost:

Thermal Vendor Cost:

Consultant Cost:

Other Cost 1:

Other Cost 2:

Other Cost 3:

Please note other energy:

Total energy applied to treatment zone:

Other energy:

Total Project Cost:

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: ___________________________ 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:** 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
- **Point of contact:** None
- **Type:** Vendor, Consultant, Vendor, Technical Applications, Other
- **Organization:** SteamTech
- **Address:**
- **City, State, Zip Code:** 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.): 500
- Thickness (ft.): 66
- 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: 1
    - Upgradient: Unknown
    - Downgradient: 3
    - Crossgradient: None
  - Post-treatment: In: 1
    - Upgradient: Unknown
    - Downgradient: 3
    - Crossgradient: None

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></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossd</td>
<td></td>
<td>0.005 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>0.001 mg/L</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>0.005 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>0.01 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
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<td></td>
<td>None</td>
<td>None</td>
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<td>Ethylbenzene</td>
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<td>1,2-dichloroethane</td>
<td>m,p-xylene</td>
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<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>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Benzene (deep)</td>
<td></td>
<td></td>
<td>0.005 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>TCE (deep)</td>
<td></td>
<td></td>
<td></td>
<td>0.01 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>PCE (deep)</td>
<td></td>
<td></td>
<td></td>
<td>0.01 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1-DCE (deep)</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>
</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

Geology:

Zone

Vadose 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

Saturated Zone:  
- Relatively homogeneous and permeable unconsolidated sediments  
- Largely permeable 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: 2335 ft amsl

Aquifer Characteristics:

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

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):</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>high (ft bgs):</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Unknown:</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>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low: 0.32</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high:</td>
<td>1</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: 31.32</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high: 97.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

S=0.007 to 0.05

Attachments:
Thermal Treatment - Design

Facility ID#: 0130

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: 5/8/2003  
Duration: 45 d  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  

Size of target zone (ft²): 90  
Thickness of target zone (ft): 55  
Depth to top of target zone (ft bgsl): 5  
Thickness of target zone below water table (ft): 28  
Number of extraction points: 1  
Number of energy delivery points: 4  

Temperature Profile:  
Initial formation temperature (deg C): 20  
Maximum representative formation temperature (deg C): 100  
Time to reach maximum representative temperature (days): 44  
Duration of treatment at representative temperature (days): 1  

Formation temperature immediately post-treatment: 7/12/2002 95  
Formation temperature post-treatment monitoring event 1: 8/5/2002 80  
Duration of post-treatment monitoring (days): 25  

Mass of contaminant removed:  
Via liquid pumping: <1.81 lb  
In vapor stream: 1234 lb  
Total: 1342 lb  

Comments:  

Attachments:  

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: ___________ kWh ___________ kWh/m³ ___________ kWh/yd³

Total energy applied to treatment zone: 109901 kw-hr ___________ kWh/m³ ___________ kWh/yd³

Other energy: 33703 ke-hr ___________ kWh/m³ ___________ kWh/yd³

Please note other energy: extracted water-115x10E6 BTUs (30% of injected energy) Total energy - 375x10E6 BTUs

Cost
Total Project Cost: 525,000

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 comments on the thermal application:

Was the Remediation Goal Achieved:

In Groundwater: fraction of total recovery. Steam heating plus vapor phase extraction yielded most of the remaining recovery.

In Soil: _______

Comment: ____________________________

Please note other energy:

Remediation Goal:

1) Quantify mass reduction of TCE and other COCs;
2) Characterize steam movement;
3) Document operation and maintenance with regards to reliability and cost.

In Soil:

Comment: ____________________________

Please note other cost:
General Site Information

File Analyzed By: JT x PD ____ Date: 10/30/2006
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: x Pilot Test ____ Full Scale System
Start of Test: ________________ End of Test: ________________ Duration: ________________
Type of Site: x Non-DOD ____ DoD

Facility Name: Former Agricultural Products
Address: ________________
City, State, Zip Code: Newark, 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 ____ 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></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></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>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</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>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>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

#### 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)

<table>
<thead>
<tr>
<th></th>
<th>Measure using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>Unknown</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)

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

### Aquifer Characteristics:

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

- Facility ID#: 0140

### Attachments:

- Comments:

- Attachments:
**Thermal Treatment - Design**

Facility ID#: 0140

- **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): ____________

<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>

- **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

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: __________
<table>
<thead>
<tr>
<th>Facility Analyzed By:</th>
<th>JT PD</th>
<th>Date: 11/15/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive Steam ERH Other:</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>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test Full Scale System</td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD DoD</td>
<td></td>
</tr>
</tbody>
</table>

- Facility Name: Guadalupe
- Address: 
- City, State, Zip Code: Guadalupe, CA
- OU# or Site #: 

- 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.): 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:

- 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: 10
  - Number outside treatment zone: 12

### 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>Chlorinated Solvents</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-dichloroethylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>4 TPH (leachate)</td>
<td>10 mg/L</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>5 PAH (leachate)</td>
<td>0.05 mg/L</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>5 TPH (leachate)</td>
<td>0.01 mg/L</td>
</tr>
<tr>
<td></td>
<td>5 TPH</td>
<td>5 mg/L</td>
</tr>
<tr>
<td></td>
<td>5 PAH</td>
<td>0.01 mg/L</td>
</tr>
<tr>
<td></td>
<td>5 BTEX</td>
<td>0.01 mg/L</td>
</tr>
<tr>
<td></td>
<td>5 Diluent</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

Diluent - Pre-treatment concentration was actually 100,000 mg/kg.

BTEX - Benzene, Toluene, Ethylbenzene, and m-, o-, p-xylene.

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? **Yes (number):**
  - **No**
  - **Yes (number):**
  - **Unknown (assume single aquifer)**

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>low value: 55 ft bgs</td>
</tr>
<tr>
<td></td>
<td>high value: 60 ft bgs</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
</tr>
</tbody>
</table>

### Flow direction

- **W**

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

- **0.003 to 0.004**
- **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>
</tr>
</thead>
<tbody>
<tr>
<td>low 75</td>
<td>Slug Test</td>
</tr>
<tr>
<td>high</td>
<td>Laboratory</td>
</tr>
<tr>
<td></td>
<td>Field data</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>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>Slug Test</td>
</tr>
<tr>
<td>high</td>
<td>Laboratory</td>
</tr>
<tr>
<td></td>
<td>Field data</td>
</tr>
</tbody>
</table>

### Comments:

- Porosity: 0.4
- Velocity: 1 ft/day

### Attachments:

- Attachment 1
- Attachment 2
- Attachment 3
- Attachment 4
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)

Treatment Cell Design:

- Yes
- No

Thermal Treatment:

- Steam
- Steam + air
- Steam + O2

Other (describe)

- 6 phase AC power
- 3 phase
- 6 phase
- AC power
- DC power

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.

Notes: 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:**

**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

### Lessons Learned

- 
- 
- 
- 
- 

### Energy

**Total Energy Used:**

- **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 X PD  Date: 4/11/2005
Type of treatment:  Conductive  X  Steam  ERH  Other: __________
Type of Contaminant:  Chlorinated Solvents  X  Petroleum Hydrocarbons  Pesticides  Other: __________
Treatment Status:  Active  X  Post  Other: __________
Type of Test:  Pilot Test  X  Full Scale System  Other: __________
Start of Test: Nov-92  End of Test: Dec-93  Duration: 21 weeks
Type of Site:  Non-DOD  X  DoD  Other: __________

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  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): ________
- Width: ________
- Thickness: ________

- 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: 14
  - Post-treatment: 11

<table>
<thead>
<tr>
<th></th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In:</td>
<td>Upgradient:</td>
</tr>
<tr>
<td></td>
<td>Upgradient:</td>
<td>Downgradient:</td>
</tr>
<tr>
<td></td>
<td>Crossgradient:</td>
<td></td>
</tr>
</tbody>
</table>

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 47
- Number of relevant soil borings with post-treatment data: 26

**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)</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>Hexane</td>
<td>Cross</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>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>5 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>Ethylbenzene</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
<td>0.005 mg/L</td>
<td>None</td>
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<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td>0.1 mg/L</td>
<td>None</td>
<td>0.001 mg/L</td>
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</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
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<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethylene</td>
<td>Xylenes</td>
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<td>5 mg/L</td>
<td>None</td>
<td>0.5 mg/L</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>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</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>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</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>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</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>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</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>
<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.
X Geology: Zone

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: 640 ft amsl

X Aquifer Characteristics:

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

Depth to water:

Aquifer 1 Aquifer 2 Aquifer 3
low value (ft bgs): 100 ___________ ___________ ___________
high value (ft bgs): 120 ___________ ___________ ___________
Unknown: ___________ ___________ ___________

X Flow direction

West

Horizontal hydraulic gradient (feet/foot):

Aquifer 1 Aquifer 2 Aquifer 3
0.0095 ___________ ___________ ___________

Vertical hydraulic gradient (feet/foot):

Aquifer 1 Aquifer 2 Aquifer 3
Unknown

X K range (ft/day)

Measured using: ___ Slug Test ___ Laboratory ___ Field data

low 4 units with differing K ___________ ___________ ___________
high see below ___________ ___________ ___________

Transmissivity (ft²/day):

Measured using: ___ Slug Test ___ Laboratory ___ Field data

low ___________ ___________ ___________
high ___________ ___________ ___________

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  
- Electical 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  
  - 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-92  
Duration:  
- 21 weeks  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  
Size of target zone (ft²):  
- 11304  
Thickness of target zone (ft):  
- 80  
Depth to top of target zone (ft bgs):  
- 60  
Thickness of target zone below water table (ft):  
- 30  
Number of energy delivery points:  
- 2  
Number of extraction points:  
- 3  

Temperature Profile:  
Initial formation temperature (deg C):  
- 23  
Maximum representative formation temperature (deg C):  
- 100  
Time to reach maximum representative temperature (days):  
- 21  
Duration of treatment at representative temperature (days):  
- 15  
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  
In vapor stream:  
- 6600 gal  
Total:  
- 7600 gal  

Comments:  
- Energy delivery points: 6 injection/electric heating and 3 electric heating only.  
- Temp of 100 deg C occurred during both steam passes.  
- Timing: Nov-92 to Jul-93 then Nov-93.  
- 1st steam (continuous) 2/13/93 to 3/11/93.  
- 2nd steam (cyclical) 6/2/93 to 8/30/93.

Attachments:  

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

X In Groundwater:

MCLs: 1,2-DCA - 1 ug/L; xylene - 1750 ug/L; toluene - 100 ug/L; benzene - 1 ug/L.

X 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

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

___ 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:

X Cost

Total Project Cost: 110 per 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

File Analyzed By: JT PD  
Type of treatment: x Conductive  _____ Steam  _____ ERH  _____ Other:  
Type of Contaminant:  _____ Chlorinated Solvents  _____ Petroleum Hydrocarbons  _____ Pesticides  _____ Wood Treating  x Other:  PCBS  
Treatment Status:  _____ Active  _____ 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  

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  

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  
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

**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>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</th>
<th>Other</th>
<th>Chemical</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossgrid</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>1,1,1,2-tetrachloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>Arclor 1254</td>
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<td>0.01 mg/kg</td>
<td>None</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>Arclor 1260</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>Total PCBs</td>
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<td>10 mg/kg</td>
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<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td>None</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>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</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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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
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<td>None</td>
</tr>
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<td>Hexane</td>
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<td>None</td>
</tr>
<tr>
<td>m/p-xylene</td>
<td>None</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>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

Samples are composite samples at 0-1 ft, 4-5 ft, 8-9 ft and 11-12 ft

**Attachments:**

---

- [Autogenerated footer image related to the document content]
**Unconsolidated Sediments**

<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>

**Comments:**

n~30%; moisture ~20%

**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>Largely permeable sediments with inter-bedded lenses of lower permeability material at 4'</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>

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

26 ft amsl

**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>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**

E

**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>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(10^-5) cm/sec</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>
### Thermal Treatment - Design

**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 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:**
- 10/11/1997
- Duration: 37 days

**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): 2

**Date** | **Temperature (deg C)**
--- | ---
Unknown | Unknown
Unknown | Unknown
Unknown | Unknown
Unknown | Unknown

**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></th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<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:**

**Attachments:**

---

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

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: X 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 X 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.):** 153
- **Width (ft.):** 74
- **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: 42
  - Post-treatment: 42
  - Upgradient: Downgradient: Crossgradient:

## Soil Borings

- **Number of relevant soil borings with pre-treatment data:** 8
- **Number of relevant soil borings with post-treatment data:** 2
- **Number inside treatment zone:** 8
- **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>Trichloroethene-78</td>
<td>None</td>
<td>None</td>
<td>50 mg/L</td>
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<td>None</td>
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<td>0.5 mg/L</td>
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<td>0.1 mg/L</td>
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<td>0.001 mg/L</td>
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<td></td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- **Chemicals of interest:** Trichloroethene (TCE), Tetrachloroethene (PCE), 1,1-Trichloroethane (1,1 TCA), 1,1-Dichloroethane (1,1 DCA), cis 1,2-Dichloroethene (cis 1,2 DCE), 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:

- [Attachment 1](0180)
- [Attachment 2](0180)
- [Attachment 3](0180)
- [Attachment 4](0180)
- [Attachment 5](0180)
- [Attachment 6](0180)
- [Attachment 7](0180)
- [Attachment 8](0180)
### General Site Assessment Data

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 150
- Width (ft.): 75
- Thickness (ft.): 2
- 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 relevant monitoring wells with post-treatment data: ____________
- Number of relevant monitoring wells with pre-treatment data: ____________

**Soil Borings:**
- Number inside treatment zone: ____________
- Number outside treatment zone: ____________

### Types of Contaminants

<table>
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<td>Soil (mg/kg)</td>
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<td></td>
<td></td>
<td>Soil (mg/kg)</td>
<td>Groundwater (mg/L)</td>
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<td></td>
</tr>
<tr>
<td><strong>Trichloroethene</strong></td>
<td><strong>Tetrachloroethene</strong></td>
<td><strong>1,1-Dichloroethane</strong></td>
<td><strong>1,2-Dichloroethene</strong></td>
<td><strong>1,1,1-Trichloroethane</strong></td>
<td><strong>1,1,2-Trichloroethane</strong></td>
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<td>0.01 mg/L, None</td>
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<tr>
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<td>0.005 mg/L, None</td>
<td>0.005 mg/L, None</td>
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<td>0.5 mg/L, None</td>
<td>0.01 mg/L, None</td>
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<td>0.5 mg/L, None</td>
<td>0.01 mg/L, None</td>
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<td>0.001 mg/L, None</td>
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<td>0.01 mg/L, None</td>
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<td>0.01 mg/L, None</td>
<td>0.01 mg/L, None</td>
</tr>
</tbody>
</table>

### Comments:

Chemicals of interest: Trichloroethene (TCE), Tetrachloroethene (PCE), 1,1-Dichloroethene (1,1 TCA), 1,1-Dichloroethene (1,1 DCA), cis 1,2-Dichloroethene (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:
# Hydrogeologic Conceptual Model

**Facility ID:** 0110

**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>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</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>Low value (ft bgs)</th>
<th>High value (ft bgs)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</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  _______  _______  Unknown
  - **High:** 4.819  _______  _______  _______  Unknown

- **Transmissivity (ft2/day):**
  - **Measured using:** Slug Test  Laboratory  Field data
  - **Low:** 158.4  _______  _______  Unknown
  - **High:**  _______  _______  _______  _______  Unknown

**Comments:**

n=30%

**Attachments:**

- [Additional information]
- [Additional information]
- [Additional information]
- [Additional information]
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:  5/14/1999

Duration:  70 d

Hydraulic Control  
- Yes  
- No

Treatment Cell Design:

Size of target zone (ft2):  7500

Thickness of target zone (ft):  10

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

Thickness of target zone below water table (ft):  12

Number of energy delivery points:  12

Number of extraction points:  3

Temperature Profile:

Initial formation temperature (deg C):  20

Maximum representative formation temperature (deg C):  90

Time to reach maximum representative temperature (days):  25

Duration of treatment at representative temperature (days):  35

Mass of contaminant removed:

- Via liquid pumping:  Unknown  
- In vapor stream:  Unknown

Total:  1943

Date  Temperature (deg C)

Formation temperature immediately post-treatment:  

Formation temperature post-treatment monitoring event 1:  

Duration of post-treatment monitoring (days):

Comments:

Attachments:

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

Energy

Total Energy Used: _________________________ kWhr __________ kWhr/m^3 __________ kWhr/yard^3

Total energy applied to treatment zone: 820,000 kw-hr __________ kWhr/m^3 __________ kWhr/yard^3

Other energy: ______________________________ kWhr/m^3 __________ kWhr/yard^3

Please note other energy: ____________________________________________________________

Cost

Total Project Cost: _______________________________

Consultant Cost: _______________________________

Thermal Vendor Cost: _______________________________

Energy Cost: ______________________________ m^3 __________ yard^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 ______ Date: 11/3/2006
Type of treatment: _____ Conductive  x  Steam  ____ ERH  ____ Other: ____________
Type of Contaminant: _____ Chlorinated Solvents  x  Petroleum Hydrocarbons  ____ Pesticides
_____ Wood Treating  ____ Other: ____________
Treatment Status: _____ Active  ____ Post
Type of Test:  x  Pilot Test  ____ Full Scale System
Type of Site: _____ Non-DOD  x  DoD

Facility Name: NAS Lemoore
Address: 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
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)(ft.): 700
- Width (ft.): 100
- Thickness (ft.): 10
- Map attachment: Unknown

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

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<tr>
<th>Chemicals of Concern</th>
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<tbody>
<tr>
<td></td>
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<td>Groundwater (mg/L) Soil (mg/kg)</td>
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</tbody>
</table>

#### Comments:

#### Attachments:
### Hydrogeologic Conceptual Model

#### Geology:

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<tr>
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<tbody>
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<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: 0 ft amsl, unknown

#### Geology:

- Is more than 1 aquifer present? Yes (number): 1

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs)</th>
<th>Flow direction</th>
<th>Horizontal hydraulic gradient (feet/foot)</th>
<th>Vertical hydraulic gradient (feet/foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Measured using:

- Slug Test
- Laboratory
- Field data

#### Measured using:

- Field data
- Laboratory
- Slug Test

#### K range (ft/day)

- Low: 0 ft/day, unknown
- High: 0 ft/day, unknown

#### Transmissivity (ft²/day)

- Low: 0 ft²/day, unknown
- High: 0 ft²/day, unknown

#### Comments:

- Shallow sandy silt permeability - 4e-12 m²
- Deeper sandy silt permeability - 14e-12 m²

#### 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 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
  - Thickness of target zone (ft): Unknown
  - Depth to top of target zone (ft bgs): 5
  - Thickness of target zone below water table (ft): 9
  - Number of extraction points: 2
  - Number of energy delivery points: 2

Temperature Profile:  
- Initial formation temperature (deg C): 25
  - Maximum representative formation temperature (deg C): 100
  - Time to reach maximum representative temperature (days): 10
  - Duration of treatment at representative temperature (days): 70

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/3/1994</td>
<td>74</td>
</tr>
</tbody>
</table>

Mass of contaminant removed:  
- Via liquid pumping: 75300 gal
  - lb: Unknown
  - kg: Unknown
- In vapor stream: 3179 gal
  - lb: Unknown
  - kg: Unknown
- Total: 78479 gal
  - lb: Unknown
  - 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

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Energy

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

- Total energy applied to treatment zone: ____________ 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:

- Other energy: ____________ kWhr/m³ ____________ kWhr/yd³
  Please note other energy: ________________________________
General Site Information

X File Analyzed By: JT  X PD  Date: 11/8/2006
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:  X  Pilot Test  ____ Full Scale System
Type of Site:  ____ Non-DOD  X  DoD

X Facility Name: NAS Alameda Point Site 5 ERH Pilot
Address: 
City, State, Zip Code: Alameda, CA
OU# or Site #: Site 5, Plume 5-1

X Primary point of contact: Steven Peck
Organization: Navy
Address: 1455 Frazee Rd., Ste. 900
City, State, Zip Code: San Diego, CA 92108
Phone #: 619-532-0786  email: steven.peck@navy.mil

X Other contacts or vendors who worked on site  ____ None
Point of contact: John McGuire
Type:  X  Vendor, Consultant  ____ Vendor, Technical Applications  ____ Other  
Organization: Shaw
Address: 
City, State, Zip Code: 
Phone #: 925-288-2220  email: john.mcguire@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

X Impacted Zone: Length (parallel to flow direction)(ft.): 230 Width (ft.): 130 Thickness (ft.): 20

- 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: None

- Number of wells relative to treatment zone:
  - Pre-treatment: 15 Post-treatment: 15
  - Pre-treatment: 5 Upgradient: 7 Downgradient: 5 Crossgradient: 0
  - Post-treatment: 5 Upgradient: 7 Downgradient: 5 Crossgradient: 0

X Soil Borings: Number of relevant soil borings with pre-treatment data: 15

- Number inside treatment zone: 6
- Number of relevant soil borings with post-treatment data: 6

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)</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></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>1 mg/L</td>
<td>None</td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>0.05 mg/L</td>
<td>None</td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphtalene</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
<td>5 mg/L</td>
<td>None</td>
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<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>0.5 mg/L</td>
<td>None</td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>0.05 mg/L</td>
<td>None</td>
<td>1 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1-dichloroethylene</td>
<td>Ethylbenzene</td>
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<td>5 mg/L</td>
<td>None</td>
<td>5 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>0.05 mg/L</td>
<td>None</td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethene</td>
<td>O-xylene</td>
<td></td>
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<td>None</td>
<td>50 mg/L</td>
<td>None</td>
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<td></td>
<td>1,1,2-trichloroethene</td>
<td>1,2-dichloroethene</td>
<td></td>
<td>0.05 mg/L</td>
<td>None</td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>0.1 mg/L</td>
<td>None</td>
<td>1 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

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:
<table>
<thead>
<tr>
<th>Zone</th>
<th>Geology:</th>
<th>Unconsolidated Sediments</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></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</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>
<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  
  - Unknown

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

- **Depth to water:**
  - Low value (ft bgs): 5
  - High value (ft bgs): 7
  - Unknown:

- **Flow direction:** North to northeast

- **Horizontal hydraulic gradient (feet/foot):** 0.004 to 0.006
  - Unknown

- **Vertical hydraulic gradient (feet/foot):**
  - Measured using:
    - Field data
    - Laboratory
    - Slug Test

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

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

**Comments:**

- S=0.007

**Attachments:**

---

---
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>______________________</th>
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</thead>
<tbody>
<tr>
<td>Type of Test:</td>
<td>Pilot test</td>
<td>Full-scale System</td>
</tr>
<tr>
<td>Geology of Treatment Zone:</td>
<td></td>
<td>Relatively homogeneous and permeable 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>Treatment Target Zone:</td>
<td>Saturated only</td>
<td>Vadose only</td>
</tr>
<tr>
<td>Start of Thermal Test:</td>
<td>6/21/2002</td>
<td>Duration: 197 d</td>
</tr>
<tr>
<td>Hydraulic Control:</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Treatment Cell Design:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size of target zone (ft²):</td>
<td>1520</td>
<td>Unknown</td>
</tr>
<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>23</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>
<tr>
<td>Temperature Profile:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>25</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>169</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>28</td>
<td>Unknown</td>
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<tr>
<td>Mass of contaminant removed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
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<tr>
<td>Total:</td>
<td>81</td>
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<tr>
<td>Comments:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attachments:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Electrode spacing - 20 ft. Vapor extraction well spacing - 15 ft.
Performance

Remediation Goal:

X In Groundwater: 10,000 ug/L for contaminant.

In Soil:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

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: 428,874 kw hour 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: 11/6/2006
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: _____ Non-DOD X DoD

Facility Name: NAS Alameda Point Full Scale
Address: __________________________
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@nay.mil

Other contacts or vendors who worked on site _____ None
Point of contact: John McGuire
Type: X Vendor, Consultant _____ Vendor, Technical Applications _____ Other: _____________
Organization: Shaw
Address: __________________________
City, State, Zip Code: __________________________
Phone #: 925-288-2220 email: john.mcuire@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
### 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></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Chlorinated Solvents
- Trichloroethylene
- Tetrachloroethylene
- 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

#### Petroleum Hydrocarbons
- Benzene
- Toluene
- 1,2-dimethylbenzene
- m,p-xylene
- o-xylene
- Benzene
- Hexane
- naphthalene
- Jet Fuel

#### Other
- Creosote
- Crossgradient

#### Groundwater (mg/L) & Soil (mg/kg)
- None
- 10 mg/L
- 0.001 mg/L
- 0.1 mg/L
- 0.01 mg/L
- 0.05 mg/L
- 0.005 mg/L
- 0.005 mg/L
- 0.1 mg/L
- 0.001 mg/L
- None

### Monitor Wells
- 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

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

### Comments

### Attachments
**General Site Assessment Data - Page 2**

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 230
- Width (ft.): 120
- Thickness (ft.): 20
- 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: 17
  - Post-treatment: 17
    - Upgradient: ______
    - Downgradient: ______
    - Crossgradient: ______

- 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>Trichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
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</tr>
<tr>
<td>1,1-dichloroethene</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>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td></td>
<td></td>
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<td>None</td>
</tr>
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<td>None</td>
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</tr>
<tr>
<td>m/p-xylene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
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<td>None</td>
</tr>
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<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

#### Facility ID#:

10215

---

**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
  - **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 ft amsl

---

**Aquifer Characteristics:**

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

- **Depth to water:**
  - **Aquifer 1**
    - Low value (ft bgs): 507
    - Unknown:
  - **Aquifer 2**
    - Low value (ft bgs): __________
    - Unknown:
  - **Aquifer 3**
    - Low 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**
  - **Unknown**

- **Low:**
  - **Aquifer 1:** 0.737
  - **Unknown:**
- **High:**
  - **Aquifer 1:** 4.819
  - **Unknown:**

**Transmissivity (ft²/day):**

- **Measured using:**
  - **Slug Test**
  - **Laboratory**
  - **Field data**
  - **Unknown**

- **Low:**
  - **Aquifer 1:** 158.4
  - **Unknown:**
- **High:**
  - **Aquifer 1:** __________
  - **Unknown:**

---

**Comments:**

- S=0.007

---

**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:  7/8/2004
Duration:  120 d

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft2):  14520
Thickness of target zone (ft):  20
Depth to top of target zone (ft bgs):  0
Thickness of target zone below water table (ft):  13
Number of energy delivery points:  30 electrodes *
Number of extraction points:  Unknown

Temperature Profile:

Initial formation temperature (deg C):  220
Maximum representative formation temperature (deg C):  92
Time to reach maximum representative temperature (days):  90
Duration of treatment at representative temperature (days):  30

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:  0 lb
In vapor stream:  3011.28 lb
Total:  3011.46 lb

Comments:

* 30 electrodes each with 4 sheet piles.

Attachments:

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

X In Groundwater:
Total concentrations of the COCs below 10,000 ppb.

In Soil:

Was the Remediation Goal Achieved:

X In Groundwater
Comment: yes

In Soil
Comment:

General comments on the thermal application:

Target temp of 92 deg C

Lessons Learned

Energy

X Total Energy Used: _____________________ kWhr _____________________ kWhr/m^3 _____________________ kWhr/yd^3

Total energy applied to treatment zone: 1455923 kW-hr _____________________ 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: _____________________
Site 5-3
Alameda, CA

Start of Test: ___________ End of Test: ___________ Duration: ___________

Type of Site: ______ Non-DOD ______ DoD

Type of Test: ______ Pilot Test ______ Full Scale System

Treatment Status: ______ Active ______ Post

Type of Contaminant: ______ Chlorinated Solvents ______ Petroleum Hydrocarbons ______ Pesticides
____ Wood Treating ______ Other: ____________________________

Type of treatment: ______ Conductive ______ Steam ______ ERH ______ 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

Facility ID#: 0213

File Analyzed By: JT PD

Date: 10/26/2006

General Site Information

Facility Name: NAS Alameda
Address: 
City, State, Zip Code: Alameda, CA
OU# or Site #: Site 5-3

Primary point of contact: John McGuire
Organization: Shaw
Address: 
City, State, Zip Code: 
Phone #: 925-288-2220 email: john.mcguire@shawgrp.com

Other contacts or vendors who worked on site ______ None
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
### General Site Assessment Data

**Facility ID:** 0213

#### 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: __________

#### 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>Crossdi</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>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>
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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>1,1,2,2-tetrachloroethane</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>

#### Comments:

- __________
- __________
- __________

#### Attachments:

- __________
- __________
- __________
### 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>Zone</th>
<th>Low (ft amsl)</th>
<th>High (ft amsl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Aquifer Characteristics:

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

#### Depth to water:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Low (ft bgs)</th>
<th>High (ft bgs)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Zone</th>
<th>Low (feet/foot)</th>
<th>High (feet/foot)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Zone</th>
<th>Low (feet/foot)</th>
<th>High (feet/foot)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### K range (ft/day)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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</thead>
<tbody>
<tr>
<td>Vadose</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**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:**
- Duration:

**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):

<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:
  - __________ kWh
  - __________ kWh/m³
  - __________ kWh/yd³

- In Soil:
  - __________ kWh
  - __________ kWh/m³
  - __________ kWh/yd³

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 x PD _______ Date: 10/26/2006
Type of treatment: _____ Conductive _____ Steam x ERH _____ Other: _________________
Type of Contaminant: _____ 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: ___________ End of Test: ___________ Duration: ___________
Type of Site: _____ Non-DOD x DoD

Facility Name: NAS Alameda
Address: ____________________________________________
City, State, Zip Code: Alameda, CA
OU# or Site #: Site 4-2

Primary point of contact: John McGuire
Organization: Shaw
Address: ____________________________________________
City, State, Zip Code: __________________________________
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 x 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**

**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>1,1-dichloroethane</td>
<td>Tetrachloroethylene</td>
<td>Benzene</td>
<td>crossgradient</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethylene</td>
<td>Trichloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>cis-1,2-dichloroethylene</td>
<td>Naphthalene</td>
<td></td>
<td>100 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>trans-1,2-dichloroethylene</td>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,2-DCE</td>
<td>1,1-dichloroethane</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>
<td>None</td>
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<td>Creosote</td>
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</table>

**Comments:**

---

**Attachments:**

---
### Hydrogeologic Conceptual Model

#### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose 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>
<tr>
<td>Saturated 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>
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<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
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<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:
- **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>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 (ft bgs):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high (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:

---
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)
- 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) (x)

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):  

Thickness of target zone (ft):  

Depth to top of target zone (ft bgs):  

Thickess of target zone below water table (ft):  

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

Facility ID#: 0215

Steam + O2

Temperature Profile:

<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:  
  - lb  
  - kg  
  - Unknown

Attachments:

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

All information is based on the preliminary design.
Cost and Performance

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:  ___________ 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: ___________________________________________________________________________________
<table>
<thead>
<tr>
<th>File Analyzed By: JT</th>
<th>PD</th>
<th>ERH</th>
<th>Date: 9/13/2006</th>
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</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam</td>
<td>ERH</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>Sep-98</td>
<td>End of Test: Mar-99</td>
<td>Duration:</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
<td></td>
</tr>
</tbody>
</table>

**Facility Name:** Naval Facility Centerville Beach in Former Transformer Bldg #2

City, State, Zip Code: 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

Point of contact:

<table>
<thead>
<tr>
<th>Type:</th>
<th>Vendor, Consultant</th>
<th>Vendor, Technical Applications</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<td></td>
<td></td>
<td>email:</td>
</tr>
</tbody>
</table>

**Characteristics of Interest**

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

**Facility ID:** 0230

### 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:**

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>In: Upgradient: Downgradient: Crossgradient:</td>
<td>In: Upgradient: Downgradient: Crossgradient:</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>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>Groundwater (mg/L) Soil (mg/kg) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>PCB Aroclor 1254</td>
<td>None</td>
<td>None 500 mg/kg None 0.1 mg/kg</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</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>None</td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</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>None</td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>p-xylene</td>
<td></td>
<td>None</td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Ethylene</td>
<td></td>
<td>None</td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>Vinyl Chloride</td>
<td></td>
<td>None</td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>None None None None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None None None None</td>
<td>None None None None</td>
</tr>
</tbody>
</table>

**Comments:**

Impacted zone limited to 20 ft bg.

**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>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>
</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
- [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>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>
<tr>
<td>Depth to water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>99</td>
<td></td>
<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

- [x] west

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

- [ ] Unknown

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

- [x] 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

**Facility ID:** 0230

<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>Steam</td>
<td>Steam + air</td>
</tr>
<tr>
<td>Other (describe)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<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 layers of lower permeability material</td>
</tr>
<tr>
<td>Largely permeable sediments with inter-bedded lenses 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>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated only</td>
</tr>
<tr>
<td>Vadose only</td>
</tr>
<tr>
<td>Both (Saturated and Vadose zones)</td>
</tr>
</tbody>
</table>

| Start of Thermal Test: | Oct-98 | Duration: 4 months |

<table>
<thead>
<tr>
<th>Hydraulic Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</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>Mar-99</td>
<td>360</td>
</tr>
</tbody>
</table>

| Duration of post-treatment monitoring (days): | 4 months |

<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>Minimal temperature data</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heaters</th>
</tr>
</thead>
<tbody>
<tr>
<td>on 6 ft spacings; vacuum heater wells spacing = 10 ft</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.</td>
</tr>
</tbody>
</table>
Check for unidentified storm drains

Cost and Performance

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:** 1.0 ppm or mg/kg DW was achieved in target treatment area

General comments on the thermal application:

**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

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:** 600,351
  - **Consultant Cost:**
  - **Thermal Vendor Cost:** 600,351
  - **Energy Cost:**
  - **Other Cost 1:**
  - **Other Cost 2:**
  - **Other Cost 3:**
  - **Please note other cost:**
Facility Name: Former Union Pacific Railroad
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
### 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 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></td>
<td></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
</tbody>
</table>

- Tetrachloroethene
- Trichloroethylene
- 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

### Comments:
- 
- 
- 

### Attachments:
- 
- 
- 

---

Facility ID: 0235
### 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: **Unknown** 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 bgs):</td>
<td>10</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

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
<td></td>
</tr>
</tbody>
</table>

#### 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 (ft^2/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>

**Comments:**

**Attachments:**

---

Facility ID#: 0235
Thermal Treatment - Design

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

Steam  
- SVE enhanced steam injection  
  - 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:  
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.
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:

Cost 1:

Cost 2:

Cost 3:
General Site Information

- File Analyzed By: JT x PD  
- Type of treatment: x Conductive  
- Type of Contaminant: x Chlorinated Solvents  
- Treatment Status:  
- Type of Test:  
- Start of Test: 6/13/2005  
- Type of Site: x Non-DOD  
- Facility Name: Richmond, CA  
- Address: Richmond, CA  
- Primary point of contact: Ralph Baker  
- Organization: TerraTherm  
- Address: 10 Stevens Road  
- City, State, Zip Code: Fitchburg, MA 01420  
- Phone #: 978-343-0300  
- Other contacts or vendors who worked on site:  
- Point of contact: Frank Szerdy  
- Type: x Vendor, Consultant  
- Organization: Geomatrix Consultants, Inc  
- Address: 210 Webster St. 12th Fl.  
- City, State, Zip Code: Oakland, CA 94612  
- Phone #: 510-663-4100  
- 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
General Site Assessment Data

Impacted Zone: Length (parallel to flow direction)(ft.): 65 | Width (ft.): 110 | Thickness (ft.): 20 | 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: Upgradient: None | Downgradient: None | Crossgradient: None
  - Post-treatment: Upgradient: None | Downgradient: None | Crossgradient: None

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>Trichloroethene</td>
<td>Benzene</td>
<td>Cross</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>50 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-dichloroethylene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethylene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Methylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>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>1 mg/kg</td>
</tr>
</tbody>
</table>

Comments:

Attachments:
## Hydrogeologic Conceptual Model

### Geology: Zone

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

- **150 ft amsl**
- **Unknown**

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unknown (assume single aquifer)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Depth to water:**
  - **low value (ft bgs):** 2
  - **high value (ft bgs):** 4
  - **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><strong>low</strong></td>
<td>0.0003</td>
<td></td>
<td><strong>Unknown</strong></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><strong>low</strong></td>
<td></td>
<td></td>
<td><strong>Unknown</strong></td>
</tr>
</tbody>
</table>

### Comments:

---

### Attachments:

---
Thermal Treatment - Design

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

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

x 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
   x Competent, but fractured bedrock (i.e. crystalline rock)
   __ Weathered bedrock, limestone, sandstone

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

x Start of Thermal Test:  
   6/13/2005  Duration: 116 d

x Hydraulic Control  
   __ Yes  x No

x Treatment Cell Design:
   Size of target zone (ft²): 9450  __ Unknown  ( ___ x ___ ft)
   Thickness of target zone (ft): 20  __ Unknown
   Depth to top of target zone (ft bgs): 6  __ Unknown
   Thickness of target zone below water table (ft): 18  __ Unknown
   Number of energy delivery points: 128  __ Unknown
   Number of extraction points: 12  __ Unknown

x Temperature Profile:
   Initial formation temperature (deg C): 17  __ Unknown
   Maximum representative formation temperature (deg C): 100  __ Unknown
   Time to reach maximum representative temperature (days): 110  __ Unknown
   Duration of treatment at representative temperature (days): 6  __ Unknown

   Date  Temperature (deg C)
   10/8/2005  100

x Duration of post-treatment monitoring (days):

x Mass of contaminant removed:
   Via liquid pumping:  __ lb  __ kg  __ Unknown
   In vapor stream: 6000  X 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 = 0.012 mg/kg  TCE = ND  DCE = 0.065 mg/kg  VC = 0.005 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater
- In Soil

- PCE = 2 mg/kg  TCE = 2 mg/kg  DCE = 17 mg/kg  VC = 0.23 mg/kg

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: 2200000 kWhr  kmWhr/m³  kWhr/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

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th>9/22/2006</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>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>9/11/1999</td>
<td>End of Test: 4/14/2000</td>
<td>Duration: 113 days</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>North Island NAS (Pilot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td>Coronado, CA</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td>IR Site 9 Area 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary point of contact:</th>
<th>Michael Pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>Navy</td>
</tr>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<td>619-556-9901</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>Richard Wong</td>
</tr>
<tr>
<td>Type:</td>
<td>Vendor, Consultant</td>
</tr>
<tr>
<td>Organization:</td>
<td>Shaw</td>
</tr>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<td>619-437-6328 x314</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

**Facility ID:** 0240

<table>
<thead>
<tr>
<th>Width (ft)</th>
<th>Thickness (ft)</th>
<th>Impacted zone as defined by documentation</th>
<th>Alternative method for determining size of impacted zone (See source zone definition attachments)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>15</td>
<td></td>
<td>Map attachment</td>
</tr>
</tbody>
</table>

### Monitor Wells

Number of relevant monitoring wells with groundwater data: None

Number of wells relative to treatment zone:

<table>
<thead>
<tr>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>In: 1</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>

### 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></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 1</td>
<td>Benzene</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetracloroethene 2</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene 1</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 4</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane 4</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>
</tr>
</tbody>
</table>

### Comments:

- None

### Attachments:

- None
| Hydrogeologic Conceptual Model | Facility ID#: 0240 |

**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  
| | 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:**  
10 (aMLLW) 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>
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</table>

<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>x</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

**Flow direction:**  
WNW

**Horizontal hydraulic gradient (feet/foot):**  
0.0004 to 0.0007  
Unknown

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

**K range (ft/day):**  
Measured using: Slug Test, Laboratory, Field data  
Low: 0.052  
High: 0.091  
Unknown

**Transmissivity (ft2/day):**  
Measured using: Slug Test, Laboratory, Field data  
Low:  
High:  
Unknown

**Comments:**  
aMLLW - above mean low level sea water

**Attachments:**  

---

---
## Thermal Treatment - Design

### Facility ID:
0240

#### 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:
- [ ] 9/11/1999
- [ ] Duration: 113 days

#### Hydraulic Control
- [ ] Yes
- [ ] No

#### Treatment Cell Design:

| Size of target zone (ft²): | 7853 |
| Thick of target zone (ft): | 6 |
| Depth to top of target zone (ft bgs): | 4 |
| Number of extraction delivery points: | 12 |
| Number of energy delivery points: | 6 |

#### 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 |

<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: 14600 lb, 6480 kg
- [ ] In vapor stream: 14000 lb, 6350 kg
- [ ] Total: 28600 lb, 12830 kg

### 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 170°F, 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: ____________ ____________ 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: 9/22/2006

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

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): 50
- Thickness (ft): 1

**Impacted Zone:**

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

**Monitor Wells:**

- Number of relevant monitoring wells with pre-treatment data: 20
- Number of relevant monitoring wells with post-treatment data: 126
- Number inside treatment zone: 20
- Number outside treatment zone: 14

**Soil Borings:**

- Number of relevant soil borings with pre-treatment data: 36
- Number of relevant soil borings with post-treatment data: 126
- Number inside treatment zone: 20
- Number outside treatment zone: 14

**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>1000 mg/kg None</td>
<td>5 mg/kg None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>1 mg/kg None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphtalene</td>
<td></td>
<td>None</td>
<td>500 mg/kg None</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>500 mg/kg None</td>
<td>3 mg/kg</td>
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<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>1000 mg/kg None</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
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</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>NFSO</td>
<td></td>
<td>None</td>
<td>None None</td>
<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>Benzene</td>
<td></td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>MTBE</td>
<td></td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>MCO</td>
<td></td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>0.1 mg/kg</td>
</tr>
<tr>
<td>4 methyl-2-enthanone</td>
<td></td>
<td></td>
<td>None</td>
<td>1000 mg/kg None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>Total xylenes</td>
<td></td>
<td></td>
<td>None</td>
<td>100 mg/kg None</td>
<td>10 mg/kg</td>
</tr>
</tbody>
</table>

**Comments:**

See attached sheets for the numbers

**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

Unknown:
- high value (ft bgs):
- low value (ft bgs):

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

WNW

Horizontal hydraulic gradient (feet/foot):

0.0004 to 0.0007

Vertical hydraulic gradient (feet/foot):

Unknown

K range (ft/day):

Measured using:
- Slug Test
- Laboratory
- Field data

low

0.052

high

0.091

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:

10 (aMLLW) ft amsl

Unknown

Attachments:

Comments:

aMLLW - above mean low level sea water
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: 10/21/2002
Duration: 32 months

Hydraulic Control  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft2): 595000
Thickness of target zone (ft): 2
Depth to top of target zone (ft bgs): 6
Thickness of target zone below water table (ft): 6
Number of energy delivery points: 44
Number of extraction points: 70

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

Mass of contaminant removed:
Via liquid pumping: 278223 lb  x  kg  Unknown
In vapor stream: 86600 lb  x  kg  Unknown
Total: 364823 lb  x  kg  Unknown

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:

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

Facility ID#: 0250

File Analyzed By: JT PD Date: 10/18/2006

Type of treatment: ___ Conductive x Steam ____ ERH ____ Other: ____________________________

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

Treatment Status: ___ Active x Post

Type of Test: ___ Pilot Test x 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: ___ None

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.): ______
- 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>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>12</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>24</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>12</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>12</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>24</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>24</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td>24</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>24</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Tetrachloroethene</td>
<td>24</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:**
- 70,000 to 135,000 gallons of diesel spilled
- Impacted area of 2.3 acres
- TPH pre: 3,670 mg/kg, post: 3190 mg/kg
- TRPH post concentration: 2083 mg/kg

**Attachments:**

---

### Identifiable Contaminants

- Benzene
- Toluene
- Xylene
- Chlorinated Solvents:
  - Trichloroethene
  - Tetrachloroethene
  - 1,1-Dichloroethene
  - vinyl Chloride
### 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:**  
  - **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>Depth to water (ft bgs)</th>
<th>Measured using:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
<td>Slug Test</td>
</tr>
<tr>
<td></td>
<td>high</td>
<td>Laboratory</td>
</tr>
<tr>
<td></td>
<td>high value</td>
<td>Field data</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction:**
  - **X** Unknown

- **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:**  
  - **High:**  
    - **X** Unknown

- **Transmissivity (ft2/day):**
  - **Measured using:**  
    - **Slug Test**  
    - **Laboratory**  
    - **Field data**  
  - **Low:**  
  - **High:**  
    - **X** 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>
<tr>
<td></td>
<td>Other (describe)</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>
<th>Relatively homogeneous and impermeable unconsolidated sediments</th>
</tr>
</thead>
<tbody>
<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>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>Sep-91</th>
<th>Duration: 746 days</th>
</tr>
</thead>
</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>
</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>
</table>

Spacing - 45 ft with wells of opposite type and 60 ft for wells of same type

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
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: __________________________

Comment: __________________________

- 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: ____________ 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: 4401120

Consultant Cost: ____________

Thermal Vendor Cost: ____________

Energy Cost: 631470

Other Cost 1: ____________

Other Cost 2: ____________

Other Cost 3: ____________

Please note other cost: ____________
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</th>
<th>Estimated Ideal Cost for Rainbow Disposal</th>
<th>Estimated Cost for a Typical site of the same size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total ($)</td>
<td>Total ($)</td>
<td>Total ($)</td>
</tr>
<tr>
<td></td>
<td>$38,230 $3.56</td>
<td>$325,960 $3.45</td>
<td>$336,200 $3.54</td>
</tr>
<tr>
<td>746</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assumed off-Line Factor</th>
<th>Site size (yd^3)</th>
<th>Site Preparation Costs</th>
<th>Permitting and Regulatory Costs</th>
<th>Non-Depreciable Equipment Costs</th>
<th>Startup and Fixed Costs</th>
<th>Labor Costs</th>
<th>Consumables and Supplies Costs</th>
<th>Utilities Costs</th>
<th>Effluent Treatment and Disposal Costs</th>
<th>Residuals and Waste Handling and Disposal Costs</th>
<th>Sampling and Analytical Costs</th>
<th>Facility Modification, Repair, and Replacement Costs</th>
<th>Site Demobilization Costs</th>
<th>TOTAL COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td>92,000</td>
<td>$338,230 $3.56</td>
<td>$16,100 $0.17</td>
<td>$522,990 $5.51</td>
<td>$758,800 $7.99</td>
<td>$1,362,000 $14.34</td>
<td>$43,430 $0.46</td>
<td>$631,470 $6.65</td>
<td>$71,100 $0.75</td>
<td>$67,200 $0.71</td>
<td>$299,900 $3.16</td>
<td>$150,700 $1.59</td>
<td>$139,200 $1.47</td>
<td>$4,401,120 $46.33</td>
</tr>
<tr>
<td>100%</td>
<td>92,000</td>
<td>$325,960 $3.45</td>
<td>$11,100 $0.12</td>
<td>$522,490 $5.50</td>
<td>$413,500 $4.35</td>
<td>$775,600 $8.16</td>
<td>$24,320 $0.26</td>
<td>$280,190 $2.95</td>
<td>$35,600 $0.37</td>
<td>$49,250 $0.52</td>
<td>$195,900 $2.06</td>
<td>$57,500 $0.61</td>
<td>$98,500 $1.04</td>
<td>$2,789,910 $29.37</td>
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<tr>
<td>75%</td>
<td>92,000</td>
<td>$336,200 $3.54</td>
<td>$14,100 $0.15</td>
<td>$524,070 $5.52</td>
<td>$435,700 $4.59</td>
<td>$1,033,600 $10.88</td>
<td>$32,420 $0.34</td>
<td>$493,020 $5.19</td>
<td>$47,400 $0.50</td>
<td>$61,400 $0.65</td>
<td>$221,900 $2.34</td>
<td>$77,600 $0.82</td>
<td>$98,500 $1.04</td>
<td>$3,375,910 $35.54</td>
</tr>
</tbody>
</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:
General Site Information

File Analyzed By: JT PD
Type of treatment: Conductive Steam ERH Other: Hot air
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: 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

**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>Tetracloroethene</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>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<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>α-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Super unleaded gasoline</td>
<td></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>
<td>None</td>
</tr>
<tr>
<td></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:**

---
### 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
  - 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

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

 Other (describe):  
- ___ Hot air

 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 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
- ___ Vadose only
- ___ Both (Saturated and Vadose zones)

 Start of Thermal Test:  
- ___ 1991
- ___ Duration: 2 years

 Treatment Cell Design:  
- ___ Hydraulic Control
- ___ Yes
- ___ No

 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:  
- ___ 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):  
- ___ Unknown

 Mass of contaminant removed:  
- ___ Via liquid pumping:  
- ___ lb
- ___ kg
- ___ Unknown
- ___ In vapor stream:  
- ___ lb
- ___ kg
- ___ Unknown
- ___ Total:  
- ___ 80000
- ___ 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:

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

Facility Name: Solvent Services
Address: 1021 Berryessa Rd
City, State, Zip Code: San Jose, CA
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
____ Hydraulic Conductivity information
____ 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: __________
- 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) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr.</td>
<td></td>
<td>None 100 mg/kg None 10 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None 100 mg/kg None 10 mg/kg</td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td></td>
<td>None 0.5 mg/kg None 10 mg/kg</td>
<td></td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td></td>
<td>None 0.05 mg/kg None 10 mg/kg</td>
<td></td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td></td>
<td>None 50 mg/kg None 50 mg/kg</td>
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</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>None 100 mg/kg None 50 mg/kg</td>
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<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
<td></td>
<td>None 50 mg/kg None 50 mg/kg</td>
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</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>2-butanone</td>
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<td>i/p-xylene</td>
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<td>1,1,2,2-tetrachloroethene</td>
<td>Tetrachloro.</td>
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<tr>
<td>Vinyl Chloride</td>
<td>total xylenes</td>
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<td>1,1,1-trichloroethane</td>
<td>Trichloroethene</td>
<td></td>
<td></td>
<td>None 0.1 mg/kg None 50 mg/kg</td>
<td></td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Acetone</td>
<td></td>
<td></td>
<td>None 50 mg/kg None 50 mg/kg</td>
<td></td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td>Tetrachloro.</td>
<td></td>
<td></td>
<td>None 500 mg/kg None 500 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Total xylenes</td>
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<td></td>
<td>None 500 mg/kg None 100 mg/kg</td>
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</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Trichloroethene</td>
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<td>None 10 mg/kg None 50 mg/kg</td>
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<td>None 50 mg/kg None 50 mg/kg</td>
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<td>Tetrachloro.</td>
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<td></td>
<td>None 500 mg/kg None 500 mg/kg</td>
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</tr>
<tr>
<td>1,1,1-trichloroethane</td>
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<td></td>
<td>None 1 mg/kg None 50 mg/kg</td>
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</tr>
<tr>
<td>Trichloroethene</td>
<td>4-methyl-2-pentanone</td>
<td></td>
<td></td>
<td>None 0.5 mg/kg None 10 mg/kg</td>
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</tr>
</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

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: 75 to 100 ft amsl  Unknown

Aquifer Characteristics:

Is more than 1 aquifer present?  X  Yes (number):  Unknown (assume single aquifer)

Depth to water:
- Low value (ft bgs): 0
- High value (ft bgs):  Unknown

Flow direction:  W

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:

Transmissivity = 200 gal per day per foot  Storativity = 0.22 both for aquifer

Flow direction from Figure 3 contours

Attachments:
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment: Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>3 phase</td>
</tr>
<tr>
<td>x</td>
<td>6 phase</td>
</tr>
<tr>
<td>x</td>
<td>AC power</td>
</tr>
<tr>
<td>x</td>
<td>DC power</td>
</tr>
<tr>
<td>x</td>
<td>Steam</td>
</tr>
<tr>
<td>x</td>
<td>Steam + air</td>
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<tr>
<td>x</td>
<td>Steam + O2</td>
</tr>
<tr>
<td>x</td>
<td>Other (describe)</td>
</tr>
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<table>
<thead>
<tr>
<th>Type of Test: Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
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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>x</td>
<td>Largely homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td>x</td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td>x</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>x</td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

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

| Start of Thermal Test:     | 8/17/1988            |
| x                         | Duration: 15 days    |
| x                         |                      |

| Hydraulic Control:        | Yes                  |
| x                         | No                   |

| Treatment Cell Design:    | 169                   |
|                           | Unknown               |
|                           | ( 13 x 13 ft)        |
| Size of target zone (ft²):|                      |
| Thickness of target zone (ft): | 18               |
| Depth to top of target zone (ft bgs): | 2                |
| Thickness of target zone below water table (ft): | 20               |
| Number of energy delivery points: | 6                 |
| Number of extraction points: | 1                  |

| Temperature Profile:      | Initial formation temperature (deg C): 26 |
|                          | Unknown                                   |
|                          | Maximum representative formation temperature (deg C): 100 |
|                          | 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>
</tr>
</thead>
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<tr>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping: 186.8 lb x kg</td>
</tr>
<tr>
<td>In vapor stream: 548.3 lb x kg</td>
</tr>
<tr>
<td>Total: 762.7 lb x kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Attachments:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></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.
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>
<thead>
<tr>
<th>Facility Name:</th>
<th>McClellan AFB Superfund Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Sacramento, CA</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td></td>
</tr>
</tbody>
</table>

| 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
### 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>None</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>None</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>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Notes:**
- **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: __________

**General Site Assessment Data**
- **Chemicals of Concern**
  - **Petroleum Hydrocarbons**
    - Benzene
    - Jet Fuel
    - Naphthalene
    - Toluene
    - Ethylbenzene
    - m/p-xylene
    - o-xylene
    - Creosote
  - **Other**
    - Cross

**Attachments:**
- __________
### Geology: 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-beded lenses of lower permeability material</td>
<td>Largely permeable sediments with inter-beded layers of lower 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>

### Aquifer Characteristics:

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

<table>
<thead>
<tr>
<th>Zone</th>
<th>Depth to water: Low value (ft bgs):</th>
<th>Depth to water: High value (ft bgs):</th>
<th>Depth to water: Unknown:</th>
</tr>
</thead>
<tbody>
<tr>
<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: _____________
  - High: _____________
  - Unknown

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

### Additional Information:

- **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>
<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>
<td></td>
<td></td>
<td></td>
<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 permeable 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>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<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>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start of Thermal Test:</td>
<td></td>
<td>Duration:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Control:</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Treatment Cell Design:

| Size of target zone (ft²): | | Unknown | (x ft²) |
| 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: | 17 |
| 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>
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<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: | 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.
Total energy applied to treatment zone:

**In Groundwater:**

**In Soil:**

Was the Remediation Goal Achieved:

**In Groundwater:**

**In Soil:**

General comments on the thermal application:

Lessons Learned

Total Energy Used:

**Total energy applied to treatment zone:**

**Other energy:**

Please note other energy:

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:
File Analyzed By: JT PD ERH ERH Date: 8/28/2006

Type of treatment: Conductive Steam ERH Other: Other:

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

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System

Start of Test: May-97 End of Test: Jul-00 Duration: 37 months

Type of Site: 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

<table>
<thead>
<tr>
<th>Impacted Zone</th>
<th>Length (parallel to flow direction)(ft.)</th>
<th>Width (ft.)</th>
<th>Thickness (ft.)</th>
<th>Impacted 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>
<tbody>
<tr>
<td></td>
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</table>

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

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

<table>
<thead>
<tr>
<th>Soil Borings</th>
<th>Number inside treatment zone:</th>
<th>Number outside treatment zone:</th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
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</tr>
</tbody>
</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></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></td>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Cross gradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>PCP</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td>Benzo(a)pyrene</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>Benzene</td>
<td>TPH - Diesel</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>Toluene</td>
<td>Diesel</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>m/p-xylene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
<th>NAPL Area - 525 ft by 150 ft: Impacted area 4.3 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Post-treatment data from June 2006 with Dioxins</td>
</tr>
<tr>
<td></td>
<td>= non-detect in ng/L</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attachments:</th>
<th></th>
<th></th>
<th></th>
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<tr>
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<td></td>
</tr>
</tbody>
</table>


## 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>
<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  x Unknown

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>x Yes (number): 3</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>
<tr>
<td>Depth to water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>35</td>
<td>75</td>
<td>120</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>
<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></th>
<th></th>
<th>x Unknown</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>x Unknown</th>
</tr>
</thead>
</table>

### K range (ft/day)

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

### Transmissivity (ft²/day):

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

### Comments:

- [Blank line]
- [Blank line]
- [Blank line]

### Attachments:

- [Blank line]
- [Blank line]
- [Blank line]
Thermal Treatment - Design

Thermal treatment:  
- Conductive  
- Electrical Resistance  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  
- Steam  
- DUS/HPO  
  - 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:  
- 5/12/1997  
- Duration: 37 months  

Hydraulic Control:  
- Yes  
- No  

Treatment Cell Design:  
- Size of target zone (ft³): 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): 20  
- Number of extraction points: 14  
- Number of energy delivery points: 12  

Temperature Profile:  
- Initial formation temperature (deg C):  
- Maximum representative formation temperature (deg C): 130  
- 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: 198,500 lb  
- In vapor stream: 238,400 lb  
- Total: 1,330,000 lb  

Comments:  
Phase I treated - 20 to 95 feet;  
Phase II treated - 20 to 125 feet  
Mass removed - 212,800 lb of in-situ oxidation and 678,300 lb of free product creosote  

Attachments:  

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

Remediation Goal:

- In Groundwater:
  - PCP - 1 ug/L; TCDD (eqv) - 0.00003 ug/L; B(a)P - 0.2 ug/L
  - __________ kWhr
  - __________ kWhr/m³
  - __________ kWhr/yd³

- In Soil:
  - __________ kWhr
  - __________ kWhr/m³
  - __________ kWhr/yd³

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:
  - __________ 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: 21,500,000
  - 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
Type of treatment: ___ Conductive ___ Steam x 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 ___ Full Scale System
Type of Site: x Non-DOD ___ DoD

x Facility Name: Lowry Landfill
Organization: EPA
City, State, Zip Code: Denver, CO
Phone #: 303-312-6579 email: ________________________________

x Primary point of contact: Bonnie Lavelle
Organization: EPA
City, State, Zip Code: Denver, CO
Phone #: 303-312-6579 email: ________________________________

x Other contacts or vendors who worked on site ___ None
Point of contact: Bill Plaehn
Type: x Vendor, Consultant ___ Vendor, Technical Applications ___ Other ________________
Organization: Parsons
City, State, Zip Code: ________________________________
Phone #: 303-764-8729 email: bill.a.plaehn@parsons.com

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
x 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**
- Map attachment

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

**Impact Zone:**
- 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 (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>Acetone</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>Methylene Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,2-dichloroethene</td>
<td>Hexane</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
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<td>trans-1,2-dichloroethene</td>
<td>Ethylbenzene</td>
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<tr>
<td>1,1-dichloroethane</td>
<td>m/p-xylene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>2-butanol</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
<td>Xylenes (perimeter)</td>
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<td>10 mg/L</td>
<td>None</td>
<td>5 mg/L</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td>Xylenes (in treat zone)</td>
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<td>10,000 mg/L</td>
<td>500 mg/kg</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>Total VOCs (perimeter)</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Total VOCs (in treat zone)</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Attachments:**

See attached sheets for concentration data.
### 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>
<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:**

- **Unconsolidated Sediments**

- **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: NW

  - Horizontal hydraulic gradient (feet/foot): 0.04 to 0.05
  - Vertical hydraulic gradient (feet/foot): _____________

  - K range (ft/day)
    - Measured using: Slug Test Laboratoy Field data
    - low: _____________
    - high: _____________
    - Transmissivity (ft²/day): Measured using: Slug Test Laboratoy Field data
    - low: _____________
    - high: _____________

- **Comments:**

  - Horzonation hydraulic gradient during treatment was 0.05 to 0.06 ft/ft

- **Attachments:**

  - _____________
  - _____________
  - _____________
  - _____________
  - _____________

- **Ground surface elevation based on wells in or adjacent to treatment zone:** 5760 ft amsl

- **Facility ID#: 0290**
### Thermal Treatment - Design

**Facility ID#:** 0290

<table>
<thead>
<tr>
<th><strong>Thermal treatment:</strong></th>
<th>Conductive</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steam:</strong></td>
<td>Steam</td>
<td>Steam + air</td>
<td>Steam + O2</td>
<td></td>
</tr>
</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 Target Zone:**
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

**Start of Thermal Test:** 3/29/2002

**Duration:** 309 day

**Hydraulic Control:**
- Yes
- No

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>75600</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>16</td>
<td>Unknown</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>10</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>6</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>220</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>2</td>
<td>Unknown</td>
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</tbody>
</table>

**Temperature Profile:**

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th>16</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>84</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>211</td>
<td>Unknown</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>98</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Date**                          | **Temperature (deg C)**
---                              | ---
1/11/2003                       | 86
4/25/2003                       | 70

**Mass of contaminant removed:**

- Via liquid pumping: 751 lb x kg Unknown
- In vapor stream: 16375 lb x kg Unknown
- Total: 17127 lb x 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:**

- **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. Difficult to 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
  - **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  ____  Date:  10/30/2006
Type of treatment:  ____  Conductive  ____  Steam  ____  ERH  x  Other:  RFH
Type of Contaminant:  ____  Chlorinated Solvents  ____  Petroleum Hydrocarbons  ____  Pesticides
____  Wood Treating  x  Other:  organochloropesticide
Treatment Status:  ____  Active  x  Post
Type of Test:  x  Pilot Test  ____  Full Scale System
Start of Test:  1992  End of Test:  1992  Duration:  1 month
Type of Site:  ____  Non-DOD  x  DoD

Facility Name:  Rocky Mountain Arsenal Basin F
Address:  ____________________________________________
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  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>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>
</tbody>
</table>

- Trichloroethene
- Tetrachloroethene
- 1,1-dichloroethene
- cis-1,2-dichloroethene
- trans-1,2-dichloroethene
- 1,2-dichloroethene
- 1,1,1-trichloroethane
- 1,1,2-trichloroethane
- Vinyl Chloride
- Other

- Benzene
- Jet Fuel
- napthalene
- organochloropesticide
- Toluene
- Ethylbenzene
- m,p-xylene
- o-xylene
- Other

- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
- None
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- None
- None
- None
- None
- None

Comments:

Attachments:
## Geology:

### Zone

<table>
<thead>
<tr>
<th>Vadose Zone</th>
<th>Saturated Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<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>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>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td>Weathered bedrock, limestone, sandstone</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></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
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</tr>
<tr>
<td>Unknown:</td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow direction</th>
<th></th>
</tr>
</thead>
</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>
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</tr>
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<tbody>
<tr>
<td>low</td>
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<td></td>
<td></td>
<td></td>
<td>Unknown</td>
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<tr>
<td>high</td>
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</tbody>
</table>

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

### Hydrogeologic Conceptual Model

- **Unconsolidated Sediments**
  - Weathered bedrock, limestone, sandstone
  - 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 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
**Thermal Treatment - Design**

**Facility ID#: 0295**

<table>
<thead>
<tr>
<th>Thermal Treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

- **Steam**
- **Steam + air**
- **Steam + O2**

**Other (describe):** RFH

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>x Pilot test</th>
<th>Full-scale System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</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>
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</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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</tr>
</tbody>
</table>

- **Start of Thermal Test:** 1992
- **Duration:** 1 month

<table>
<thead>
<tr>
<th>Hydraulic Control</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<tr>
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</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>
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</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): |                     |

<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>Treated - 50 yd³</td>
</tr>
</tbody>
</table>

**Attachments:**

---

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Please note other cost:

Energy Cost:

Thermal Vendor Cost:

Consultant 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 ___ Date: 9/26/2006
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: 3/3/2002 End of Test: 3/15/2002 Duration: 12 days
Type of Site: ___ Non-DOD ___ DoD

Facility Name: Rocky Mountain Arsenal
Organization: TerraTherm
Address: 356 Broad Street
City, State, Zip Code: Commerce City, CO
OU# or Site #: Hex Pit
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: rbaker@terratherm.com

Primary point of contact: Ralph Baker
Organization: TerraTherm
Address: 356 Broad Street
City, State, Zip Code: Commerce City, CO
Phone #: 978-343-0300 email: rbaker@terratherm.com

Other contacts or vendors who worked on site ___ None
Type: ___ Vendor, Consultant ___ Vendor, Technical Applications x 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
- 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 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: 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></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Chloroform</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>dieldrin</td>
<td>None</td>
<td>100 mg/kg</td>
<td>None</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>dieldrin</td>
<td>None</td>
<td>10,000 mg/kg</td>
<td>None</td>
<td>100 mg/kg</td>
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<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td>chlorodane</td>
<td>None</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td>styrene</td>
<td>None</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td>styrene</td>
<td>None</td>
<td>100 mg/kg</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>styrene</td>
<td>None</td>
<td>10,000 mg/kg</td>
<td>None</td>
<td>1,000 mg/kg</td>
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<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td>hexachlorobenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>o-xylene</td>
<td>hexachlorobenzene</td>
<td>None</td>
<td>None</td>
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<td>None</td>
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<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>o-xylene</td>
<td>hexachlorobenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td>vinyl</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Carbon Tetrachloride</td>
<td></td>
<td></td>
<td>None</td>
<td>5 mg/kg</td>
<td>None</td>
<td>5 mg/kg</td>
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<tr>
<td></td>
<td>Chloroform</td>
<td></td>
<td></td>
<td>None</td>
<td>5 mg/kg</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td></td>
<td></td>
<td>None</td>
<td>1 mg/kg</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
</tbody>
</table>

Comments:

Three stated impacted areas of 3200 yd³, 2550 yd³, and 2005 yd³.
### 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>
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<td></td>
<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>
<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>
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<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>No</td>
<td>Yes (number):</td>
<td>x</td>
</tr>
<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>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):

- Measured using: Slug Test, Laboratory, Field data
- low: 0.008
- high: Unknown
- Unknown: x

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

- Measured using: Slug Test, Laboratory, Field data
- low: unknown
- high: unknown
- Unknown: x

### K range (ft/day)

- Measured using: Slug Test, Laboratory, Field data
- low: unknown
- high: unknown
- Unknown: x

### Transmissivity (ft²/day)

- Measured using: Slug Test, Laboratory, Field data
- low: unknown
- high: unknown
- Unknown: x

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

- 5280 ft amsl
- Unknown

### Attachments:

- 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:  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  x Vadose only  x Both (Saturated and Vadose zones)

Start of Thermal Test:  3/3/2002  Duration:  12 days

Hydraulic Control:  x 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 extraction points:  10  Number of energy delivery points:  213

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):  2

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.
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 magnehelic gauge taps and ball valves at vapor tea 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

Please note other energy: __________________________________________________________

**Cost**

Total Project Cost: ____________________________

____ Consultant Cost: ____________________________

____ Thermal Vendor Cost: ____________________________

____ Energy Cost: ____________________________ m³ ___________ yd³

x Other Cost 1: 1954700

x Other Cost 2: 370000

x Other Cost 3: ____________________________

Please note other cost: x Other Cost 1: design and construction

x Other Cost 2: horizontal dewatering well installation

x 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 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: 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: ____________________________________
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

Other Vendor, Technical Applications Vendor, Consultant Other
Organization: _______________________________________
Address: __________________________________________
City, State, Zip Code: __________________________________
Phone #: ____________________
email: ______________________
### General Site Assessment Data

**Facility ID:** 0305

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

### 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>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross-link</td>
<td>None</td>
<td>None</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>
<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>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</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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<td>Vinyl Chloride</td>
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<td></td>
<td>None</td>
<td>None</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>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></th>
<th>ft amsl</th>
<th>Unknown</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>
</table>

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
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</table>

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

<table>
<thead>
<tr>
<th>Flow direction</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
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</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Transmissivity (ft²/day):</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>
<tr>
<td>low</td>
</tr>
<tr>
<td>high</td>
</tr>
<tr>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### Comments:

[Blank space for comments]

#### Attachments:

[Blank space for attachments]
Thermal Treatment - Design

Facility ID#: 0305

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:  
Duration: ________________

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:  

<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 delivery points:</td>
<td>________________</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</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 |

<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.
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

<table>
<thead>
<tr>
<th>File Analyzed By</th>
<th>JT</th>
<th>PD</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>2/7/1997</td>
<td></td>
</tr>
<tr>
<td>End of Test</td>
<td>3/9/1997</td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td>30 d</td>
<td></td>
</tr>
<tr>
<td>Type of Site</td>
<td>Non-DOD</td>
<td>DoD</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Dover Air Force Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code</td>
<td>Dover, DE</td>
</tr>
<tr>
<td>OU# or Site</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary point of contact</th>
<th>Tim McHale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization</td>
<td>Dover National Test Site</td>
</tr>
<tr>
<td>Address</td>
<td>Bldg 909 Arnold Drive Ext</td>
</tr>
<tr>
<td>City, State, Zip Code</td>
<td>Dover AFB, DE 19902</td>
</tr>
<tr>
<td>Phone #</td>
<td>302-677-4103</td>
</tr>
<tr>
<td>email</td>
<td><a href="mailto:timothy.mchale@dover.af.mil">timothy.mchale@dover.af.mil</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</td>
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<tr>
<td>Organization</td>
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<tr>
<td>Address</td>
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<tr>
<td>City, State, Zip Code</td>
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</tr>
<tr>
<td>Phone #</td>
<td></td>
</tr>
<tr>
<td>email</td>
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</table>

### QA/QC

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
</tr>
</thead>
<tbody>
<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.): __________
- 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>
</tr>
</thead>
<tbody>
<tr>
<td>Upgradient</td>
</tr>
<tr>
<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>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>Crossdi</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>
</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>
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<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
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<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</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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<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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</table>

**Comments:**

No contaminants of concern. They used two tracers that mimicked DNAPL, i.e. Perfluoromethylcyclohexane (PMCH) and perfluorononemethylcyclohexane (PTMCH).
### Hydrogeologic Conceptual Model

#### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Vadose Zone</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></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>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated Zone</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></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>
</tr>
<tr>
<td></td>
<td></td>
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</table>

#### Geology:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Ground surface elevation based on wells in or adjacent to treatment zone:</td>
<td>Oct-35</td>
<td>ft amsl</td>
<td>Unknown</td>
</tr>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>Yes (number):</td>
<td>Unknown (assume single aquifer)</td>
<td></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>25</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
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</tbody>
</table>

#### Flow direction

| NW | |

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

| x | Unknown |

#### 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>
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</thead>
<tbody>
<tr>
<td>low</td>
<td>6.5</td>
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<tr>
<td>high</td>
<td>27.8</td>
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#### Transmissivity (ft2/day):

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<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>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

### Attachments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

---

**Facility ID**: 0110
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance

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
- x Both (Saturated and Vadose zones)

Start of Thermal Test:  
- 2/7/1997
- Duration: 30 d

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft2): 900
Thickness of target zone (ft): 15
Depth to top of target zone (ft bgs): 20
Thickness of target zone below water table (ft): 10
Number of energy delivery points: 6
Number of extraction points: 1

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:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping: Unknown (30 x 30 ft)
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

x Energy

Total Energy Used: 200000 kWhr

kWhr

kWhr/m^3

kWhr/yd^3

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

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

Please note other energy:

x 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 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: X Pilot Test ___ Full Scale System
Start of Test: 8/18/1999 End of Test: 7/12/2000 Duration: 203 d
Type of Site: X Non-DOD ___ DoD

X Facility Name: Cape Canaveral
Address: __________________________________________________________________________
City, State, Zip Code: Florida
OU# or Site #: LC34

X 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

X Other contacts or vendors who worked on site ___ None
Point of contact: Stephen Antonioli
Type: X 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

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

**X** Monitor Wells: Number of relevant monitoring wells with groundwater data: **None**
- **X** Number of wells relative to treatment zone:
  - Pre-treatment In: **_** Uppgradient: **_** Downgradient: **_** Crossgradient: **_**
  - Post-treatment In: **_** Uppgradient: **_** Downgradient: **_** Crossgradient: **_**

**X** Soil Borings: Number of relevant soil borings with pre-treatment data: **None**
- **X** Number inside treatment zone: **None**
- **X** Number outside treatment zone: **None**

**X** 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>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>TCE</td>
<td></td>
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<td>Tetrachloroethene</td>
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<td>None</td>
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</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
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<td>trans-1,2-dichloroethene</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>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
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<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
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<td>None</td>
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<td>VC</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</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:**

---
Hydrogeologic Conceptual Model

**Geology:**

**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:**
- Unknown ft amsl

**Aquifer Characteristics:**
- Is more than 1 aquifer present?
  - No
  - Yes (number): 2
- Depth to water:
  - low value (ft bgs): 5
  - high value (ft bgs): 46

**Flow direction**

**Horizontal hydraulic gradient (feet/foot):**
- Measured using:
  - Slug Test
  - Laboratory
  - Field data
  - Unknown
- Low: 0.000009 to 0.0007
- High: 0.000005 to 0.0008

**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
- Low: 0.14 to 13.7
- High: 2.7 to 3.3

**Transmissivity (ft2/day):**
- Measured using:
  - Slug Test
  - Laboratory
  - Field data
  - Unknown
- Low: 3.2
- High: 1.6

**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
- Lower Sand unit: K = 2.7 to 3.3 ft/day
- Average: 1.6 ft/day

**Attachments:**

---
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>_____ Conductive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>_____ Electrical Resistance</td>
</tr>
<tr>
<td></td>
<td>3 phase</td>
</tr>
<tr>
<td></td>
<td>Steam</td>
</tr>
<tr>
<td></td>
<td>_____ Steam</td>
</tr>
<tr>
<td>Other (describe)</td>
<td></td>
</tr>
</tbody>
</table>

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

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

| Hydraulic Control | xYes | No |

| Treatment Cell Design: | Size of target zone (ft²): 3750 | _____ Unknown | ( _____ x _____ ft) |
| Treatment Cell Design: | Thickness of target zone (ft): 42 | _____ Unknown |
| Treatment Cell Design: | Depth to top of target zone (ft bgs): 1 | _____ Unknown |
| Treatment Cell Design: | Thickness of target zone below water table (ft): 41 | _____ Unknown |
| Treatment Cell Design: | Number of extraction delivery points: 13 | _____ Unknown |
| Treatment Cell Design: | Number of extraction points: 12 | _____ Unknown |

| Temperature Profile: | Initial formation temperature (deg C): 26 | _____ Unknown |
| Temperature Profile: | Maximum representative formation temperature (deg C): | _____ Unknown |
| Temperature Profile: | Time to reach maximum representative temperature (days): | _____ Unknown |
| Temperature Profile: | Duration of treatment at representative temperature (days): | _____ Unknown |
| Temperature Profile: | Formation temperature immediately post-treatment: | | |
| Temperature Profile: | Formation temperature post-treatment monitoring event 1: | | |
| Temperature Profile: | Duration of post-treatment monitoring (days): | | |

| Mass of contaminant removed: | Via liquid pumping: | _____ lb | _____ kg | _____ Unknown |
| Mass of contaminant removed: | In vapor stream: | _____ lb | _____ kg | _____ Unknown |
| Mass of contaminant removed: | Total: | 2150 | _____ lb | _____ kg | _____ Unknown |

Comments:

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: 172500 kWhr

- Total energy applied to treatment zone: 172500 kWhr
- Other energy: Please note other energy:

Cost

Total Project Cost: 568742

- Consultant Cost:
- Thermal Vendor Cost:
- Energy Cost: 72484 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:** X Conductive X Steam ERH Other: 
- **Type of Contaminant:** X Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other: 
- **Treatment Status:** X Active X Post
- **Type of Test:** X Pilot Test X Full Scale System
- **Start of Test:** 7/19/2001
- **End of Test:** 12/28/2001
- **Duration:** 160 d
- **Type of Site:** X Non-DOD X DoD

### Facility Name
- **Cape Canaveral**
- **City, State, Zip Code:** Florida
- **OU# or Site #:** LC34

### Primary point of contact
- **Name:** Jackie Quinn
- **Organization:** Kennedy Space Center
- **City, State, Zip Code:** Santa Barbara, CA
- **Phone #:** 321-867-8410
- **email:** jacqueline.w.quinn@nasa.gov

### Other contacts or vendors who worked on site
- **Type:** X Vendor, Consultant X Vendor, Technical Applications X Other
- **Organization:** IWR
- **City, State, Zip Code:** Cape Canaveral
- **Phone #:** 805-966-7757
- **email:** jackie.quinn@nasa.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

**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>Width:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative method for determining size of impacted zone</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>
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**Monitor Wells:**

<table>
<thead>
<tr>
<th>Number of wells relative to treatment zone:</th>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Soil Borings:**

<table>
<thead>
<tr>
<th>Number of relevant soil borings with post-treatment data:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
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</thead>
<tbody>
<tr>
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<td></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>
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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>Trichloroethene</td>
<td>X</td>
<td>X</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>X</td>
<td>Naphthalene</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
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<td>X</td>
<td>X</td>
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<td>1,2-dichloroethane</td>
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<td>methylbenzene</td>
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<td>X</td>
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<td>X</td>
</tr>
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<td>1,1,2-trichloroethane</td>
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<td></td>
<td></td>
<td>None</td>
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</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
**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>x</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>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>

| x | Ground surface elevation based on wells in or adjacent to treatment zone: | 5 ft amsl | Unknown |

<table>
<thead>
<tr>
<th>x</th>
<th>Aquifer Characteristics:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>No</td>
</tr>
<tr>
<td>Depth to water:</td>
<td>Aquifer 1</td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>46</td>
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<tr>
<td>high value (ft bgs):</td>
<td>4</td>
</tr>
<tr>
<td>Unknown:</td>
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</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Flow direction</th>
</tr>
</thead>
</table>

| x | Horizontal hydraulic gradient (feet/foot): | 0.000690 to 0.0007 | 0.000565 to 0.0008 |
|---|------------------------------------------|

| x | Vertical hydraulic gradient (feet/foot): | Unknown |

<table>
<thead>
<tr>
<th>x</th>
<th>K range (ft/day):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured using:</td>
<td>Slug Test</td>
</tr>
<tr>
<td>low</td>
<td></td>
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<tr>
<td>high</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Transmissivity (ft²/day):</th>
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</thead>
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<tr>
<td>Measured using:</td>
<td>Slug Test</td>
</tr>
<tr>
<td>low</td>
<td></td>
</tr>
<tr>
<td>high</td>
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</table>

**Comments:**

<table>
<thead>
<tr>
<th>Upper sand unit</th>
<th>K= 0.14 to 13.7 ft/day</th>
<th>average 9.7 ft/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle fine-grained unit</td>
<td>K= 2.1 to 4.9 ft/day</td>
<td>average - 3.2 ft/day</td>
</tr>
<tr>
<td>Lower Sand unit</td>
<td>K= 2.7 to 3.3 ft/day</td>
<td>average - 1.6 ft/day</td>
</tr>
</tbody>
</table>

**Attachments:**

- ________________________________
  - ________________________________
  - ________________________________
  - ________________________________
<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
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<tr>
<td>Thermal treatment:</td>
<td>Conductive</td>
</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>
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<tr>
<td></td>
<td>DC power</td>
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<td>Steam</td>
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<td>Steam + air</td>
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<tr>
<td></td>
<td>Steam + O2</td>
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<tr>
<td>Other (describe)</td>
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<tr>
<td>Type of Test:</td>
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<td>Full-scale System</td>
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<tr>
<td>Geology of Treatment Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower</td>
</tr>
<tr>
<td></td>
<td>permeability material</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher</td>
</tr>
<tr>
<td></td>
<td>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>
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<tr>
<td></td>
<td>Vadose only</td>
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<tr>
<td></td>
<td>Both (Saturated and Vadose zones)</td>
</tr>
<tr>
<td>Start of Thermal Test:</td>
<td>7/19/2001</td>
</tr>
<tr>
<td></td>
<td>Duration: 160 d</td>
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<tr>
<td>Hydraulic Control:</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Size of target zone (ft²):</td>
<td>1750</td>
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<td>Thickness of target zone (ft):</td>
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<td>Unknown</td>
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<tr>
<td>Depth to top of target zone (ft bgs):</td>
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<tr>
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<td>Unknown</td>
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<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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<td>Number of extraction points:</td>
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<td>Initial formation temperature (deg C):</td>
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<td>Maximum representative formation temperature (deg C):</td>
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<td>Time to reach maximum representative temperature (days):</td>
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<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>
<td>Duration of post-treatment monitoring (days):</td>
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<td></td>
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<tr>
<td>Mass of contaminant removed:</td>
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<td>Via liquid pumping:</td>
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<td>lb</td>
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<tr>
<td></td>
<td>kg</td>
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<tr>
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<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.
Cost and Performance

Remediation Goal:

___ In Groundwater:

___ In Soil:

Was the Remediation Goal Achieved:

___ In Groundwater

___ In Soil

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:

___ Total energy applied to treatment zone:

___ Other energy:

Please note other energy:

___ Cost

Total Project Cost: 1201175

___ Consultant Cost:

___ Thermal Vendor Cost:

___ Energy Cost: 13902

___ 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 ____ Date: _________
Type of treatment: ______ Conductive ______ Steam x 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: 27-Dec End of Test: 10-Oct Duration: 250 days
Type of Site: x Non-DOD ______ DoD

Facility Name: FDOT Greensboro Project
Address: ______________________________________________________
City, State, Zip Code: Greensboro, FL
OU# or Site #: __________________________________________________

Primary point of contact: Jimmy Bailey
Organization: Florida Department of Transportation
Address: PO Box 607
City, State, Zip Code: Chipley, Florida 32428-0607
Phone #: __________________ email: ______________________________

Other contacts or vendors who worked on site ______ None
Point of contact: David Rountree
Type: x Vendor, Consultant ______ Vendor, Technical Applications ______ Other _______
Organization: WRS Infrastructure & Environment, Inc.
Address: 625 East Tennessee Street, Suite 100
City, State, Zip Code: Tallahassee, FL 32308-4939
Phone #: 850-531-9860 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:** (141)

<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>Impact 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>

<table>
<thead>
<tr>
<th>Monitor Wells:</th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-treatment:</td>
<td>Number of wells relative to treatment zone:</td>
</tr>
<tr>
<td></td>
<td>Post-treatment:</td>
<td>Number of wells relative to treatment zone:</td>
</tr>
<tr>
<td></td>
<td>Pre-treatment: In:</td>
<td>Upgradient:</td>
</tr>
<tr>
<td></td>
<td>Post-treatment: In:</td>
<td>Upgradient:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of relevant soil borings with post-treatment data:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number inside treatment zone:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number outside treatment zone:</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>
<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>Trichloroethylene</td>
<td>Benene</td>
<td>Crossdi</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>Diesel</td>
<td>5,000 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>Gasoline (BTEX)</td>
<td>5,000 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>50 mg/L</td>
<td>None</td>
<td>1 mg/L</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
</tr>
<tr>
<td>1,2-dichloroethene</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>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
<td>Total xylenes</td>
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<td>5 mg/L</td>
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<td>1,1,2,2-tetrachloroethane</td>
<td>MTBE</td>
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<td>1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</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>
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<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Notes:**

- All COCs were nondetect in post treatment samples but they did not give the detection limit.

**Attachments:**

- [Attachment 0343]
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
<th>vadose Zone</th>
<th>saturated Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<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: 255 ft amsl

#### 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>10</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: N-NE

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

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>x</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>0.005752</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>

#### Vertical hydraulic gradient (feet/foot): 0.005752

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

<table>
<thead>
<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>x</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>1.91</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>5.19</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>
<th>x</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>
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</tbody>
</table>

#### Comments:

<p>| |</p>
<table>
<thead>
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<tbody>
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<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>

#### Attachments:

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
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</tbody>
</table>

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Facility ID#: 0141
<table>
<thead>
<tr>
<th>Thermal Treatment</th>
<th>Facility ID#: 0343</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td></td>
</tr>
<tr>
<td>x Conductive</td>
<td></td>
</tr>
<tr>
<td>x Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 phase</td>
</tr>
<tr>
<td></td>
<td>Steam</td>
</tr>
<tr>
<td></td>
<td>Other (describe)</td>
</tr>
<tr>
<td><strong>Type of Test:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full-scale System</td>
</tr>
<tr>
<td><strong>Geology of Treatment Zone:</strong></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 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><strong>Treatment Target Zone:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Both (Saturated and Vadose zones)</td>
</tr>
<tr>
<td><strong>Start of Thermal Test:</strong></td>
<td>2-Jan</td>
</tr>
<tr>
<td><strong>Hydraulic Control:</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Size of target zone (ft2):</strong></td>
<td>4305</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><strong>Temperature Profile:</strong></td>
<td></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>
</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></td>
</tr>
<tr>
<td>In vapor stream:</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td></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.
Please note other energy:

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: __________ kWh m³ yd³

Total energy applied to treatment zone: __________ kWh m³ yd³

Other energy: __________ kWh m³ 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

- **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:** 2/21/2005 **End of Test:** 5/16/2005 **Duration:** 85 d
- **Type of Site:** Non-DOD DoD
- **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:** 0447

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

Impact zone as defined by documentation: 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: [ ]
  - Pre-treatment: [ ]
  - 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>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-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
</tr>
<tr>
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<td>1,1,2-trichloroethene</td>
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</tr>
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<td>Vinyl Chloride</td>
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<td>None</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-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 __________ 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: __________________________________________________________________________________________
<table>
<thead>
<tr>
<th><strong>Thermal Treatment - Design</strong></th>
<th><strong>Facility ID#: 0347</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td>Conductive</td>
</tr>
<tr>
<td></td>
<td>Electrical Resistance</td>
</tr>
<tr>
<td></td>
<td>3 phase</td>
</tr>
<tr>
<td><strong>Steam</strong></td>
<td>6 phase</td>
</tr>
<tr>
<td></td>
<td>AC power</td>
</tr>
<tr>
<td></td>
<td>DC power</td>
</tr>
<tr>
<td></td>
<td>Steam + air</td>
</tr>
<tr>
<td></td>
<td>Steam + O2</td>
</tr>
<tr>
<td></td>
<td>Other (describe)</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>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><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>2/21/2005</td>
</tr>
<tr>
<td></td>
<td>Duration: 85 d</td>
</tr>
<tr>
<td><strong>Hydraulic Control</strong></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
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<td><strong>Treatment Cell Design:</strong></td>
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<tr>
<td>Size of target zone (ft2):</td>
<td>17222</td>
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<tr>
<td>Thickness of target zone (ft):</td>
<td>Unknown</td>
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<td>Depth to top of target zone (ft bgs):</td>
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<td>Thickness of target zone below water table (ft):</td>
<td>Unknown</td>
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<tr>
<td>Number of extraction points:</td>
<td>23</td>
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<td>Number of energy delivery points:</td>
<td>23</td>
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<tr>
<td><strong>Temperature Profile:</strong></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>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
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<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>Unknown</td>
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<tr>
<td><strong>Formation temperature immediately post-treatment:</strong></td>
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<tr>
<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><strong>Mass of contaminant removed:</strong></td>
<td></td>
</tr>
<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>2000</td>
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<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:**
  - 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

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th>5/12/2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam</td>
<td>X</td>
<td>ERH</td>
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<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
<td>X</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
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<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td>________________</td>
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<td>Type of Test:</td>
<td>Pilot Test</td>
<td>Full Scale System</td>
<td>________________</td>
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<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
<td>________________</td>
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<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Young Rainey Star Center</th>
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<tbody>
<tr>
<td>Address:</td>
<td>________________</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Largo, FL</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td>Northeast Site Area A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary point of contact:</th>
<th>Joe Daniel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>SM Stoller Corporation</td>
</tr>
<tr>
<td>Address:</td>
<td>7887 Bryan Dairy Rd, Suite 260</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Largo, FL 33777</td>
</tr>
<tr>
<td>Phone #:</td>
<td>727-549-0603</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:joe.daniel@pio.doe.gov">joe.daniel@pio.doe.gov</a></td>
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<table>
<thead>
<tr>
<th>Other contacts or vendors who worked on site</th>
<th>None</th>
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</thead>
<tbody>
<tr>
<td>Point of contact:</td>
<td>Jack Craig</td>
</tr>
<tr>
<td>Type:</td>
<td>Vendor, Consultant</td>
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<tr>
<td>Vendor, Technical Applications</td>
<td>Other</td>
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<td>Organization:</td>
<td>Department of Energy</td>
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<td>7887 Bryan Daisy Road, Suite 195</td>
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<tr>
<td>City, State, Zip Code:</td>
<td>Largo, FL 33777</td>
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<tr>
<td>Phone #:</td>
<td>412-386-4754</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:jack.craig@lm.doe.gov">jack.craig@lm.doe.gov</a></td>
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### QA/QC

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
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<tbody>
<tr>
<td>Good pre- and post-treatment groundwater data</td>
</tr>
<tr>
<td>Good temperature profile vs. time information</td>
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<tr>
<td>Groundwater elevations</td>
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<tr>
<td>Hydraulic Conductivity information</td>
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</table>
### General Site Assessment Data

- **Facility ID:** 0150

#### Impacted Zone
- Length (parallel to flow direction)(ft.): 550
- Width (ft.): 54
- Thickness (ft.): 11
- 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:
  - Pre-treatment: 5
  - Post-treatment: 74
- Number of wells relative to treatment zone:
  - Pre-treatment: In: 8, Upgradient: 14, Downgradient: 1, Crossgradient: 1
  - Post-treatment: In: 16, Upgradient: 14, Downgradient: 1, Crossgradient: 1

#### Soil Borings
- Number of relevant soil borings with pre-treatment data: 26
- Number of relevant soil borings with post-treatment data: 26
- Number inside treatment zone: 46
- Number outside treatment zone: 16

#### 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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<tr>
<td></td>
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<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>Crossdr.</td>
<td></td>
<td>5 mg/L</td>
<td>5 mg/kg</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
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<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
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<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td></td>
<td>1 mg/L</td>
<td>5 mg/kg</td>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td></td>
<td>1 mg/L</td>
<td>0.1 mg/kg</td>
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<td>Ethylbenzene</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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#### Comments:

- Additional comments can be added here.

#### Attachments:

- Source zone definition attachments
- Map attachment
### 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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<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>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>
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<table>
<thead>
<tr>
<th>Saturated Zone:</th>
<th>Unconsolidated Sediments</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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<tr>
<td></td>
<td>Largely permeable sediments with inter-beded lenses of lower permeability material</td>
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<tr>
<td></td>
<td>Largely impermeable sediments with inter-beded layers of higher permeability material</td>
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<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
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| Ground surface elevation based on wells in or adjacent to treatment zone: | 17 ft amsl | Unknown |

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
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<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>No</td>
<td>Yes (number):</td>
<td>Unknown (assume single aquifer)</td>
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<tr>
<td>Depth to water:</td>
<td>low value (ft bgs):</td>
<td>1 (Average 5)</td>
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</tr>
<tr>
<td></td>
<td>high value (ft bgs):</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
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</table>

| Flow direction | ESE |

| Horizontal hydraulic gradient (feet/foot): | 0.002 | 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>
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<tbody>
<tr>
<td>low</td>
<td>0.99</td>
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<td>Unknown</td>
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<tr>
<td>high</td>
<td>7.1</td>
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<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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</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**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 ________ Electrical Resistance: ETDP

___ 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: 10/3/2002  Duration: 134d

Hydraulic Control:  ____ Yes  ____ No

Treatment Cell Design:

Size of target zone (ft2): 10000  Unknown (100 x 100 ft)

Thickness of target zone (ft): 35  Unknown

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

Thickness of target zone below water table (ft): 30  Unknown

Number of energy delivery points: 78  Unknown

Number of extraction points: 78  Unknown

Temperature Profile:

Initial formation temperature (deg C): 28  Unknown

Maximum representative formation temperature (deg C): 100  Unknown

Time to reach maximum representative temperature (days): 68  Unknown

Duration of treatment at representative temperature (days): 70  Unknown

Date  Temperature (deg C)

2/19/2003  105

4/23/2003  85

Mass of contaminant removed:

Via liquid pumping: ____________ lb  ____________ kg  Unknown

In vapor stream: ____________ lb  ____________ kg  Unknown

Total: 9920 or 3880 x lb  ____________ kg  Unknown

Comments: Mass removed provides the high and low calculations

Heating cycles - ERH only for hot floor 10/3/02 to 10/22/02 and steam+ERH 10/23/02 to 2/17/03

Volume treated

10000 yd3 (1816000 ft3)

Attachments: ________________________________

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

Remediation Goal:

- In Groundwater:
  - ug/L - TCE - 11000; cis-1,2-DCE - 50000; methylene chloride - 20000; Toluene - 5500; 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
- 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: 3800000
- 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: 11/15/2006

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: End of Test: 5/15/2006 Duration: 

Type of Site: Non-DOD DoD

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@gjo.doe.gov

Other contacts or vendors who worked on site: None

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

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:** 0160

**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>Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethylene</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>1,2-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1-dichloroethane</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>None</td>
<td>None</td>
<td>None</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>Chlorinated Solvents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petroleum Hydrocarbons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Pre-treatment Concentration per Chemical</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></td>
<td></td>
<td></td>
<td></td>
<td></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><strong>Vadose Zone</strong></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><strong>Saturated Zone</strong></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>x</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): |                       |                       |
| Low                                         |                       |                       |
| High                                        |                       |                       |

| Vertical hydraulic gradient (feet/foot):   |                       |                       |
| Low                                         |                       |                       |
| High                                        |                       |                       |

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

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

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

<table>
<thead>
<tr>
<th>Field</th>
<th>amsl</th>
<th>Unknown</th>
</tr>
</thead>
</table>

### Attachments:

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:**

- [Attach comments here if applicable]
## Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0360</th>
</tr>
</thead>
</table>

### Thermal Treatment
- Conductive
- Electrical Resistance: ETDSP
  - 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
- 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 extraction points: ____________ Unknown
- Number of energy delivery 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: 4000 lb _____ kg Unknown
- In vapor stream: 14000 lb _____ kg Unknown
- Total: 18000 lb _____ kg Unknown

### Comments
- Mass removed provides the high and low calculations
- Heating cycles - ERH only for hot
- floor 10/3/02 to 10/22/02 and steam+ERH 10/23/02 to 2/17/03
- Volume treated:
  - 10000 yd³ (1816000 ft³)

### 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: ___ 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

x File Analyzed By: JT x PD ______ Date: 1/9/2007
Type of treatment: ______ Conductive ______ Steam ______ ERH x Other: in situ soil mixing w/steam
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: Jan-03 End of Test: ________________ Duration: ______
Type of Site: ______ Non-DOD x DoD

x Facility Name: Cape Canaveral AF Station SLC 15 Pilot
Address: ______________________________________________________
City, State, Zip Code: Cape Canaveral, FL
OU# or Site #: Space Launch Complex 15, Solid Waste Management Unite (SMWU C030)

x 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

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: 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 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>Hexane</td>
<td>Cross</td>
<td>500 mg/L</td>
<td>500 mg/kg</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>
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<td>None</td>
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<td>None</td>
</tr>
<tr>
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<td>Ethylbenzene</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>o-xylene</td>
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<td>None</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>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Freon 113</td>
<td>500 mg/L</td>
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<td>None</td>
<td>None</td>
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</tr>
<tr>
<td></td>
<td>Total VOCs</td>
<td>1,000 mg/kg</td>
<td></td>
<td>None</td>
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</tr>
</tbody>
</table>

**Comments:**

Source was Considered to be anywhere w/dissolved TCE above 10 parts per million (1% solubility). Estimated 582 kg TCE mass.

**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>
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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>
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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:

- **Is more than 1 aquifer present?**  Yes
- **Depth to water:**
  - **low value (ft bgs):** 5
  - **high value (ft bgs):** 100
- **Flow direction:** North (usually)
- **Flow direction:** sometimes East
- **Horizontal hydraulic gradient (feet/foot):** $10^{-3}$ to $10^{-4}$
- **Vertical hydraulic gradient (feet/foot):** Unknown

### K range (ft/day)

- **Measured using:** Slug Test
- **Measured using:** Laboratory
- **Measured using:** Field data
- **K range (ft/day):**
  - **low:** 10
  - **high:** 10

### Transmissivity (ft²/day)

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

### 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

### Attachments:

- Facility ID#: 0362
### Thermal Treatment - Design

**Facility ID#:** 0362

#### Thermal treatment:
- [ ] Conductive
- [ ] Electrical Resistance

#### Electrical Resistance:
- [ ] 3 phase
- [ ] 6 phase
- [ ] AC power
- [ ] DC power

#### Steam:
- [ ] Steam
- [ ] Steam + air
- [ ] Steam + O2
- [ ] 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 lenses of lower permeability material
- [ ] Competent, but fractured bedrock (i.e. crystalline rock)

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

#### Start of Thermal Test:
- [ ] Jan-03
- [ ] Duration: 6 months

#### Hydraulic Control:
- [ ] Yes
- [ ] No

#### Size of target zone (ft²):
- [ ] 7764

#### 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:
- [ ] 1 per cell

#### Number of extraction points:
- [ ] 1 per cell

#### Temperature Profile:

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

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

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

#### 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.
**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: ___________ 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: ___________
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 Los Angeles, CA 90064

Phone #: 310-445-9851 email: plamori@bemsys.com

Other contacts or vendors who worked on site: None

Point of contact: Vendor, Consultant Vendor, Technical Applications Other

Organization: BEM Systems

Address: 2216 South Bentley Ave. #14 Los Angeles, CA 90064

Phone #: 310-445-9851 email: plamori@bemsys.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 relevant soil borings with post-treatment data: __________
  - 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: __________

### Types of Contaminants

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Petroleum Hydrocarbons</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>500 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Toluene</td>
<td>500 mg/L</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</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>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>α-xylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Hexane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Freon 113</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Freon 113</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Freon 113</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Freon 113</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Freon 113</td>
<td>α-xylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Total VOCs</td>
<td>Trichloroethene</td>
<td>500 mg/L</td>
<td>None</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:

---

---
### 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 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:

- **10 ft amsl**
- **Unknown**

#### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - **No**
  - **x Yes** (number): 2
  - **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 bgd):</td>
<td>5</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgd):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Flow direction**
  - North (usually)
  - sometimes East

- **Horizontal hydraulic gradient (feet/foot):**
  - $10^{-3}$ to $10^{-4}$

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

- **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**

#### Comments:

- Vertical K in clay 0.0001 ft/day

#### Attachments:

- Facility ID#: 0363
Thermal Treatment - Design

- 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 
  - In situ mixing with steam

- 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 
  - Both (Saturated and Vadose zones)

- Start of Thermal Test: Mar-04 
  - Duration: 6 months

- Treatment Cell Design: 
  - Yes 
  - No

- Size of target zone (ft²): 27900 
  - Unknown 
  - (155 x 180 ft)

- Thickness of target zone (ft): 15 
  - Unknown

- Depth to top of target zone (ft bgs): 10 
  - Unknown

- Thickness of target zone below water table (ft): 15 
  - Unknown

- Number of energy delivery points: 1 per cell 
  - Unknown

- Number of extraction points: 1 per cell 
  - 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: 
  - 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: 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

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

Remediation Goal:

- In Groundwater: ___________ kWh r/m³, ___________ kWh r/yd³, 80% removal
- In Soil: __________________________________________________________________

Was the Remediation Goal Achieved:

- In Groundwater: __________________________________________________________________
- Comment: _____________________________________________________________________
- In Soil: _____________________________________________________________________
- Comment: ___________________________________________________________________

General comments on the thermal application:

Goal: reduce the identified 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: ___________ kWh r, ___________ kWh r/m³, ___________ kWh r/yd³

- Total energy applied to treatment zone: ___________ kWh r/m³, ___________ kWh r/yd³
- Other energy: ___________ kWh r/m³, ___________ kWh r/yd³
- Please note other energy: ___________________________________________________________________

Cost

Total Project Cost: ___________, ___________, ___________, (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  ERH  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
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 Unit (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

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: 11
- Post-treatment: 11
- Number of wells relative to treatment zone:
  - Pre-treatment: In: 11, Upgradient: 7, Downgradient: 9, Crossgradient: 2
  - Post-treatment: In: 11, Upgradient: 7, Downgradient: 9, Crossgradient: 2

Soil Borings:
- Number of relevant soil borings with pre-treatment data: 23
- Number of relevant soil borings with post-treatment data: 23
- Number inside treatment zone: 23/23
- 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>Crosstr</td>
<td>500 mg/L</td>
<td>500 mg/kg</td>
</tr>
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<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
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<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>
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<td>None</td>
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<td>1,1,2-trichloroethane</td>
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<td>None</td>
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<td></td>
<td>Vinyl Chloride</td>
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<td>None</td>
<td>None</td>
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<td></td>
<td>Freon 113</td>
<td></td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>Total VOC's</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 272 kg TCE mass.
### 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>
<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:** 10 ft amsl

**Aquifer Characteristics:**

<table>
<thead>
<tr>
<th>Aquifer</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>2</td>
<td></td>
</tr>
</tbody>
</table>

**Depth to water:**

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low value (ft bg):</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>High value (ft bg):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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):**

<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>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Transmissivity (ft²/day):**

<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></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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

**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: Oct-04
Duration: 4 months

Hydraulic Control: 
- Yes
- No

Treatment Cell Design:
Size of target zone (ft^2): 17825
Thickness of target zone (ft): 20
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: 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 Unknown kg
In vapor stream: Unknown lb Unknown kg
Total: 13272 lb Unknown kg

Comments:
Treated 48,000 yd^3 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
- In Soil

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 ___________ kWhr/m³ ___________ kWhr/yd³

- Total energy applied to treatment zone: ___________ kWhr/m³ ___________ kWhr/yd³
- Other energy: ___________ kWhr/m³ ___________ kWhr/yd³

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:** x Conductive x Steam ERH Other: __________
- **Type of Contaminant:** _______ Chlorinated Solvents x Petroleum Hydrocarbons _______ Pesticides
- **Wood Treating Other: __________**
- **Treatment Status:** x Active x Post
- **Type of Test:** x Pilot Test x Full Scale System
- **Start of Test:** __________ End of Test: __________ Duration: __________
- **Type of Site:** x 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:** x Vendor, Consultant _____ Vendor, Technical Applications x 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**

- **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 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 Chemicals</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>Crossdi</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrahydrofuran</td>
<td>Jet Fuel</td>
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<td>None</td>
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<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>
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<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</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></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>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Average Pre-treatment Concentration per Chemical**

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

- **Comments:**

- **Attachments:**
### Geology: Unconsolidated Sediments

**Vadose 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

**Saturated 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

### 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>

**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>

**Facility ID#:**

**0365**
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#:</th>
<th>0365</th>
</tr>
</thead>
</table>

<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></td>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td></td>
<td>AC power</td>
<td>DC power</td>
</tr>
<tr>
<td>x Steam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steam</td>
<td>Steam + air</td>
</tr>
<tr>
<td></td>
<td></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>
</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>
</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>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></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>
</table>

<table>
<thead>
<tr>
<th>Treatment Cell Design:</th>
<th>87120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²):</td>
<td>Unknown</td>
</tr>
<tr>
<td>(___ x ___ ft)</td>
<td></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>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>15</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Formation temperature immediately post-treatment:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
<td></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:

- **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: ___________
| 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: | 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-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:** [Omitted]

**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) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Benzene</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</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>
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<td>None</td>
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<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></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>
</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-trichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</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>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- Unknown
- Map attachment
- Alternative method for determining size of impacted zone (See source zone definition attachments)
- Number inside treatment zone:
- Number outside treatment zone:
- Number of relevant monitoring wells with groundwater data:
- Pre-treatment:
- Post-treatment:
- None
- Number of relevant soil borings with pre-treatment data:
- Pre-treatment:
- Post-treatment:
- None
- Number of relevant soil borings with post-treatment data:
- None
- Length (parallel to flow direction)(ft.):
- Width (ft.):
- Thickness (ft.):
- Impacted zone as defined by documentation
- Soil Borings:
- Monitor Wells:
- Chemicals of Concern:
- Facility ID:
- 0368
### Hydrogeologic Conceptual Model

#### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Vadose Zone:</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>
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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>

<table>
<thead>
<tr>
<th>Zone</th>
<th>Saturated Zone:</th>
</tr>
</thead>
<tbody>
<tr>
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<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>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>
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<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

**Facility ID:** 0368

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive ___</th>
<th>Electrical Resistance ___</th>
</tr>
</thead>
</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 ___ | 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 ___ |

| 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>
</tbody>
</table>

| 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

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

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:** Confidential Manufacturing Plant
- **Address:** Doraville, GA
- **OU# or Site #:**

### Facility Analysis

- **File Analyzed By:** JT PD
- **File ID #:**
- **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 Contacts

- **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
  - **Type of Vendor:** Vendor, Consultant
  - **Vendor, Technical Applications:**
  - **Other:**
  - **Organization:** TRS
  - **Address:** 4137 Jensome Lane
  - **City, State, Zip Code:** Franklin, TN
  - **Phone #:** 615-791-5772
  - **Email:** gbeyke@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

**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>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>Trichloroethene</td>
<td>Hexane</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</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>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>Ethylbenzene</td>
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<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>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td></td>
<td>Other</td>
<td>None</td>
<td>None</td>
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</tbody>
</table>

**Comments:**
- The specialty fuel has a boiling point of 228°C and a viscosity of 2 mm²/s @ 90°C.
- Impacted zone was 4,900 ft² up to a 10 ft thick.
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 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

Ground surface elevation based on wells in or adjacent to treatment zone: 1050 ft amsl Unknown

Aquifer Characteristics:

Is more than 1 aquifer present? No Yes (number): 2 3 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>23</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction: No significant flow

Horizontal hydraulic gradient (feet/foot): <0.01 x Unknown

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></td>
<td></td>
<td>x Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Transmissivity (ft²/day)

<table>
<thead>
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<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:

Average depth to water was 24 feet

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:  5/27/1999  
Duration:  198 days

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>4000</th>
<th>Unknown</th>
<th>( _ x _ ft)</th>
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</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>20</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>6</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>50</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>50</td>
<td>Unknown</td>
<td></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>Unknown</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
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<tbody>
<tr>
<td>In vapor stream:</td>
<td>Unknown</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
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<tr>
<td>Total:</td>
<td>Unknown</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
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: _______ 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</th>
<th>PD</th>
<th>Date:</th>
<th>10/30/2006</th>
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</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td></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>
<td></td>
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<tr>
<td>Treatment Status:</td>
<td>Active</td>
<td>Post</td>
<td></td>
<td></td>
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<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>2006</td>
<td></td>
<td></td>
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<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
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</table>

### Facility Name

<table>
<thead>
<tr>
<th>Cartersville, GA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
</tr>
<tr>
<td>OU# or Site #:</td>
</tr>
</tbody>
</table>

### Primary point of contact

<table>
<thead>
<tr>
<th>David Fleming</th>
</tr>
</thead>
<tbody>
<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>
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</tbody>
</table>

### Other contacts or vendors who worked on site

<table>
<thead>
<tr>
<th>None</th>
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<tbody>
<tr>
<td>Point of contact:</td>
</tr>
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<td>Organization:</td>
</tr>
<tr>
<td>Address:</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
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<td>Phone #:</td>
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<td>email:</td>
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### QA/QC

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
</tr>
</thead>
<tbody>
<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

**Facility ID:** 0777

<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></td>
<td></td>
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<td></td>
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</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>
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<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of wells relative to treatment zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-treatment: In:</td>
</tr>
<tr>
<td>Post-treatment: In:</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Number of relevant soil borings with post-treatment data:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<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

<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>
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<td>Crossdi</td>
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<tr>
<td></td>
<td>Trichloroethene</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>
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<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
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<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<tr>
<td></td>
<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>None</td>
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<td>1,1,2-trichloroethene</td>
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<td></td>
<td>Vinyl Chloride</td>
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<td></td>
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<td></td>
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</tr>
</tbody>
</table>

### Comments:

- None

### Attachments:

- None
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)

Depth to water:
- Low value (ft bgs): __15___
- 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

**Facility ID#: 0373**

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
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<tr>
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<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>
<th></th>
</tr>
</thead>
<tbody>
<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>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>2006</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Hydraulic Control</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thermal Cell Design:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²):</td>
<td>10000</td>
<td>Unknown</td>
<td>( __ x ___ ft²)</td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>24</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>15</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>15</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>55</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>55</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formation temperature immediately post-treatment:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Formation temperature post-treatment monitoring event 1:</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>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
<td>__________</td>
<td>__lb</td>
<td>__kg</td>
<td>Unknown</td>
</tr>
<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>

### 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:

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>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>File Analyzed By</td>
<td>JT PD</td>
</tr>
<tr>
<td>Date</td>
<td>10/30/2006</td>
</tr>
<tr>
<td>Type of treatment</td>
<td>Conductive, Steam, ERH</td>
</tr>
<tr>
<td>Type of Contaminant</td>
<td>Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides, Wood Treating</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</td>
<td>2006</td>
</tr>
<tr>
<td>Type of Site</td>
<td>Non-DOD, DoD</td>
</tr>
</tbody>
</table>

**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:**  
**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
### 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>Crossdip</td>
<td></td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>10 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>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>
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<td>Ethylbenzene</td>
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<td></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>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
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<td>5 mg/kg</td>
</tr>
<tr>
<td>Methylene Chloride</td>
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<td></td>
<td>None</td>
<td>100 mg/kg</td>
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<tr>
<td>DCE</td>
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<td></td>
<td></td>
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<td></td>
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<td></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></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>

### Saturated Zone:

<table>
<thead>
<tr>
<th>Unconsolidated Sediments</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>

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

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</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>
</tr>
<tr>
<td>Depth to water: low value (ft bgs):</td>
<td>20</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>
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</tr>
</tbody>
</table>

### Flow direction

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>

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

|                      |                      |                      |

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

|                      |                      |                      |

### K range (ft/day)

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

### Transmissivity (ft²/day)

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

### Comments:

- 
- 
- 

### Attachments:

- 
- 
- 

---

Facility ID#: 0175
## Thermal Treatment - Design

### 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 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**
- **Vadose only**
- **Both (Saturated and Vadose zones)**

### Start of Thermal Test: 
- 2006

### Hydraulic Control: 
- Yes
- No

### Treatment Cell Design: 
- **Conductive**
- **Electrical Resistance**
- 3 phase
- 6 phase
- AC power
- DC power
- Steam
- Steam + air
- Steam + O2
- Other (describe)

### Size of target zone (ft²): 
- 16357

### Thickness of target zone (ft): 
- 20

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

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

### Number of energy delivery points: 
- 65

### Number of extraction points: 
- 65

### 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>

### Duration of post-treatment monitoring (days): 
- 0

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

- 17 foot electrode spacing

### Attachments: 

---

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

Remediation Goal:

In Groundwater:

In Soil:

methylene Chloride - 0.08; PCE - 0.08; TCE - 0.13; DCE - 0.53; VC - 0.04 mg/kg

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
Type of treatment: Conductive Steam ERH Other: __________
Type of Contaminant: Chlorinated Solvents 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: 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): __________
- 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>Trichloroethylene</td>
<td>Benzene</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>anthracene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>anthracene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
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<td>Benzene</td>
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<td>None</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td>1 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
</tr>
<tr>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>1 mg/L</td>
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<td>0.1 mg/L</td>
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<td>1,2-dichloroethane</td>
<td>n-p-xylene</td>
<td>2-methynaphthalene</td>
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<td>None</td>
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<td>o-xylene</td>
<td>benzo(a)anthracene</td>
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<td>None</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>o-xylene</td>
<td>5 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
</tr>
<tr>
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<td>o-xylene</td>
<td>benzo(a)pyrene</td>
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<td>None</td>
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<tr>
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<td>Vinyl Chloride</td>
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<td></td>
</tr>
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<tr>
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<td></td>
<td>benzo(e)pyrene</td>
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<td>fluoranthene</td>
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<td></td>
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<td>fluorene</td>
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<td>fluorine</td>
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<td>None</td>
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<td></td>
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<td>naphtalene</td>
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<td>0.05 mg/L</td>
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<td></td>
<td></td>
<td>naphtalene</td>
<td>None</td>
<td>0.1 mg/kg</td>
<td></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:

____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
### General Site Assessment Data

**Facility ID:** 0380

#### 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 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: 4
- 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>
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<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
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<td>Jet Fuel</td>
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<td>xylene</td>
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<td>Toluene</td>
<td></td>
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<td>Ethylbenzene</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:

- None

#### Attachments:

- None
### Geology:

**Vadose Zone:**
- x Relatively homogeneous and permeable unconsolidated sediments
- x 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:**
- 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

### Aquifer Characteristics:

- **Is more than 1 aquifer present?** No
- **Yes (number):** 2
- **Unknown (assume single aquifer):**

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<thead>
<tr>
<th>Aquifer</th>
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<tr>
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<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

- **Depth to water:**
  - **low value (ft bgs):** 12
  - **high value (ft bgs):** 16
  - **Unknown:**

- **Flow direction:** SW

- **Horizontal hydraulic gradient (feet/foot):** 0.0072 (ave)
  - **Measured using:** Field data
  - **Vertical hydraulic gradient (feet/foot):**
    - **Measured using:** Field data

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

<table>
<thead>
<tr>
<th>Range</th>
<th>Measured using</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>34.3</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>Flow direction</th>
<th>Measured using</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW</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:**

### Flow direction:
- **SW**

### Horizontal hydraulic gradient varied from 0.0026 to 0.0091.  
**K=0.0121 cm/sec**

### Comments:

- Horizontal hydraulic gradient varied from 0.0026 to 0.0091.  
**K=0.0121 cm/sec**

### Attachments:
Thermal Treatment - Design

<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>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notes:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Notes:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility ID: 0380</td>
<td></td>
</tr>
</tbody>
</table>

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

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

Start of Thermal Test:  4/5/2002
Duration: 1204

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:  
- Size of target zone (ft²): 10,000
- Thickness of target zone (ft): 8
- Depth to top of target zone (ft bgs): 8
- Thickness of target zone below water table (ft): 4
- Number of energy delivery points: 11
- Number of extraction points: 41

Temperature Profile:  
- Initial formation temperature (deg C): 20
- Maximum representative formation temperature (deg C): 90
- Time to reach maximum representative temperature (days): 110
- Duration of treatment at representative temperature (days): 10

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:    |   |   | Unknown
- Total: 44000   | lb | kg | Unknown

Electrode spacing of 18 ft; vapor recovery wells spacing of 40 ft; 23 vapor and 18 dural phase extraction wells.
Performance

Remediation Goal:

- In Groundwater: Cleanup in mg/L - Benzene-469; Benzo(a)pyrene-2; benzo(b)fluoranthene-2; chrysene-2; naphthalene-428; Toluene-1316000
- 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 mg/L

General comments on the thermal application:

- 
- 
- 
- 
- 
- 

Lessons Learned

- 
- 
- 
- 
- 

Energy

Total Energy Used: 1678000 kWhr

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

Total energy applied to treatment zone: 

Other energy: 

Please note other energy: 

Cost

Total Project Cost: 1301169

<table>
<thead>
<tr>
<th>x</th>
<th>Consultant Cost:</th>
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</thead>
</table>

<table>
<thead>
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</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Energy Cost: 259000 kWhr</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Other Cost 1: 1042169 m³</th>
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</thead>
</table>

Please note other cost: 

<table>
<thead>
<tr>
<th>x</th>
<th>Other Cost 1: ERH system operation and maintenance</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Other Cost 2:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Other Cost 3:</th>
</tr>
</thead>
</table>
**General Site Information**

- **File Analyzed By:** JT PD  
- **Date:** 9/18/2006
- **Type of treatment:** x Conductive x Steam  
- **Type of Contaminant:** x Chlorinated Solvents  
- **Treatment Status:** x Active  
- **Type of Test:** x Full Scale System  
- **Start of Test:** Dec-95  
- **Type of Site:** x Non-DOD  
- **Facility Name:** AG Communications  
- **Address:** 400 North Wolfe Rd  
- **City, State, Zip Code:** North Lake, IL  
- **OU# or Site #:**  

**Secondary contacts or vendors who worked on site**  
- **Type:** None

**QA/QC**

- **Characteristics of Interest:**  
  - 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: __________

- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Post-treatment: __________

- 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: __________

**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>
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<td>Benzene</td>
<td>Crossdr</td>
<td>10 mg/L</td>
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</tr>
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<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
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<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>
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<td>Toluene</td>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td></td>
<td>None</td>
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</tr>
</tbody>
</table>

**Groundwater (mg/L) Soil (mg/kg)**

- 0.1 mg/L 

**Comments:**

Impacted 160,000 ft² total with VOC impacting 11,000 ft²

**Attachments:**

Figure 3-1
## Hydrogeologic Conceptual Model

### Geology:

#### Zone

<table>
<thead>
<tr>
<th>Vadose 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>
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</table>

<table>
<thead>
<tr>
<th>Saturated Zone</th>
<th>Unconsolidated Sediments</th>
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<tbody>
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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?

<table>
<thead>
<tr>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
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<tbody>
<tr>
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</table>

#### Depth to water:

<table>
<thead>
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<th>low value (ft bgs):</th>
<th>high value (ft bgs):</th>
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<tr>
<td>17</td>
<td>44</td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Flow direction

| ESE |          |          |

### 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>
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<tbody>
<tr>
<td>low</td>
<td>sec comments</td>
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<td>Unknown</td>
</tr>
<tr>
<td>high</td>
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<td></td>
<td></td>
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</tbody>
</table>

#### Transmissivity (ft^2/day):

<table>
<thead>
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<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>

### Comments:

See attached map (Figure 1-4)

Attachments:

Figure 1-4
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: Dec-95
Duration: 5.5 years

Hydraulic Control
- Yes
- No

Treatment Cell Design:
Size of target zone (ft2): 10800
Thickness of target zone (ft): Unknown
Depth to top of target zone (ft bgs): 17
Thickness of target zone below water table (ft): Unknown
Number of energy delivery points: 57
Number of extraction points: 282

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 Unknown kg
In vapor stream: Unknown lb Unknown kg
Total: 40,000 lb Unknown kg

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.
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

- **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:** 1993
- **End of Test:** 1994
- **Duration:** 
- **Type of Site:**
  - Non-DOD
  - DoD

## Facility Name: AG Communications

- **Address:** 400 North Wolfe Rd
- **City, State, Zip Code:** North Lake, IL

## 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
### 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)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>10 mg/L</td>
<td>None</td>
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<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>
<td>cis,1,2-Dichloroethene</td>
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<tr>
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<tr>
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<td>None</td>
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<td>None</td>
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<tr>
<td>o-xylene</td>
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<td>None</td>
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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: Zone</th>
<th>Unconsolidated Sediments</th>
<th>Vadose Zone:</th>
</tr>
</thead>
<tbody>
<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>

### 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
- Unknown

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

**Depth to water:**
- Low value (ft bgs): 17
- High value (ft bgs): 440
- Unknown:

**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: Unknown
- High: Unknown

### Comments:
- See attached x-section
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0391</th>
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</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 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: 1993

Duration of Thermal Test: ________

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

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:  
- lb  
- kg

Comments:  

Attachments:  

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

Remediation Goal:
____ In Groundwater: ______________________
____ In Soil: ______________________

Was the Remediation Goal Achieved:
____ In Groundwater
Comment: ______________________
____ In Soil
Comment: ______________________

Please note other energy:
______________________ kWhr/yd³
______________________ kWhr/m³
### 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
- **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
## 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>
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<td>Crossgradient</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
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<td>Trichloroethene</td>
<td>BTEX</td>
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</tbody>
</table>

## Comments:

- 
- 
- 
- 

## Attachments:

- 
- 
- 
- 

**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 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:**
- Unknown ft amsl

**Aquifer Characteristics:**
- Is more than 1 aquifer present? **No**
- Unknown (assume single aquifer)
- **X**

**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):**
- **X**
- 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#:** 0395
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:  
   - Jul-04
   - Duration: 

Hydraulic Control
   - Yes
   - No

Treatment Cell Design:

Size of target zone (ft²):  
   - 3600
   - Unknown
   - ( ___ x ___ ft)

Thickness of target zone (ft):
   - 10
   - Unknown

Depth to top of target zone (ft bgs):
   - 4
   - Unknown

Thickness of target zone below water table (ft):
   - 6
   - Unknown

Number of energy delivery points:  
   - 10
   - Unknown

Number of extraction points:  
   - 12
   - 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

Date

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:  
   - 3700
   - ___ lb
   - ___ kg
   - Unknown

Comments:

Attachments:

19 ft spacing

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

Comment:

In Soil

Comment:

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: 588812 kWhr

kWhr kWhr/m³ kWhr/yd³

kWhr/m³ kWhr/yd³

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:
Facility ID#: 0400

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: Circuit Assembling Facility

Address: Harwood Heights, IL

City, State, Zip Code: Harwood Heights, IL

OU# or Site #: ____________

Primary point of contact: Jeff Pope

Organization: Clayton Group

Address: 3140 Finley Rd

City, State, Zip Code: Downers Grove, IL

Phone #: 630-795-3211 email: j pope@claytongrp.com

Other contacts or vendors who worked on site: None

Point of contact: Bill Heath

Type: Vendor, Consultant Vendor, Technical Applications Other

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

**Facility ID:** (000)

<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>
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<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
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</tbody>
</table>

**Average Pre-treatment Concentration per Chemical:**
- Groundwater (mg/L): None
- Soil (mg/kg): None

**Average Post-treatment Concentration per Chemical:**
- Groundwater (mg/L): None
- Soil (mg/kg): None

**Comments:**

- None

**Attachments:**

- None
**Hydrogeologic Conceptual Model**

**Facility ID#: 0400**

---

**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)

| 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): |
--- |
| 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 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:

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

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: 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: ____________
Type of Site: Non-DOD DoD

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

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>
<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>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<td>None</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
<td></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></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td></td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td></td>
<td></td>
<td></td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
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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>Jet Fuel</td>
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<td>Benzene</td>
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<td>Toluene</td>
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<td>Ethylene</td>
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<tr>
<td>o-xylene</td>
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<td></td>
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<td>1,1-dichloroethane</td>
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<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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<td>None</td>
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</tr>
</tbody>
</table>

**Comments:**

Impacted zone of 13000 yd³ (up to 38 ft bgs)

**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>Saturated Zone</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>
</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 (ft bgs):</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high (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):

<table>
<thead>
<tr>
<th>Measured using:</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):

<table>
<thead>
<tr>
<th>Measured using:</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:

- Additional information about the hydrogeologic model

#### Attachments:

- Additional documentation or data related to the conceptual model
### Thermal Treatment - Design

#### 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:
- **Duration:**

#### 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

#### 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.

---

**Date** | **Temperature (deg C)**
--------- | ---------------------

**Formation temperature immediately post-treatment:** ____________

**Formation temperature post-treatment monitoring event 1:** ____________

**Duration of post-treatment monitoring (days):** ____________

---

**Facility ID#:** 0410

**Treated - 12,500 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:


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:

Comment: Please note other energy: __________________________________________

Expense

Total Project Cost:  120/yd³

Consultant Cost: __________________________________________________________

Thermal Vendor Cost: _____________________________________________________

Energy Cost:  300000

Other Cost 1:  capital cost

Other Cost 2:  ____________________________________________________________

Other Cost 3:  ____________________________________________________________

Please note other cost:  _________________________________________________
### General Site Information

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Analyzed By</td>
<td>JT x PD</td>
</tr>
<tr>
<td>Date</td>
<td>10/16/2006</td>
</tr>
<tr>
<td>Type of treatment</td>
<td>Conductive x Steam x ERH x Other:</td>
</tr>
<tr>
<td>Type of Contaminant</td>
<td>x Chlorinated Solvents x Petroleum Hydrocarbons x Pesticides x Wood Treating Other:</td>
</tr>
<tr>
<td>Treatment Status</td>
<td>x Active x Post</td>
</tr>
<tr>
<td>Type of Test</td>
<td>x Pilot Test x Full Scale System</td>
</tr>
<tr>
<td>Duration</td>
<td>120 d</td>
</tr>
<tr>
<td>Type of Site</td>
<td>x Non-DOD x DoD</td>
</tr>
</tbody>
</table>

### Facility Name

- **Operating Dry Cleaner**

### Address

- **City, State, Zip Code:** Chicago, IL suburb

### Primary point of contact

- **Point of contact:** Jeff Pope
- **Organization:** Clayton Group

### Other contacts or vendors who worked on site

- **Point of contact:** Jeff Pope
- **Type:** Vendor, Consultant x Vendor, Technical Applications x Other |
- **Organization:** Clayton Group

### 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

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<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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<td>None</td>
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<tr>
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<td>Vinyl Chloride</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Notes
- 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: __________
- 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:
  - Pre-treatment In: _____ Upgradient: _____ Downgradient: _____ Crossgradient: _____
  - Post-treatment In: _____ Upgradient: _____ Downgradient: _____ Crossgradient: _____
- Number of wells inside treatment zone: __________ Number of wells outside treatment zone: __________
Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
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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>
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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  x  Unknown

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

Aquifer Characteristics:

- Depth to water:
  - low value (ft bgs): 70
  - 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: 2.83E-05  __________  __________  __________
  - high: __________  __________  __________

- Transmissivity (ft²/day)
  - Measured using: Slug Test  Laboratory  Field data
  - low: __________  __________  __________  x  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
- 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:  
- 11/18/2002
- Duration: 120 d

Hydraulic Control  
- Yes
- No

Treatment Cell Design:  
- Size of target zone (ft2): 1200
- Thickness of target zone (ft): 10
- Depth to top of target zone (ft bg): 4
- Thickness of target zone below water table (ft): 0
- Number of energy delivery points: 17
- Number of extraction points: 13

Temperature Profile:  
- Initial formation temperature (deg C): 10
- Maximum representative formation temperature (deg C): 80
- Time to reach maximum representative temperature (days): 47
- Duration of treatment at representative temperature (days): 60

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

Date  

Temperature (deg C)  

Comments:  

Attachments:  

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

Remediation Goal:

x In Groundwater: 

x In Soil: 

All PCE samples to less than 529 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:

_____________________________________________________________________________________________________

_____________________________________________________________________________________________________

_____________________________________________________________________________________________________

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Lessons Learned

_____________________________________________________________________________________________________

_____________________________________________________________________________________________________

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_____________________________________________________________________________________________________

_____________________________________________________________________________________________________

Energy

Total Energy Used: _______ 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: _______________________

____ 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:

Yes, average PCE concentration = 62 mg/kg
General Site Information

File Analyzed By: JT PD

Date: 10/16/2006

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: 6/25/2003
End of Test: 7/15/2005
Duration: 251

Type of Site: 
- Non-DOD
- DoD

Facility Name: Lockformer Site

City, State, Zip Code: Lisle, IL 60532

OU# or Site #: __________

Primary point of contact: Steve Faryan

Organization: EPA Region 5

Address:

City, State, Zip Code: __________

Phone #: 312-353-9351
email: faryan.steve@epa.gov

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:

City, State, Zip Code: Springfield, IL

Phone #: 217-782-5504
email: stan.komperda@epa.state.il.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
## 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>CCl₃</td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>CCl₄</td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>Upgradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Post-treatment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>Upgradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
<td>Downgradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Ethylbenzene</td>
<td>Crossgradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<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>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>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### General Site Assessment Data

#### Impacted Zone:
- 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:

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

### Soil Characteristics

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

### Chemicals of Concern

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

### Comments:

### Attachments:
### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>1. Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>2. Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>3. Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>4. Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>5. Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>6. Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>1. Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>2. Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>3. Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>4. Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>5. Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<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:

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): **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>55</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</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**

<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>

**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:

- **Unknown**

### Attachments:

- **Unknown**

- **Unknown**

- **Unknown**
### Thermal Treatment - Design

**Thermal treatment:**
- [ ] Conductive
- [x] Electrical Resistance

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

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

- [x] Other (describe)

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

**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 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
- [x] Both (Saturated and Vadose zones)

**Start of Thermal Test:**
6/25/2003
**Duration:** 751

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

**Treatment Cell Design:**
- [ ] Yes
- [ ] No

**Size of target zone (ft²):**
- 17750

**Thickness of target zone (ft):**
- 17

**Depth to top of target zone (ft bgs):**
- 1

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

**Number of energy delivery points:**
- 214

**Number of extraction points:**
- 214

**Temperature Profile:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>13</td>
<td>Unknown</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>95</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></td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of post-treatment monitoring (days):</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Method</th>
<th>Weight</th>
<th>Units</th>
<th>Notes</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:**
Treated 3 to 40 ft in Areas 1 and 2, but only treated 3 to 15 ft in the Degreaser Area.

**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

x Total energy applied to treatment zone: 9015000 kWhr ___________________________ ___ 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: 9/13/2006

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: Former Electronics Manufacturing
Address: 419 Entiat Street, Suite A
City, State, Zip Code: Kennewick, WA 99336

Primary point of contact: Bill Heath
Organization: CES
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
### 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>Trichloroethene</td>
<td>Benzene</td>
<td>Crossflow</td>
<td>10 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</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>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
<td>1 mg/L</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>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-Dichloroethene</td>
<td>m,p-Xylene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,1-Trichloroethene</td>
<td>o-Xylene</td>
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<td>10 mg/L</td>
<td>None</td>
<td>0.1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-Trichloroethene</td>
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<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
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<td></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>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:

#### Attachments:

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

<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): ___________ ___________ ___________  x Unknown
Vertical hydraulic gradient (feet/foot): ___________ ___________ ___________  x Unknown

K range (ft/day)  

| | Measured using:  Slug Test  Laboratory  Field data |
|---|----------------|----------------|---------------|
| low | 0.028 | | | Unknown |
| high | 0.24 | |

Transmissivity (ft²/day):

| | Measured using:  Slug Test  Laboratory  Field data |
|---|----------------|----------------|---------------|
| low | | | | Unknown |
| high | | | |

Comments:

K = 10⁻⁵ to 10⁻⁴ cm/sec

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)

Duration: 170 days

Hydraulic Control:  
- Yes  
- 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 extraction points: 107  
- Number of energy delivery 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

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:

Lessons Learned

Energy

Total Energy Used:

x kWhr kWhr/m³ kWhr/yd³

Total energy applied to treatment zone:

Other energy: kWhr/m³ kWhr/yd³

Please note other energy:

Cost

Total Project Cost: 32/yd³

x Energy Cost: 148000 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>
<th>Facility ID#: 0420</th>
</tr>
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<tbody>
<tr>
<td>File Analyzed By: JT PD Date: 9/13/2006</td>
<td></td>
</tr>
<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</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:</td>
<td>12/1/1998 End of Test: 4/30/1999 Duration:</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD DoD</td>
</tr>
</tbody>
</table>

| Other: |
| City, State, Zip Code: Skokie, IL |
| OU# or Site #: |

| Primary point of contact: Bill Heath |
| Organization: CES |
| 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:** 

  - **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>Soap</td>
<td>Diesel</td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>Tetrachloroethene</td>
<td>BTEX</td>
<td></td>
<td>1.0 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>1,1-dichloroethane</td>
<td></td>
<td></td>
<td>1.0 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>1,2-dichloroethane</td>
<td></td>
<td></td>
<td>0.01 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>1,1,2-Trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- 
- 
- 

**Attachments:**

- 
- 
- 

---
### Geology: Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Vadose Zone:</th>
<th>Saturated Zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></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 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>
<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>

### Ground surface elevation based on wells in or adjacent to treatment zone:
- Unknown 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></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</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>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)
- 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>
</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>

### 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>
</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>

### Comments:

\[ K = 10^{-5} \text{ to } 10^{-4} \text{ cm/sec} \]

### 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>x</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>x</td>
<td></td>
</tr>
</tbody>
</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>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>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>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Start of Thermal Test: 12/1/1998
Duration: 18 weeks

<table>
<thead>
<tr>
<th>Treatment Cell Design:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

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: 165  
Number of extraction points: 37

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
<th>Initial formation temperature (deg C):</th>
<th>10</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum representative formation temperature (deg C):</td>
<td>100</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Time to reach maximum representative temperature (days):</td>
<td>60</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Duration of treatment at representative temperature (days):</td>
<td>70</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):  

<table>
<thead>
<tr>
<th>Mass of contaminant removed:</th>
<th>Via liquid pumping:</th>
<th></th>
<th></th>
<th></th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In vapor stream:</td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unknown</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: ___________ 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: ______________________________________________________________________

___ Other Cost 1:

___ Other Cost 2:

___ Other Cost 3:

___ Please note other cost: ______________________________________________________________________

___ Energy Cost:

___ Consultant Cost:

___ Thermal Vendor Cost:

___ Other 1:

___ Other 2:

___ Other 3:

___ Please note other cost:

___ Other Cost 1:

___ Other Cost 2:

___ Other Cost 3:

Total Project Cost: $32/cubic yard

Cost and Performance Facility ID#: 0420
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th>11/1/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductive</td>
<td>Steam</td>
<td>ERH</td>
<td>Other:</td>
<td></td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Pesticides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Treating</td>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Status:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>Post</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot Test</td>
<td>Full Scale System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Non-DOD</td>
<td>DoD</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Facility Name: | Naval Station Great Lakes |
| Address: | Decauter Ave |
| City, State, Zip Code: | Great Lakes, IL 60088 |
| OU# or Site #: | Site 22 |

| Primary point of contact: | Bob Davis |
| Organization: | Tetra Tech |
| Address: | 661 Andersen Dr., Foster Plaza 7 |
| City, State, Zip Code: | Pittsburgh, PA 15220 |
| Phone #: | 412-921-7251 |
| email: | robert.davis@tttn.us.com |

| Other contacts or vendors who worked on site | None |
| Point of contact: | David Fleming |
| Type: | Vendor, Consultant |
| Organization: | TRS |
| Address: | 7421-A Warren Ave SE |
| City, State, Zip Code: | Snoqualmie, WA 98065 |
| 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 | | |
### 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>DCM</td>
<td>Benzene</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></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Napthalene</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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<tr>
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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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<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
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<td></td>
<td>1,1,2-trichloroethene</td>
<td></td>
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<td>None</td>
</tr>
<tr>
<td></td>
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<td></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>

### General Site Assessment Data

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): 30
  - Width (ft.): 10
  - Thickness (ft.): 3 to 20
- **Types of Contaminants**:
  - Chlorinated Solvents
  - Petroleum Hydrocarbons
  - Other

<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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<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>Napthalene</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>
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<td>None</td>
<td>None</td>
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<tr>
<td></td>
<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-trichloroethene</td>
<td>o-xylene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethene</td>
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<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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</table>

### Comments:

- None

### Attachments:

- None
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>
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<tr>
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<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>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</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: | 600 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>Aquifer 1</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 | southerly |

---

| Horizontal hydraulic gradient (feet/foot): | 0.1 | 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>0.2</td>
<td></td>
<td></td>
<td></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>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</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:

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  

- 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:  

5/23/2006  

Duration: 134 days

Hydraulic Control  

- Yes  

- No

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): 104

Duration of treatment at representative temperature (days): 104

Date | Temperature (deg C)  
--- | ---  
5/23/2006 | 100

Formation temperature immediately post-treatment: 

Formation temperature post-treatment monitoring event 1: 

Duration of post-treatment monitoring (days): N/A

Mass of contaminant removed:

- Via liquid pumping: 

- In vapor stream: 

- Total:

  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
- In Soil: 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:

- Total energy applied to treatment zone: 632,866 kWhr/m³ kWhr/yd³
- Other energy: Please note other energy:

Cost

Total Project Cost:

- Consultant Cost: 360,000
- Thermal Vendor Cost: 446,000
- Energy Cost: m³ yd³
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:
- Other Cost 3:

Please note other cost:
General Site Information

File Analyzed By: JT PD  Date: 10/16/2006
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: 9/22/2004 End of Test: 11/1/2004 Duration: 56 d
Type of Site: Non-DOD DoD

Facility Name: Confidential IL
City, State, Zip Code: Olney, IL
OU# or Site #:

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
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: TRS
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: _______
- 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 soil borings with pre-treatment data: _______
- Number of 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>
</tbody>
</table>

**Comments:**

**Attachments:**

---

**Area 1**

---
## 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: __________

### 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></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Crossd</td>
<td></td>
<td>None</td>
<td>10,000 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethylene</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>
<td></td>
<td>None</td>
<td>None</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-dichloroethene</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>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>1,2-dichloroethene</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></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>
</tr>
</tbody>
</table>

### Comments:

Area 2

### Attachments:

---

0425
Geology: | Zone | Unconsolidated Sediments |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</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

Depth to water:

- Low value (ft bgs): 20
- 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
- Low: Unknown
- High: Unknown

Transmissivity (ft²/day):

- Measured using: Slug Test
- Low: Unknown
- High: Unknown

Comments:

- Very tight soils

Attachments:

10 foot spacing
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:  
- 9/22/2004
Duration: 56 day

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft2):  
- 400

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):  
- 20

Maximum representative formation temperature (deg C):  
- 200

Time to reach maximum representative temperature (days):  
- 28

Duration of treatment at representative temperature (days):  
- 28

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:  
- 690

Date
Temperature (deg C)

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: Conductive

Electrical Resistance: Area 2

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

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

Start of Thermal Test: 9/22/2004 Duration: 56 days

Hydraulic Control: Yes No

Treatment Cell Design:

Size of target zone (ft2): 600 Unknown ( 30 x 20 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: 8 Unknown

Number of extraction points: 8 Unknown

Temperature Profile:

Initial formation temperature (deg C): 20 Unknown

Maximum representative formation temperature (deg C): 95 Unknown

Time to reach maximum representative temperature (days): 48 Unknown

Duration of treatment at representative temperature (days): 8 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: 690 lb kg

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:

In Groundwater:

In Soil:

IL EPA Csat = 4440.78 mg/kg and a site specific goal of 75.18 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: x

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: 232000

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: __________
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
OU# or Site #: ________________________________

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
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: __________

- Number of relevant monitoring wells with post-treatment data: __________

- Number of relevant monitoring wells with pre-treatment data: __________

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

- 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>Trichloroethylene</td>
<td>Benzene</td>
<td>Cross gradient</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</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>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>
<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>
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<tr>
<td></td>
<td>1,1,2-dichloroethane</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>Methylene chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>100 mg/kg</td>
</tr>
</tbody>
</table>

Comments:

- Impacted area of 16,000 yd3

Attachments:

- \[\text{Attachments}\]
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>
<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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</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

<table>
<thead>
<tr>
<th>Aquifer Characteristic</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>X</td>
<td>Yes (number): 2</td>
<td></td>
</tr>
<tr>
<td>Depth to water:</td>
<td>6 (perched)</td>
<td></td>
<td>25 (average)</td>
</tr>
<tr>
<td>Flow direction</td>
<td>NW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal hydraulic gradient (feet/foot):</td>
<td>0.00328</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
<td></td>
<td></td>
<td>X Unknown</td>
</tr>
<tr>
<td>K range (ft/day)</td>
<td></td>
<td>Field data</td>
<td></td>
</tr>
<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>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmissivity (ft²/day):</td>
<td>Field data</td>
<td></td>
<td></td>
</tr>
<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>Unknown</td>
</tr>
<tr>
<td>high</td>
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</tbody>
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Comments:_________________________________________________________________________

Attachments:_______________________________________________________________________
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID: 0440</th>
</tr>
</thead>
<tbody>
<tr>
<td>x Thermal treatment:</td>
<td></td>
</tr>
<tr>
<td>x Conductive</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 Steam + air</td>
<td>Steam + O2</td>
</tr>
<tr>
<td>x Other (describe)</td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td></td>
</tr>
<tr>
<td>x Pilot test</td>
<td>x Full-scale System</td>
</tr>
<tr>
<td>Geology of Treatment Zone:</td>
<td></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>
</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></td>
</tr>
<tr>
<td>x Saturated only</td>
<td>x Vadose only</td>
</tr>
<tr>
<td>x Both (Saturated and Vadose zones)</td>
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<tr>
<td>Start of Thermal Test:</td>
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</tr>
<tr>
<td>12/8/1999</td>
<td>Duration: 329 days</td>
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<tr>
<td>x Hydraulic Control</td>
<td></td>
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<tr>
<td>x Yes</td>
<td>x No</td>
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<tr>
<td>Size of target zone (ft^2):</td>
<td>24500</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>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
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</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>92</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>30</td>
</tr>
<tr>
<td>x Temperature Profile:</td>
<td></td>
</tr>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>13</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>west 90 / east 80</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>288</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>41</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>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>Date</td>
<td>Temperature (deg C)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></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.
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: 

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**

- **Facility Name:** Former Steel Manufacturing Facility
- **Address:** Clayton Group
- **City, State, Zip Code:** Fort Wayne, IN 46802
- **OU# or Site #:**
- **Facility ID#:** 0445
- **Start of Test:** 7/9/2005
- **End of Test:** 20-Dec
- **Duration:** 164 d
- **Type of Test:** Full Scale System
- **Type of Site:** Non-DOD
- **Type of Treatment:** Conductive Steam ERH
- **Type of Contaminant:** Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides
- **Treatment Status:** Active
- **Primary point of contact:** Jon Hacker
  - **Organization:** Ft. Wayne Steel Corp
  - **Address:** 3140 Finley Rd
  - **City, State, Zip Code:** Downers Grove, IL 60515
  - **Phone #:** 630-795-3211
  - **Email:** jhacker@valbruna.us
- **Other contacts or vendors who worked on site:** None
  - **Point of contact:** Jeff Pope
    - **Type:** Vendor, Consultant
    - **Organization:** Clayton Group
    - **Address:** 3140 Finley Rd
    - **City, State, Zip Code:** Downers Grove, IL 60515
    - **Phone #:** 630-795-3211
    - **Email:** pope@claytongrp.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: __________ No
  - 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>Hexane</td>
<td>Crossdi</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Chloroform</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</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>
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<tr>
<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</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>
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<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<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>
<td>None</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>5,000 mg/kg</td>
<td></td>
<td>100 mg/L</td>
<td>5,000 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>100 mg/L</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Estimated 60,000 lbs of TCE in the soil.**

**Comments:**

- Estimated 60,000 lbs of TCE in the soil.

**Attachments:**

- [Attachment 1](link)
- [Attachment 2](link)
- [Attachment 3](link)
### Hydrogeologic Conceptual Model

**Unconsolidated Sediments**

<table>
<thead>
<tr>
<th>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>Vadose Zone</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</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></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>Aquifer 1 Aquifer 2 Aquifer 3</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
- Unknown: __________

**Transmissivity (ft²/day):**

- low: __________
- high: __________
- Measured using: Slug Test Laboratory Field data
- Unknown: __________

### Attachments:

---

### Comments:

---

---
Thermal Treatment - Design

Thermal treatment:  

- Conductive

- Electrical Resistance Areas A, B, and C

- 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

Treatment Target Zone:  

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:  

- 7/6/2005
- Duration: 164 d

- Yes
- No

Treatment Cell Design:

- Size of target zone (ft²): 13289
- Thickness of target zone (ft): 14 to 26
- Depth to top of target zone (ft bgs): 8
- Thickness of target zone below water table (ft): 12 to 24
- Number of energy delivery points: 41
- Number of extraction points: 30

Temperature Profile:

- Initial formation temperature (deg C): 1 3
- Maximum representative formation temperature (deg C): 90
- Time to reach maximum representative temperature (days): 80
- 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: Unknown
- In vapor stream: Unknown
- Total: 24348

Comments:

<table>
<thead>
<tr>
<th>Area</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2872 ft² at 8 to 22 ft</td>
</tr>
<tr>
<td>B</td>
<td>1699 ft² at 8 to 34 ft</td>
</tr>
</tbody>
</table>

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 kWh</th>
<th>Total energy applied to treatment zone: kWh/m³ kWh/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other energy: kWh/m³ kWh/yd³</td>
<td>Please note other energy: ------------------------</td>
</tr>
</tbody>
</table>

### Cost

<table>
<thead>
<tr>
<th>Total Project Cost:</th>
<th>Consultant Cost:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>x Thermal Vendor Cost: 435302</td>
<td>Energy Cost: m³ yd³</td>
<td>Other Cost 1:</td>
</tr>
<tr>
<td>Other Cost 2:</td>
<td>Other Cost 3:</td>
<td>Please note other cost: Other Cost 1:</td>
</tr>
<tr>
<td>Other Cost 2:</td>
<td>Other Cost 3:</td>
<td>Please note other cost: Other Cost 1:</td>
</tr>
<tr>
<td>Other Cost 2:</td>
<td>Other Cost 3:</td>
<td>Please note other cost: Other Cost 1:</td>
</tr>
<tr>
<td>Other Cost 2:</td>
<td>Other Cost 3:</td>
<td>Please note other cost: Other Cost 1:</td>
</tr>
</tbody>
</table>
General Site Information

File Analyzed By: JT x 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

x 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

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Facility ID#:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150</td>
<td>10</td>
<td>750</td>
<td>0450</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></td>
<td></td>
</tr>
</tbody>
</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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
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</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>1,1,2-trichloroethane</td>
<td>Trichloroethene</td>
<td>BTEX</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>1,1,1-trichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>trans-1,2-dichloroethane</td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>1,1,1-trichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,2,2-trichloroethane</td>
<td>n-xylene</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
</tbody>
</table>

### Attachments:

- Larger treatment area

- 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 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>
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<th>Other</th>
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</tr>
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<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Hexane</td>
<td>Crossdr</td>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
<td>None</td>
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<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</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>
<td>None</td>
<td>None</td>
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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>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
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</tbody>
</table>

#### Comments:

- Smaller treatment area

#### 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>Largely permeable 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 layers 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>
</tbody>
</table>

### Aquifer Characteristics:

- Is more than 1 aquifer present? **No**
- Ground surface elevation based on wells in or adjacent to treatment zone: **Unknown** ft amsl

### Aquifer Depth:

- Depth to water:
  - Low value (ft bgs): **22**
  - High value (ft bgs): **25**
  - Unknown: **Unknown**

### Flow Direction:

- **Unknown**

### Hydraulic Gradient:

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

### Hydraulic Conductivity (ft/day):

- K range:
  - Low: **1,420 (10^-5) ft/day**
  - High: **709 (10^-5) ft/day**

### Transmissivity (ft²/day):

- Measured using:
  - Slug Test: **Unknown**
  - Laboratory: **Unknown**
  - Field data: **Unknown**

### Comments:

- **k = 0.005 to 0.025 millidarcy**

### Attachments:

- [Blank field]
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Larger treatment zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Resistance</td>
<td>3 phase</td>
<td>6 phase</td>
</tr>
<tr>
<td>Steam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam + air</td>
<td>Steam + O2</td>
<td></td>
</tr>
<tr>
<td>Other (describe)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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: **Jul-97**
Duration: 63 d

Hydraulic Control: 
- **X** Yes
- **No**

Treatment Cell Design:

| Size of target zone (ft2): | 7600 | 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 |  

| Date | Temperature (deg C) |  
| Formation temperature immediately post-treatment: |  
| Formation temperature post-treatment monitoring event 1: | Jun-98 | <37 |  
| Duration of post-treatment monitoring (days): |  

Mass of contaminant removed:

| Via liquid pumping: | lb | kg |  
| In vapor stream: | lb | kg |  
| Total: | lb | kg |  

Attachments:

Well spacing of 7.5 ft (triangular).

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

Thermal treatment: x Conductive  x Electrical Resistance  x Smaller Treatment area

☐ 3 phase  ☑ 6 phase  ☑ AC power  ☑ DC power

☐ Steam  ☑ Steam + air  ☑ Steam + O2

☐ Other (describe)

☐ Yes  ☑ No

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:
☑ 1997

Duration:
☑ 60 d

Hydraulic Control:
☐ Yes  ☑ No

Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>600</th>
<th>Unknown</th>
<th>( 30 x 20 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>12</td>
<td>Unknown</td>
<td></td>
</tr>
<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>
<td></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>&gt;100</td>
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<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>60</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>x</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:

<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.
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: _______ 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: 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: 2/14/2003 End of Test: 9/6/2003 Duration: 175 d
Type of Site: ___Non-DOD ___DoD

Facility Name: DOE Paducah Gaseous Diffusion Plant
Address: ____________________________________________
City, State, Zip Code: Paducah, KY (McCracken County)
OU# or Site #: ______________________________________

Primary point of contact: Bryan Clayton
Organization: Bechtel-Jacobs
Address: ____________________________________________
City, State, Zip Code: ______________________________________
Phone #: 270-441-5412 email: btc@bechteljacobs.org

Other contacts or vendors who worked on site: ___None
Point of contact: David Williams & David Dollins
Type: Vendor, Consultant Vendor, Technical Applications ___Other EPA / DOE
Organization: EPA / DOE
Address: ____________________________________________
City, State, Zip Code: ______________________________________
Phone #: 4045628554 / 2704416819 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: __________
  - 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: 0 / 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>Trichloroethylene</td>
<td>Benzene</td>
<td>Cross</td>
<td>1,000 mg/L</td>
<td>100 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>Other</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>α-xylene</td>
<td></td>
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<td>None</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

Estimated 209,000 gallons of TCE was released

### 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>
<td></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></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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<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: **370 ft amsl**

- Unknown

- **Is more than 1 aquifer present?**
  - **No**
  - **X** 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>16</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Flow direction: **N**

- Horizontal hydraulic gradient (feet/foot): Unknown

- Vertical hydraulic gradient (feet/foot): Unknown

- **K range (ft/day)**
  - Measured using: ___ Slug Test ___ Laboratory ___ Field data
  - **low** 100
  - **high** 1000

- 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

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 permeable 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:  
- □ 2/14/2003  
- □ Duration: 175 d

Hydraulic Control:  
- □ Yes  
- □ No

Treatment Cell Design:

Size of target zone (ft²): 6825  
Thickness of target zone (ft): 94  
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

Formation temperature immediately post-treatment: 91
Formation temperature post-treatment monitoring event 1: 58
Duration of post-treatment monitoring (days):

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: 10377 lb  kg  Unknown

Comments:

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
x Performance
   - Remediation Goal:
     - In Groundwater: RGA (~50-90') groundwater to less than 1% TCE solubility (11000ppb)
     - In Soil: UCRS (0-50') to reduce TCE in soil by 75%

Was the Remediation Goal Achieved:
   - In Groundwater
     - Comment: Yes a 99.1% reduction
   - In Soil
     - Comment: Yes, a 98% reduction

General comments on the thermal application:

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.

x Energy
   - Total Energy Used: 2283850 kWhr
   - Total energy applied to treatment zone: kWhr/m^3 kWhr/yd^3
   - Other energy: kWhr/m^3 kWhr/yd^3

   Please note other energy: ____________________________

x Cost
   - Total Project Cost: 6300000
   - Consultant Cost: ____________________________
   - Thermal Vendor Cost: ____________________________
   - Energy Cost: kWhr/m^3 kWhr/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 x Other: RFH
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: 1-Oct
End of Test: ___________duration: ________
Type of Site: x Non-DOD ___ DoD

Facility Name: Confidential, Boston, MA

City, State, Zip Code: Boston, MA
OU# or Site #: 

Primary point of contact: Karen Brody or Joseph Fiacco
Organization: ERM
Address: 399 Boylston St., 6th Floor
City, State, Zip Code: Boston, MA 02116
Phone #: 617-646-7800 email: Karen.brody@erm.com

Other contacts or vendors who worked on site ___ None
Point of contact: Ray Kasevich
Type: x Vendor, Consultant ___ Vendor, Technical Applications ___ Other ___
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

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>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>Crossdr</td>
<td>None</td>
<td>None</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>
<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>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
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<td>None</td>
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<td>trans-1,2-dichloroethene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
<td></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>o-xylene</td>
<td></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></td>
<td></td>
<td>None</td>
<td>None</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>
<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>
<td>None</td>
<td>None</td>
</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:

- **Unconsolidated Sediments**
  - Low value (ft bgs):
  - High value (ft bgs):
  - 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:
  - High:
  - Unknown:

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

#### Comments:

- Additional comments or notes on the hydrogeologic conceptual model.

#### Attachments:

- Any supporting documents or files related to the hydrogeologic conceptual model.

---

*Facility ID#: 0495*
# 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)

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

**Start of Thermal Test:**

**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>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</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>

**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:**
  - **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

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 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 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>1,1,1-trichloroethane</td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>10 mg/L</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>1 mg/L</td>
<td>0.5 mg/kg</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>0.01 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
<td></td>
<td>1 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,1,1,2-tetrachloroethane</td>
<td>m+p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,1,1,2-tetrachloroethane</td>
<td>o-xylene</td>
<td></td>
<td>1 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>1,1,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,2,2-tetrachloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2,2-trichloroethane</td>
<td>1,2-dichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,2,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,2,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,2,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,2,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,2,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,2,2-trichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- Comments: __________

---

**Attachments:**

- Page 29 - Pilot report (appendix A) for pre data and pg 34 for post data
- Appendix D in Appendix A - Soils data
### Hydrogeologic Conceptual Model

#### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>x 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>x 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>Elevation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 ft amsl</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is more than 1 aquifer present?</td>
<td>No</td>
</tr>
<tr>
<td>Depth to water</td>
<td>15 ft bgs</td>
</tr>
<tr>
<td></td>
<td>high 10 ft bgs</td>
</tr>
<tr>
<td>Flow direction</td>
<td>WSW</td>
</tr>
<tr>
<td>Horizontal hydraulic gradient (feet/foot)</td>
<td>Unknown</td>
</tr>
<tr>
<td>Vertical hydraulic gradient (feet/foot)</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### K range (ft/day)

<table>
<thead>
<tr>
<th>K range</th>
<th>Measured using</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>Slug Test</td>
<td>Laboratory</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

#### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Transmissivity</th>
<th>Measured using</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>Slug Test</td>
<td>Laboratory</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**K = 3.5e-5 cm/s**

**No GW elevation data yet**

**Attachments:**

---
Thermal Treatment - Design

Thermal treatment: 
  x Conducive
  x Electrical Resistance

Steam 
  x 3 phase 
  x 6 phase 

Steam + O2 
  x Steam + air
  x Steam + O2

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 
  ___ 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): 
  7700 
  ___ 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:

Date 

Temperature (deg C)

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days):

Mass of contaminant removed:

Via liquid pumping: 

In vapor stream: 

Total: 
  89.9 
  x lb 
  ___ kg 
  ___ Unknown

Comments:

Attachments:

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

- **In Groundwater:** 1. determine the potential effectiveness, implementability, and cost of using ERH to treat entire source area; 2. 85% reduction in VOCs in pilot test area; 3. develop cost info
- **In Soil:**

Was the Remediation Goal Achieved:

- **In Groundwater**
  
  **Comment:** No, cis-1,2-DCE went way up
- **In Soil**

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

- **Total Energy Used:** 616786 kWhr
  
  **kWhr** kWhr/m³ kWhr/yd³

  **Total energy applied to treatment zone:**

  **Other energy:** 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</th>
<th>Date:</th>
<th>7/26/2006</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>7/31/2003</td>
<td>End of Test:</td>
<td>9/22/2003</td>
</tr>
<tr>
<td>Duration:</td>
<td>53 days</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Facility Name: Naval Weapons Industrial Reserve Plant

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 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: __________
  - 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></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrahydrofluoromethane</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>cis,1,2-dichloroethene</td>
<td>0.5 mg/L</td>
<td>None</td>
<td>0.005 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td>1 mg/L</td>
<td>10 mg/kg</td>
<td>0.5 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>5 mg/L</td>
<td>100 mg/kg</td>
<td>0.5 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>1 mg/L</td>
<td>50 mg/kg</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>1 mg/L</td>
<td>10 mg/kg</td>
<td>0.1 mg/L</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>Tetrachloroethene</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>1,1,2,2-tetrachloroethene</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>Tetrachloroethene</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>1,1,2,2-tetrachloroethene</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>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**
- Post-treatment GW data - pg. 33 and pre-treatment GW - pg. 32
- Soil samples only have pre data and benzene was ND in all soil samples based on the detection limit
- Source zone was 50 ft by 20 ft by 18.5 ft (9.5 to 28 ft)

### Attachments:

- [Map attachment]
- [Source zone definition attachments]
- [Post-treatment GW data]
- [Pre-treatment GW data]
- [Soil borings data]
- [Monitor wells data]
### Hydrogeologic Conceptual Model

**Geology:**
- **Vadose 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
- **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:**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Aquifer Characteristics:**
- Is more than 1 aquifer present? **Unknown (assume single aquifer)**

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low: 10.5</td>
</tr>
<tr>
<td></td>
<td>high: 20.5</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
</tr>
</tbody>
</table>

**Flow direction:**
- NNW

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

<table>
<thead>
<tr>
<th>Zone</th>
<th>Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Transmissivity (ft²/day):**
- Measured using: Slug Test

<table>
<thead>
<tr>
<th>Zone</th>
<th>Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**
- **K = 3.5e-5 cm/s to 11.2e-7 cm/s**
- No GW elevation data yet

**Attachments:**

---

**Facility ID#:** 0501

---
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:  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

Formation temperature immediately post-treatment:  9/22/2003  92
Formation temperature post-treatment monitoring event 1:
Duration of post-treatment monitoring (days):

Mass of contaminant removed:
Via liquid pumping:  Unknown  Unknown
In vapor stream:  Unknown  Unknown
Total:  69.5  Unknown

Comments:  
6 months of post-treatment sampling
Attachments:  
19,425 ft³ or 719 yd³

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Please note other energy:

General comments on the thermal application:

23% of total 726,391 kWhr

Lessons Learned

Energy

Total Energy Used: 167070 kWh  kW/m³  kW/h/yd³

__ Total energy applied to treatment zone: __ kW/m³  __ kW/h/yd³

__ Other energy: __ kW/m³  __ kW/h/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: 10/26/2006
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
### General Site Assessment Data

**Implied Zone:**
- Length (parallel to flow direction) (ft.): 125
- Width (ft.): 150
- 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 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

**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>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetra-1,1-dichloroethene</td>
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<td>cis-1,2-dichloroethene</td>
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<td>None</td>
<td>None</td>
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<td>None</td>
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<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>Ethylbenzene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>1,1,1-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:**

---

**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>
</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>[ ]</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): [ ]

<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>0.011</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>0.36</td>
<td></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>
</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

**Facility ID#: 0505**

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

- **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
  - [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

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

- **Start of Thermal Test:**
  - [x] Jun-01

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

- **Treatmeent Cell Design:**

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

- **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 |

<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>
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</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>
<tr>
<td></td>
<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: ___ 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: ______________________________________________

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:** May-00  
  - **End of Test:** Jun-01  
  - **Duration:** 15 months  
  - **Type of Site:** Non-DOD DoD  

- **Facility Name:** Manufacturing Facility - Plastics  
  - **Address:**  
  - **City, State, Zip Code:** Holyoke, MA  
  - **OU# or Site #:**  

- **Primary point of contact:**  
  - **Organization:** ENSR  
  - **Address:** 2 Technology Park Drive  
  - **City, State, Zip Code:** Westford, MA 01886  
  - **Phone #:** 978-589-3000  
  - **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 #:**  

- **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

**Facility ID:** 0510

<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>Map attachment</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>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 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>
</tr>
<tr>
<td>Types of Contaminants</td>
<td>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Other</td>
<td>Groundwater (mg/L)</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------</td>
<td>------------------</td>
<td>--------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>Benzene</td>
<td>Crossdrift</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethane</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-Trichloroethane</td>
<td>styrene</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>

**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>
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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: __________ ft amsl  __________ Unknown

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:  

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>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>

Comments:  

Attachments:  

Facility ID#: 0510
Thermal Treatment: Conductive | Electrical Resistance
---|---
6 phase | 3 phase | AC power | DC power
Steam | Steam | Steam + air | Steam + O2
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-beded layers of higher permeability material
- Largely impermeable sediments with inter-beded 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: Mar-00 | Duration: 15 months

Hydraulic Control: Yes | No

Thermal Treatment Design:
- Size of target zone (ft^2):
- Thickness of target zone (ft):
25
- 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: lb | kg | Unknown
- In vapor stream: lb | kg | Unknown
- Total: lb | kg | Unknown

Comments:
22,500 yd^3 treated in two areas of 1600 yd^2 and 1100 yd^2

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: $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

- **Facility Name:** Former Manufactured gas plant
- **Address:**
- **City, State, Zip Code:** North Adams, MA
- **OU# or Site #:**

### Primary point of contact
- **Name:** Ralph Baker
- **Organization:** TerraTherm
- **Address:** 356 Broad Street
- **City, State, Zip Code:** Fitchburg, MA
- **Phone #:** 978-343-0300
- **email:** rbaker@terratherm.com

### Other contacts or vendors who worked on site
- **Point of contact:** None
- **Type:**
  - Vendor, Consultant
  - Vendor, Technical Applications
  - Other
- **Organization:**
- **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
**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: __________
  - 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>
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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>Crosscrt</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachlorethene</td>
<td>Jet Fuel</td>
<td>TPH*</td>
<td></td>
<td>None</td>
<td>1,000 mg/kg</td>
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<tr>
<td>1,1-Dichloroethene</td>
<td>Naphthalene</td>
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<td></td>
<td>None</td>
<td>500 mg/kg</td>
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<td>Benzene</td>
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<td>None</td>
<td>1,000 mg/kg</td>
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<tr>
<td>trans,1,2-Dichloroethene</td>
<td>Toluene</td>
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<td></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>1,2-Dichloroethene</td>
<td>m/p-xylene</td>
<td>toluene</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>1,1,1-Trichloroethene</td>
<td>o-xylene</td>
<td>benzene</td>
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<td>None</td>
<td>10 mg/kg</td>
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<td>Pentachlorophenol</td>
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<tr>
<td>Vinyl Chloride</td>
<td>Phenanthrene</td>
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<td></td>
<td>100 mg/kg</td>
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<tr>
<td></td>
<td>Methy napthalene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Anthracene</td>
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<td>10 mg/kg</td>
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<tr>
<td></td>
<td>Benzo(a)anthracene</td>
<td></td>
<td></td>
<td>10 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Phenol</td>
<td></td>
<td></td>
<td>10 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Chloroform</td>
<td></td>
<td></td>
<td>10 mg/kg</td>
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<tr>
<td></td>
<td>Pyrene</td>
<td></td>
<td></td>
<td>None</td>
<td>50 mg/kg</td>
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<tr>
<td></td>
<td>Fluoranthene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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</tbody>
</table>

**Comments:**

- *C11 - C22 aromatics*

  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:

<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>
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<tr>
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<tr>
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<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>
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</tr>
<tr>
<td></td>
<td>x Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

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

#### Depth to water:

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Flow direction:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

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

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

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

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</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:

- Geology is all fill.
- Local aquifer outside of the gas holder is DTW = 33 ft

### Attachments:

- [Attachments Link]
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal treatment</td>
<td>Conductive</td>
</tr>
<tr>
<td>Type of Test</td>
<td>Full-scale System</td>
</tr>
<tr>
<td>Geology of Treatment Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td>Treatment Target Zone</td>
<td>Saturated only</td>
</tr>
<tr>
<td>Start of Thermal Test</td>
<td>3/17/2005</td>
</tr>
<tr>
<td>Hydraulic Control</td>
<td>Yes</td>
</tr>
<tr>
<td>Treatment Cell Design</td>
<td></td>
</tr>
<tr>
<td>Size of target zone (ft²)</td>
<td>1020</td>
</tr>
<tr>
<td>Thickness of target zone (ft)</td>
<td>12</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs)</td>
<td>5</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>8</td>
</tr>
<tr>
<td>Temperature Profile</td>
<td></td>
</tr>
<tr>
<td>Initial formation temperature (deg C)</td>
<td>16</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C)</td>
<td>325</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days)</td>
<td>291</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days)</td>
<td>79</td>
</tr>
<tr>
<td>Date</td>
<td>Temperature (deg C)</td>
</tr>
<tr>
<td>3/17/2005</td>
<td>271</td>
</tr>
<tr>
<td>6/3/2005</td>
<td>123</td>
</tr>
<tr>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Mass of contaminant removed</td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping</td>
<td>16,700 gal of coal tar</td>
</tr>
<tr>
<td>In vapor stream</td>
<td>166,000 as naphthalene</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

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

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 617°F (325°C).
Remediation Goal:

- 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

- Total Energy Used: 701,000 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: 850,000
  Energy Cost: 55,000 m³ yd³
  Other Cost 1: 
  Other Cost 2: 
  Other Cost 3: 
- Please note other cost: Other Cost 1: -237/ton
Facility Name: South Eastern MA
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: Ralph Baker

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></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></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
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<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
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<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>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
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<tr>
<td>1,1,1-trichloroethene</td>
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<td>1,1,2-trichloroethene</td>
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<td>Vinyl Chloride</td>
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<tr>
<td>Other</td>
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</tr>
<tr>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td></td>
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</tr>
<tr>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>M+p-xylene</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td></td>
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<tr>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Types of Contaminants

- **Chlorinated Solvents**: Trichloroethene, Tetrachloroethene, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, 1,1,1-trichloroethene, 1,1,2-trichloroethene, Vinyl Chloride.
- **Petroleum Hydrocarbons**: Benzene, Jet Fuel, Naphthalene, Toluene, Ethylbenzene, M+p-xylene, o-xylene.
- **Other**: None.

### Comments:

-Temporary notes on the impact of contaminants:

### Attachments:

- List of relevant soil borings with pre-treatment data: 1.
- Number of relevant soil borings with post-treatment data: 20.
- Number of wells relative to treatment zone:
  - Pre-treatment: In: 1, Upgradient: 0, Downgradient: 13, Crossgradient: 1.
  - Post-treatment: In: 0, Upgradient: 2, Downgradient: 13, Crossgradient: 1.

### Facility ID:

- ID: 0517
### Hydrogeologic Conceptual Model

#### Geology: Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Zone 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 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>
</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: 200 ft amsl Unknown

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>X No</th>
<th>Yes (number):</th>
<th>X 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):              | 14  |               |                                  |
| high value (ft bgs):             | 16  |               |                                  |
| Unknown:                         |     |               |                                  |

| Flow direction                   | North |               |                                  |

| Horizontal hydraulic gradient (feet/foot): | 0.01 |               | Unknown |
| Vertical hydraulic gradient (feet/foot):  |     |               | Unknown |

| K range (ft/day)                  | Measured using: | Slug Test | Laboratory | Field data |                    |
| low                               | 28             |           |            |           | Unknown             |
| high                              |                |           |            |           |                     |

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

- 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.

#### Facility ID#: 0517

#### Comments:

- 

#### Attachments:

- 

- 

Thermal Treatment - Design

Thermal treatment: X Conductive In Situ Thermal Desorption

Electrical Resistance

___ 3 phase  ___ 6 phase  ___ AC power  ___ DC power

Steam

___ 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

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: 8/15/2007  Duration: 214 Days

Hydraulic Control  X Yes  No

Treatment Cell Design:

Size of target zone (ft2): 10,175  ___ Unknown  ( ___ x ___ ft)

Thickness of target zone (ft): 21  ___ Unknown

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

Thickness of target zone below water table (ft): 5 to 7  ___ Unknown

Number of energy delivery points: 24  Lateral Screens were Used for Vapor Extraction  ___ Unknown

Number of extraction points:  ___ Unknown

Temperature Profile:

Initial formation temperature (deg C): 15  ___ Unknown

Maximum representative formation temperature (deg C): 150 (vadose), 100 (saturated)  ___ Unknown

Time to reach maximum representative temperature (days): 200 Days  ___ Unknown

Duration of treatment at representative temperature (days): 150  ___ Unknown

Date

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: 2  lb  kg  Unknown

In vapor stream: 15,000  x  lb  kg  Unknown

Total: >=15000  x  lb  kg  Unknown

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.
**Remediation Goal:**

- **In Groundwater:**
- **In Soil:**

**Was the Remediation Goal Achieved:**

- **In Groundwater:**
  - Comment:
- **In Soil:**
  - Comment: 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**

<table>
<thead>
<tr>
<th>Total Energy Used:</th>
<th>1,900,000</th>
<th>x kWh</th>
<th>kWh/m³</th>
<th>kWh/yard³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy applied to treatment zone:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other energy:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Please note other energy: ________________________________

**Cost**

| Total Project Cost: | | | | |
|--------------------|---------------------|-------------------|-------------------|
| Consultant Cost: | | | |
| Thermal Vendor Cost: | 1,370,000 | | |
| Energy Cost: | 266,000 | | |
| 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: 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: 10/11/2002 End of Test: 1/9/2003 Duration: 90 d
Type of Site: Non-DOD DoD

Facility Name: Silresim Superfund Site
Address: ____________________________
City, State, Zip Code: Lowell, MA
OU# or Site #: ____________________________

Primary point of contact: Jim DiLorenzo
Organization: EPA
Address: ____________________________
City, State, Zip Code: ____________________________
Phone #: 617-918-1247 email: dilorenzo.jim@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**

**X** Impacted Zone:
- Length (parallel to flow direction)(ft.): 725
- Width (ft.): 225
- Thickness (ft.): 60
- 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: None
  - Pre-treatment: 1
  - 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

**X** Soil Borings:
- Number of relevant soil borings with pre-treatment data: 10
- Number of relevant soil borings with post-treatment data: 5
- Number inside treatment zone: 5
- 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></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>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>100 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>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>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>5 mg/L</td>
<td>100 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
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<td>None</td>
<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td></td>
<td>100 mg/L</td>
<td>None</td>
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<tr>
<td>1,1,2-trichloroethane</td>
<td>Xylenes</td>
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<td>500 mg/kg</td>
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<td>1,1,2,2-tetrachloroethane</td>
<td>Styrene</td>
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<td>10 mg/L</td>
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<tr>
<td>Vinyl Chloride</td>
<td>Acetone</td>
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<td>10 mg/L</td>
<td>10 mg/kg</td>
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<tr>
<td>Chlorofluorocarbons</td>
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<td>50 mg/L</td>
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<tr>
<td>Chlorobenzene</td>
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<td>10 mg/L</td>
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<tr>
<td>Total VOCs</td>
<td></td>
<td></td>
<td></td>
<td>500 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>Total chlorinated VOCs</td>
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<td></td>
<td></td>
<td>500 mg/L</td>
<td>None</td>
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<tr>
<td>Total aromatics</td>
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<td></td>
<td>50 mg/L</td>
<td>None</td>
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<tr>
<td>VOCs - Ketones</td>
<td></td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

**Attachments:**
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

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 X Yes (number): 1 Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>1</th>
<th>2</th>
<th>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>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flow direction Northwest

X Horizontal hydraulic gradient (feet/foot): 0.017 0.009 / 0.021 Unknown

Vertical hydraulic gradient (feet/foot): 0.079 - 0.183 Unknown

X K range (ft/day)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>1.1</td>
<td>0.31</td>
<td>0.27</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>Aquifer</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>

X 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 layers of lower permeability material
  - ___ Largely permeable 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:**
  - ___ 10/11/2002
  - ___ Duration: ___ d

- **Hydraulic Control:**
  - ___ Yes
  - ___ No

- **Treatment Cell Design:**
  - Size of target zone (ft²): ___ 50
  - Thickness 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 energy delivery points: ___ 12
  - Number of extraction 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

- **Mass of contaminant removed:**
  - Via liquid pumping: ___ ___ lb ___ kg ___ Unknown
  - In vapor stream: ___ ___ lb ___ kg ___ Unknown
  - Total: ___ 1500 ___ lb ___ kg ___ Unknown

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

<table>
<thead>
<tr>
<th>Energy</th>
<th>Total Energy Used: 286,200 kWhr</th>
<th>kWhr</th>
<th>kWhr/m^3</th>
<th>kWhr/yd^3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total energy applied to treatment zone:</td>
<td>kWhr/m^3</td>
<td>kWhr/yd^3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other energy:</td>
<td>kWhr/m^3</td>
<td>kWhr/yd^3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Please note other energy:</td>
<td>kWhr/m^3</td>
<td>kWhr/yd^3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost</th>
<th>Total Project Cost: 1,600,000</th>
<th>Consultant Cost:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thermal Vendor Cost: 400,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy Cost: 30,000 m^3</td>
<td>yd^3</td>
</tr>
<tr>
<td></td>
<td>Other Cost 1: 180,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other Cost 2: 140,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other Cost 3: 800,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Please note other cost:</td>
<td>Other Cost 1:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other Cost 2:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other Cost 3:</td>
</tr>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------</td>
<td>-------</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></td>
<td>End of Test:</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
</tr>
</tbody>
</table>

**QA/QC**

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
</tr>
</thead>
<tbody>
<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>
</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: 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 relevant soil borings with post-treatment data: None
- Number of relevant soil borings with pre-treatment data: None
- Soil Borings: Number of relevant monitoring wells with groundwater data: None
- Number of relevant soil borings with post-treatment data: None
- Number of relevant soil borings with pre-treatment data: 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>
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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>Crosslink</td>
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<td>Naphthalene</td>
<td></td>
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<tr>
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</tbody>
</table>

### Comments:

Estimated 60,000 lbs of TCE in the soil.
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):
- low: _____________
- high: _____________

Measured using: Slug Test Laboratory Field data

Transmissivity (ft²/day):
- low: _____________
- high: _____________

Measured using: Slug Test Laboratory Field data

Comments:

Attachments:
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0528</th>
</tr>
</thead>
</table>

- **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
  - Largely homogeneous and impermeable unconsolidated sediments
  - Largely permeable sediments with inter-bedded lenses of lower permeability materials
  - 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 Cell Design:**

  - **Size of target zone (ft2):** 8377
  - **Unknown**
  - (116 x 54 ft²)

  - **Thickness of target zone (ft):** 56
  - **Unknown**

  - **Depth to top of target zone (ft bgs):** 29
  - **Unknown**

  - **Thickness of target zone below water table (ft):** 25
  - **Unknown**

  - **Number of energy delivery points:** 24
  - **Unknown**

  - **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:**
  - **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**

  - **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.
Remediation Goal:

- In Groundwater: ____________________________
  
- In Soil: ____________________________
  90% reduction in soil of 9.7 mg/kg

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: ____________________________

Please note other cost:
### General Site Information

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<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th>11/4/2006</th>
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</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>____ Conductive</td>
<td>x Steam</td>
<td>____ ERH</td>
<td>____ Other:</td>
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<tr>
<td>Type of Contaminant:</td>
<td>x 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>x Post</td>
<td>____</td>
<td>____</td>
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<tr>
<td>Type of Test:</td>
<td>x Pilot Test</td>
<td>____ Full Scale System</td>
<td>____</td>
<td>____</td>
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<tr>
<td>Start of Test:</td>
<td>9/1/2002</td>
<td>End of Test:</td>
<td>11/19/2002</td>
<td>Duration:</td>
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<td>____ Non-DOD</td>
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<td>____</td>
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</table>

### Facility Name: Loring Air Force Base

City, State, Zip Code: Limestone, ME

### Primary point of contact: Eva Davis

Organization: US EPA - Kerr Laboratories

City, State, Zip Code: Ada, OK 74820

Phone #: 580-436-8548 email: davis.eva@epamail.epa.gov

### Other contacts or vendors who worked on site

<table>
<thead>
<tr>
<th>Point of contact:</th>
<th>Naji Akladiss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>____ Vendor, Consultant</td>
</tr>
<tr>
<td>Organization:</td>
<td>ME Department of Environmental Protection</td>
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</table>

City, State, Zip Code: Augusta, ME 04333

Phone #: | email: | ____ |

### QA/QC

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
</tr>
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<tbody>
<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

**Facility ID:** 0530

- **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: __________
    - Post-treatment: __________
  - Pre-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>
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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>
</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>Crossdr</td>
<td></td>
<td>0.005 mg/L</td>
<td>1 mg/kg</td>
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<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>0 mg/L</td>
<td>10 mg/kg</td>
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<tr>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
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<td></td>
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<td>0.05 mg/kg</td>
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<td>Benzene</td>
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<td></td>
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<td>0.1 mg/kg</td>
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<td></td>
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<td>0.05 mg/kg</td>
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<td>1,1-dichloroethane</td>
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<td>0.001 mg/L</td>
<td>1 mg/kg</td>
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<td>m/p-xylene</td>
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<td>Benzene</td>
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<td></td>
<td>0.001 mg/L</td>
<td>0.05 mg/kg</td>
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<td>Toluene</td>
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<td>Vinyl Chloride</td>
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<td>0 mg/L</td>
<td>0.05 mg/kg</td>
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**Comments:**

___________________________________________________________________________________

**Attachments:**

___________________________________________________________________________________
### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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</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

### Aquifer Characteristics:

**Ground surface elevation based on wells in or adjacent to treatment zone:** 740 ft amsl  
**Unknown:**

<table>
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<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
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<tbody>
<tr>
<td>Depth to water:</td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td></td>
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<td>low value (ft bgs):</td>
<td>20</td>
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<tr>
<td>high value (ft bgs):</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
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**Flow direction:** SW

**Horizontal hydraulic gradient (feet/foot):** 0.03
**Vertical hydraulic gradient (feet/foot):**

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

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<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
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</table>

**Transmissivity (ft^2/day):**

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<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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<td>low</td>
<td>1.10E-05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>1.10E-03</td>
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### Comments:

... 

### Attachments:

...
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#</th>
<th>0530</th>
</tr>
</thead>
</table>

**Thermal treatment:**
- [x] Conductive
- [ ] 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
- [x] 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] 9/1/2002
- [ ] Duration: 83 d

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

**Treatment Cell Design:**

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<th>Size of target zone (ft²):</th>
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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>
<td>70 to 80</td>
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<tr>
<td>Number of energy delivery points:</td>
<td>9</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>7</td>
</tr>
</tbody>
</table>

**Temperature Profile:**

| Initial formation temperature (deg C): | 7 |
| Maximum representative formation temperature (deg C): | 75 |
| Time to reach maximum representative temperature (days): | 83 |
| Duration of treatment at representative temperature (days): | 1 |

**Formation temperature immediately post-treatment:**

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

**Formation temperature post-treatment monitoring event 1:**

<table>
<thead>
<tr>
<th>Duration of post-treatment monitoring (days):</th>
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</thead>
</table>

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th>3.3 lb</th>
<th>x kg</th>
<th>Unknown</th>
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</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td>4.03 lb</td>
<td>x kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>7.36 lb</td>
<td>x kg</td>
<td>Unknown</td>
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</table>

**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
- In Soil

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

Energy

Total Energy Used: 445.03 kWhr

- Total energy applied to treatment zone: 357.25 kWhr
- Other energy: 87.78 kWhr

Please note other energy: extracted steam energy

Cost

Total Project Cost: 1918850

- Consultant Cost:
- Thermal Vendor Cost: 863000
- Energy Cost:
- Other Cost 1: 375800
- Other Cost 2: 426050
- Other Cost 3: 254000

Please note other cost:

Characterization: post-sampling, reporting, and miscellaneous
**General Site Information**

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<tr>
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<th>JT PD</th>
<th>Date: 10/30/2006</th>
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<tr>
<td>Type of treatment:</td>
<td>Conductive, Steam, ERH, Other: Hot air</td>
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<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>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test, Full Scale System</td>
<td></td>
</tr>
<tr>
<td>Start of Test:</td>
<td>1/16/1996</td>
<td></td>
</tr>
<tr>
<td>End of Test:</td>
<td>Mar-98</td>
<td></td>
</tr>
<tr>
<td>Duration:</td>
<td>2 years</td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD, DoD</td>
<td></td>
</tr>
</tbody>
</table>

**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
e-mail: connelly.terry@epa.gov

**Other contacts or vendors who worked on site:** None

Point of contact:

<table>
<thead>
<tr>
<th>Type:</th>
<th>Vendor, Consultant, Vendor, Technical Applications, Other</th>
</tr>
</thead>
<tbody>
<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>e-mail:</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

#### 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: 24
- 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></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrahydrofluorohydrocarbon</td>
<td></td>
<td></td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trans-1,2-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td></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>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td></td>
<td></td>
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<td>None</td>
<td>None</td>
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<tr>
<td>1,1,1-trichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
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</tbody>
</table>

#### Comments:
- __________
- __________
- __________

#### Attachments:
- __________
- __________
- __________
### 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:

- **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)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water</th>
<th>Flow direction</th>
<th>Horizontal hydraulic gradient</th>
<th>Vertical hydraulic gradient</th>
<th>K range (ft/day)</th>
<th>Transmissivity (ft2/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low (ft bgs):</td>
<td></td>
<td>Measured using: Slug Test</td>
<td></td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>high (ft bgs):</td>
<td></td>
<td>Laboratoy</td>
<td></td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td></td>
<td>Unknown:</td>
<td></td>
<td>Field data</td>
<td></td>
<td>Unknown</td>
<td>Field data</td>
</tr>
</tbody>
</table>

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

- __________ ft amsl
- __________ Unknown

### Flow direction

- __________

- __________

- __________

### Water table elevation based on wells in or adjacent to treatment zone

- __________ ft amsl
- __________ Unknown

### Facility ID#:

- 0532
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>Steam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam + air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam + O2</td>
</tr>
</tbody>
</table>

<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>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>16-Jan-96</th>
<th>Duration:</th>
<th>2 years</th>
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</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 extraction points:</td>
</tr>
<tr>
<td>Number of energy delivery 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>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></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>-----------</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>-----------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<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:  ___________  kWh  ___________  kWhr/m²  ___________  kWhr/yd²

Total energy applied to treatment zone:  ___________  kWh/m³  ___________  kWhr/yd³

Other energy:  ___________  kWh/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>X</th>
<th>File Analyzed By: JT PD</th>
<th>Date: 9/18/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Type of treatment:  Conductive Steam ERH Other:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment Status: Wood Treating Other:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type of Test: Pilot Test Full Scale System</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Start of Test: 1995 End of Test: 2001</td>
<td>Duration: 59 months</td>
</tr>
<tr>
<td></td>
<td>Type of Site: Non-DOD DoD</td>
<td></td>
</tr>
</tbody>
</table>

X Facility Name: Bell Lumber and Pole Company

| Organization: Western Research Institute |
| Address: 365 N. 9th St. |
| City, State, Zip Code: New Brighton, MY |
| OU# or Site #: | |

Primary point of contact: Lyle Johnson

| Organization: Western Research Institute |
| Address: 365 N. 9th St. |
| City, State, Zip Code: New Brighton, MY |
| Phone #: 307-721-2281 email: lylej@uwyo.edu |

Other contacts or vendors who worked on site None

Point of contact: Vendor, Consultant Vendor, Technical Applications Other

Organization: Western Research Institute

| Address: 365 N. 9th St. |
| City, State, Zip Code: New Brighton, MY |
| Phone #: | email: lylej@uwyo.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 | |
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: ______

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 22
- 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) 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>Benzene</td>
<td>Jet fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Naphthalene</td>
<td>Phenol</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
<td>Polyethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Hexane</td>
<td>Polyurethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1-dichloroethane</td>
<td>Benzene</td>
<td>Polyethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>Toluene</td>
<td>Polyethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>n-xylene</td>
<td>Polyethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>n-xylene</td>
<td>Polyethylene</td>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
<td>n-xylene</td>
<td>Polyethylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

2 acres impacted

**Attachments:**

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

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____________________________________________________________________________________________________________________________
### 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:

<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):
- 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

### Comments:
- Confining layer K=1(10⁻⁷) cm/s
- Radial velocity is 0.1 ft/day

### Attachments:
- 
- 
- 
- 
- 
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0535</th>
</tr>
</thead>
</table>

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

- **Steam**
  - [ ] Hot water
  - [ ] 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
  - [ ] Vadose only
  - [ ] Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - [x] 1995
  - **Duration:**
    - [ ] 59 months
  - **Hydraulic Control:**
    - [ ] Yes
    - [ ] No

- **Treatment Cell Design:**
  - **Size of target zone (ft²):**
    - [ ] 26136
    - [ ] 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):**
    - [x] 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):**
    - [x] 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
    - [x] Unknown
  - **In vapor stream:**
    - [ ] lb
    - [ ] kg
    - [x] Unknown
  - **Total:**
    - [ ] 500,000
    - [x] lb
    - [ ] kg
    - [x] Unknown

- **Comments:**

- **Attachments:**

---

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

Cost

Total Project Cost: 1858400

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 ERH  Date: 10/26/2006
Type of treatment:  Conductive  Steam  ERH  Other: RFH
Type of Contaminant:  Chlorinated Solvents  Petroleum Hydrocarbons  Pesticides
Type of Contaminant:  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@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:**

---

**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:
  - [ ]

**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>
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<td>None</td>
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<tr>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
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<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></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></td>
<td>1,2-dichloroethene</td>
<td>n-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>GRO</td>
<td></td>
<td>100 mg/L</td>
<td>100 mg/L</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td></td>
<td>100 mg/L</td>
<td>100 mg/L</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
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<td>100 mg/L</td>
<td>50 mg/kg</td>
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<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

---

**Attachments:**

---
### Hydrogeologic Conceptual Model

**Facility ID:** 0540

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
<th>Aquifer Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Is more than 1 aquifer present?</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
<td>Yes (number):</td>
</tr>
<tr>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td>Unknown (assume single aquifer)</td>
</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Aquifer 1</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td>Aquifer 2</td>
</tr>
<tr>
<td>Saturated Zone</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Aquifer 3</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>Unknown</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:** 

<table>
<thead>
<tr>
<th>ft amsl</th>
<th>Unknown</th>
</tr>
</thead>
</table>

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Depth to water:</th>
<th>30</th>
<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>
<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>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>53.9</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>

**K = 0.019 cm/sec**

**Comments:**

**Attachments:**

---

---

---
**Thermal Treatment - Design**

**Facility ID#: 0540**

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

- **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:**
  - 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):
  - 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:

- **Comments:**

- **Attachments:**

---

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

  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: ______________________ 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>
<th>Facility ID#: 0545</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Analyzed By: JT PD</td>
<td>Date: 10/30/2006</td>
</tr>
<tr>
<td>Type of treatment:</td>
<td>Type of Test:</td>
</tr>
<tr>
<td>Conductive Steam ERH</td>
<td>Pilot Test Full Scale System</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>Start of Test:</td>
</tr>
<tr>
<td>Chlorinated Solvents</td>
<td>End of Test:</td>
</tr>
<tr>
<td>Petroleum Hydrocarbons</td>
<td>Duration:</td>
</tr>
<tr>
<td>Wood Treating</td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
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<tr>
<td>Treatment Status:</td>
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</tr>
<tr>
<td>Active Post</td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td></td>
</tr>
<tr>
<td>Non-DOD DoD</td>
<td></td>
</tr>
</tbody>
</table>

| 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: None |
| 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**

**Facility ID:** 0545

---

**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:** ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

- **Post-treatment:** ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

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

- **Pre-treatment:** ______
  - In: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

- **Post-treatment:** ______
  - In: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

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

- **Post-treatment:** ______
  - In: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

**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>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td></td>
<td>trans-1,2-dichloroethene</td>
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<td>None</td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
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<td>1,1,1-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td></td>
<td>1,1,2-trichloroethane</td>
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<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Groundwater (mg/L) Soil (mg/kg)**

- **Pre-treatment:**
  - In: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

- **Post-treatment:**
  - In: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

**Number of relevant soil borings with post-treatment data:** ______

**Number outside treatment zone:** ______

**Soil Borings:**
- Number of relevant soil borings with post-treatment data: ______

**Number inside treatment zone:** ______

**Chemical:**
- Benzene
- Jet Fuel
- Naphthalene
- Toluene
- Ethylbenzene
- m,p-xylene
- o-xylene
- Tetrachloroethene
- 1,1-dichloroethane
- cis-1,2-dichloroethene
- trans-1,2-dichloroethene
- 1,1-dichloroethene
- 1,2-dichloroethane
- 1,1,1-trichloroethane
- 1,1,2-trichloroethane
- 1,1,2,2-tetrachloroethane
- Vinyl Chloride

**Groundwater (mg/L) Soil (mg/kg)**

- **Pre-treatment:**
  - In: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

- **Post-treatment:**
  - In: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______

**Facility ID:** 0545

---

**Comments:**

- None
- None
- None
- None

**Attachments:**

- None
- None
- None
- None
### Geology:

#### 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
- __________ ft
- __________ ft
- __________ ft
- 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:
- High:
- Measured using: Slug Test, Laboratory, Field data
- Unknown

#### Transmissivity (ft²/day):

- Low:
- High:
- Measured using: Slug Test, Laboratory, Field data
- 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
- **Type of Test:**
  - Pilot test
  - Full-scale System
  - RFH
- **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:**
  - 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:
- **Date** | **Temperature (deg C)**
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<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: .................................................................

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: 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**

### 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>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>
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</tr>
<tr>
<td>Tetrachloroethene</td>
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<tr>
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<td>None</td>
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</tr>
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<td>None</td>
<td>None</td>
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<td>None</td>
<td>None</td>
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<td>None</td>
</tr>
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<td>1,1-dichloroethane</td>
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<tr>
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<td>None</td>
</tr>
<tr>
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</tr>
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<td>Naphtalene</td>
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</tr>
<tr>
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<td>o-xylene</td>
<td>None</td>
<td>None</td>
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<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- Additional comments can be added here.

### Attachments:

- Map attachment
- Source zone definition attachments
- Map attachment
- General Site Assessment Data
- Impacted Zone:
- Monitor Wells:
- Soil Borings:
- Number of wells relative to treatment zone:
- Number of wells outside treatment zone:
- Number of relevant monitoring wells with groundwater data:
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number of wells relative to treatment zone:
- Number of relevant monitoring wells with groundwater data:
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number of wells relative to treatment zone:
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- Number of relevant soil borings with post-treatment data:
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- Number of relevant monitoring wells with groundwater data:
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- Number of relevant monitoring wells with groundwater data:
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- Number of relevant monitoring wells with groundwater data:
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- Number of relevant soil borings with post-treatment data:
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- Number of relevant monitoring wells with groundwater data:
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- Number of relevant soil borings with post-treatment data:
- Number of wells relative to treatment zone:
- Number of relevant monitoring wells with groundwater data:
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number of wells relative to treatment zone:
- Number of relevant monitoring wells with groundwater data:
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
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- Number of relevant monitoring wells with groundwater data:
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number of wells relative to treatment zone:
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- Number of relevant soil borings with post-treatment data:
- Number of wells relative to treatment zone:
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- Number of relevant soil borings with post-treatment data:
- Number of wells relative to treatment zone:
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- Number of relevant soil borings with post-treatment data:
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- Number of relevant monitoring wells with groundwater data:
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- Number of relevant soil borings with post-treatment data:
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- Number of relevant monitoring wells with groundwater data:
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- Number of relevant soil borings with post-treatment data:
- Number of wells relative to treatment zone:
- Number of relevant monitoring wells with groundwater data:
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
- Number of wells relative to treatment zone:
- Number of relevant monitoring wells with groundwater data:
- Number of relevant soil borings with pre-treatment data:
- Number of relevant soil borings with post-treatment data:
### 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): 
  - 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):**
  - 

- **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

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

- ft amsl
- Unknown

### Facility ID:
- 0550
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
  - 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

Geology of Treatment 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 bg):  
- Thickness of target zone below water table (ft):  
- Number of extraction points:  
- Number of energy delivery points:  
- Thickness of target zone (ft):  
- Size of target zone (ft2):  

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:

37 yd3 treated

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: ___________ 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:

- 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 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 x Post

Type of Test: ___ Pilot Test ___ Full Scale System

Start of Test: ___ Apr-97 End of Test: ___ Jul-97 Duration: varied

Type of Site: ___ 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: Paulette 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-isetts.paulettta@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

____ 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>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>

| 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: | 10 | | | |
| Number of relevant soil borings with post-treatment data: | 10 | | | |
| Number inside treatment zone: | Number outside treatment zone: | | | |

### Types of Contaminants

<p>| Chemicals of Concern | | | | |</p>
<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>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>Benzene</td>
<td>Crosslink</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel (a)</td>
<td>None</td>
<td>1,000 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>Naphthalene (b)</td>
<td>None</td>
<td>1 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td>Benzene (c)</td>
<td>None</td>
<td>1 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>Toluene (d)</td>
<td>None</td>
<td>1 mg/kg</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,2-Dichloroethane</td>
<td>m/p-xylene</td>
<td>None</td>
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<td>None</td>
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<tr>
<td>1,1,1-Trichloroethane</td>
<td>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,2-Trichloroethane</td>
<td>vinyl chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Concentration averages at different depths for thermal blanket 1 demo**

**Attachments:**

---

(Additional content as needed)
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:

Soil Borings: Number of relevant soil borings with groundwater 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>
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</tr>
<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>Arclor 1260 @10&quot;</td>
<td>None</td>
<td>100 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>Arclor 1260 @15&quot;</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>Arclor 1260 @15&quot;</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td>Arclor 1260 @24&quot;</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td>None</td>
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<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-trichloroethene</td>
<td>o-xylene</td>
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</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>Other</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:
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: __________ (111 samples)
- Number of relevant soil borings with post-treatment data: __________ (111 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></td>
<td></td>
<td></td>
<td>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>Trihalomethane</td>
<td></td>
<td></td>
<td></td>
<td>None None</td>
<td>None None</td>
</tr>
<tr>
<td>Tetrahalomethane</td>
<td></td>
<td></td>
<td></td>
<td>None 1,000 mg/kg None 0.01 mg/kg</td>
<td>None 1,000 mg/kg None 0.01 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None 100 mg/kg None 0.01 mg/kg</td>
<td>None 100 mg/kg None 0.01 mg/kg</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>None 10 mg/kg None 0.01 mg/kg</td>
<td>None 10 mg/kg None 0.01 mg/kg</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>None 1 mg/kg None 0.01 mg/kg</td>
<td>None 1 mg/kg None 0.01 mg/kg</td>
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<tr>
<td>1,1-dichloroethane</td>
<td></td>
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<td></td>
<td>None 1 mg/kg None 0.01 mg/kg</td>
<td>None 1 mg/kg None 0.01 mg/kg</td>
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<tr>
<td>1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None 5 mg/kg None 0.01 mg/kg</td>
<td>None 5 mg/kg None 0.01 mg/kg</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td></td>
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<td>None 1 mg/kg None 0.01 mg/kg</td>
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<tr>
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<td>None 0.1 mg/kg None 0.01 mg/kg</td>
<td>None 0.1 mg/kg None 0.01 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
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</tr>
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<td></td>
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<td>None None</td>
<td>None None</td>
</tr>
</tbody>
</table>

Concentration averages at different depths for thermal wells demo at multiple depths

Comments: None

Attachments: None
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: 40 ft amsl

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></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): 40
- 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  x Laboratory  ___ Field data
  - low 3 x 10E-3 md
  - high 50 md
- Transmissivity (ft²/day):
  - Measured using: Slug Test  x Laboratory  ___ Field data
  - low
  - high

Comments:


Thermal Treatment - Design

| Facility ID: | 0560 |

- **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
  - 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)

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

- **Start of Thermal Test:**
  - 3/13/1997

- **Duration:**
  - 32 days

- **Number of extraction points:**

- **Number of energy delivery points:**

- **Thickness of target zone below water table (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:**

- **Treatment Cell Design:**

- **Temperature Profile:**
  - **Initial formation temperature (deg C):**
    - 33.8
  - **Maximum representative formation temperature (deg C):**
    - 315
  - **Time to reach maximum representative temperature (days):**
    - 30
  - **Duration of treatment at representative temperature (days):**
    - 1

- **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: _____________ __________ __________ kg __________ kg
  - In vapor stream: _____________ __________ __________ kg __________ kg
  - Total: _____________ __________ __________ kg __________ kg

- **Comments:**

- **Attachments:**

---

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

<table>
<thead>
<tr>
<th>Facility ID#:</th>
<th>0560</th>
</tr>
</thead>
</table>

**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
- 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:**
- 7/6/1997
- Duration: 22 days

**Hydraulic Control:**
- Yes
- No

**Treatment Cell Design:**
- Size of target zone (ft²): 310
- 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): 31.4
- Maximum representative formation temperature (deg C): 155
- Time to reach maximum representative temperature (days): 22
- Duration of treatment at representative temperature (days): 1

**Mass of contaminant removed:**
- Via liquid pumping: 0 lb x kg
- In vapor stream: 0 lb x kg
- Total: 0 lb x kg

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

<table>
<thead>
<tr>
<th>Facilty ID#: 0560</th>
</tr>
</thead>
</table>

**Thermal Wells**

- 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

**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):**

<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: 40 lb x kg
- In vapor stream: 4(10^-10) lb x kg
- Total: 40 lb x kg

**Comments:**

- Mass in thermal well application only
- Thermal wells on a 5ft center spacing

**Attachments:**

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

**Goals of all 3 demos:**
1. Clean soils within arrays to achieve <2 ppm total PCBs.
2. Show stack discharges could meet compliance stds with the state and federal for PCBs and polychlorinated dibenzo-dioxins/dibenzofurans (PCDDs/PCDFs).
3. Obtain a system destruction and removal efficiency (DRE) for PCBs greater than 99.9999%.

**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>Total energy applied to treatment zone:</td>
<td>kWh/m³</td>
<td>kWh/yd³</td>
<td></td>
</tr>
<tr>
<td>Other energy:</td>
<td>kWh/m³</td>
<td>kWh/yd³</td>
<td></td>
</tr>
</tbody>
</table>

**Cost**

<table>
<thead>
<tr>
<th>Total Project Cost:</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Consultant Cost:</td>
<td></td>
</tr>
<tr>
<td>Thermal Vendor Cost:</td>
<td></td>
</tr>
<tr>
<td>Energy Cost:</td>
<td>m³</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 x PD 
- **Date:** 11/3/2006
- **Type of treatment:** Conductive x Steam ERH Other: 
- **Type of Contaminant:** Chlorinated Solvents x Petroleum Hydrocarbons Pesticides x Wood Treating Other: 
- **Treatment Status:** Active x Post 
- **Type of Test:** Pilot Test x Full Scale System 
- **Start of Test:** 
- **End of Test:** 
- **Duration:** 120 d 
- **Type of Site:** x Non-DOD x 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:** McMillian-McGee 
  - **Address:** 
  - **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 x 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:** 0562

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Chlorinated Solvents</th>
<th>Hydrocarbons</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>Résine</td>
<td>Crossdr</td>
<td></td>
</tr>
<tr>
<td>Tetracloroethene</td>
<td>Jet Fule</td>
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</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>1,1-dichloroethene</td>
<td>Ethylbenzene</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>α-xylene</td>
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<td>1,1,2,2-tetrachloroethane</td>
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</tr>
<tr>
<td>Vinyl Chloride</td>
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</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>
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<tbody>
<tr>
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<td>None</td>
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</table>

#### 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>
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<tbody>
<tr>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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</table>

### Monitor Wells

Number of relevant monitoring wells with groundwater data: None

#### 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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<tbody>
<tr>
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</tr>
</tbody>
</table>

#### Number of wells relative to treatment zone:

<table>
<thead>
<tr>
<th>Post-treatment</th>
<th>In:</th>
<th>Upgradient:</th>
<th>Downgradient:</th>
<th>Crossgradient:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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### 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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</tbody>
</table>

### Comments:

- Comments:
  - None
  - None
  - None

### Attachments:

- Attachments:
### Hydrogeologic Conceptual Model

#### Facility ID:
0562

<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>
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<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vadose Zone:</th>
<th>Saturated Zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<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>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>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<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:**

- **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:**
- [x] Conductive
- [ ] Electrical Resistance

**Type of Test:**
- [x] Pilot test
- [ ] 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-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:**
- [x] Saturated only
- [ ] Vadose only
- [ ] Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- Duration: 120 d

**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>

**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:**
- 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>Units</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
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<tbody>
<tr>
<td>Via liquid pumping</td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>In vapor stream</td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>Total</td>
<td>69000</td>
<td>x</td>
<td></td>
<td>Unknown</td>
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</tbody>
</table>

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

**Attachments:**
- 24 ft spacing
General comments on the thermal application:

Goal: 99% reduction

Lessons Learned

Energy

Total Energy Used: 203.58 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: 

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:
**General Site Information**

- **File Analyzed By:** JT PD ______
- **Date:** 10/13/2006
- **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:** 6/24/2005 ______ **End of Test:** 10/18/2005 ______ **Duration:** 117 d
- **Type of Site:** ______ Non-DOD ______ DoD

- **Facility Name:** Operating Industrial Manufacturing Facility, Confidential Location, Missouri
- **Address:** ____________________________
- **City, State, Zip Code:** Missouri
- **OU# or Site #:** ____________________________

- **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:** bwilliams@SECOR.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
### 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>
<td></td>
<td></td>
<td>地上水 (mg/L)</td>
<td>矿物 (mg/kg)</td>
</tr>
<tr>
<td>}\n</td>
<td>Tetrachloroethylene</td>
<td>Benzene</td>
<td>Crossdye</td>
<td></td>
<td>10 mg/L</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Jet Fuel</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<td>Naphthalene</td>
<td></td>
<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>
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<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
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<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:

- Map attachment
- Alternative method for determining size of impacted zone (See source zone definition attachments)
Hydrogeologic Conceptual Model

X 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  X Unknown

X 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

X 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:

The geology is a residual clay with variable limestone and chert floaters

Attachments:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0564</th>
</tr>
</thead>
</table>

#### Thermal treatment:
- [ ] Conductive
- [x] 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
- [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
- [ ] Vadose only
- [x] Both (Saturated and Vadose zones)

#### Start of Thermal Test:
- [x] 6/24/2006
- [ ] Duration: 117 d

#### Hydraulic Control
- [ ] Yes
- [ ] No

#### Treatment Cell Design:
- Size of target zone (ft²): 700
- Thickness of target zone (ft): 18
- Depth to top of target zone (ft bgs): 4
- Thickness of target zone below water table (ft): 20
- Number of energy delivery points: 13
- Number of extraction points: 33

#### Temperature Profile:
- Initial formation temperature (deg C): 24
- Maximum representative formation temperature (deg C): 100
- Time to reach maximum representative temperature (days): 57
- Duration of treatment at representative temperature (days): 64

#### Date | Temperature (deg C)
--- | ---
Unknown | Unknown
Unknown | Unknown
Unknown | Unknown
Unknown | 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  x  Unknown
- In vapor stream: _______ lb  _______ kg  x  Unknown
- Total: _______ lb  _______ kg  x  Unknown

#### Comments:

The extraction points were 18 electrode/vapor recovery wells and 13 additional vapor recovery wells, of which only 1 was used.

#### Attachments:

---

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

Facility ID#: 0564

Performance

Remediation Goal:

- In Groundwater:

- In Soil:

At a 90% upper confidence limit, reduce TCE in soil to 0.4 mg/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 kWh

- 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:
<table>
<thead>
<tr>
<th>General Site Information</th>
<th>Facility ID#: 0565</th>
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<tbody>
<tr>
<td>x File Analyzed By: JT PD</td>
<td>Date: 10/18/2006</td>
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<tr>
<td>Type of treatment:</td>
<td></td>
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<tr>
<td>Type of Contaminant:</td>
<td></td>
</tr>
<tr>
<td>Treatment Status:</td>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td></td>
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<tr>
<td>Start of Test:</td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>x Non-DOD</td>
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</table>

<table>
<thead>
<tr>
<th>x Facility Name: George's Conoco</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
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<tr>
<td>City, State, Zip Code: Ronan, MT</td>
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<tr>
<td>OU# or Site #:</td>
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</tbody>
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<table>
<thead>
<tr>
<th>x Primary point of contact: Ken Manchester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization: MSE Technology Applications</td>
</tr>
<tr>
<td>Address: 200 Technology Way</td>
</tr>
<tr>
<td>City, State, Zip Code: Butte, MT</td>
</tr>
<tr>
<td>Phone #: 406-494-7397 email: <a href="mailto:ken.manchester@mse-ta.com">ken.manchester@mse-ta.com</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>x Other contacts or vendors who worked on site</th>
<th>None</th>
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<tbody>
<tr>
<td>Point of contact: Jeffrey A. Kuhn</td>
<td></td>
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<tr>
<td>Type: Vendor, Consultant Vendor, Technical Applications Other</td>
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<tr>
<td>Organization: Montana Dept. of Environmental Quality</td>
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<tr>
<td>Address: PO Box 20090</td>
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<tr>
<td>City, State, Zip Code: Helena, MT 59620-0901</td>
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<tr>
<td>Phone #: 406-841-5000 email: <a href="mailto:jkuhn@state.mt.us">jkuhn@state.mt.us</a></td>
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<thead>
<tr>
<th>QA/QC</th>
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<tbody>
<tr>
<td>____ Characteristics of Interest</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>
</tr>
</tbody>
</table>
Impacted Zone:  
Length (parallel to flow direction)(ft.): Unknown  
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  
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>
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<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>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>cis-1,2-dichloroethene</td>
<td></td>
<td>Benzene</td>
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<td>10 mg/L</td>
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<td>1,1,2-trichloroethane</td>
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<td>None</td>
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</tbody>
</table>

Comments:

4,000 to 6,000 gallons of premium gasoline released  
soil except for 1,1,2-trichloroethane and the highest TPH Concentration at 35 ug/L

Attachments:

__________________________________________________________________________
### Hydrogeologic Conceptual Model

#### Facility ID:

<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>
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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>
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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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low (ft bgs): 2</td>
</tr>
<tr>
<td></td>
<td>high (ft bgs): 18</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)

<table>
<thead>
<tr>
<th>K range (ft/day)</th>
<th>Measured using:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slug Test</td>
</tr>
<tr>
<td></td>
<td>Laboratory</td>
</tr>
<tr>
<td></td>
<td>Field data</td>
</tr>
<tr>
<td>low</td>
<td>6.028</td>
</tr>
<tr>
<td>high</td>
<td></td>
</tr>
</tbody>
</table>

- Transmissivity (ft²/day):

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

- Comments:

<table>
<thead>
<tr>
<th>Comments:</th>
<th>K = 10 e-6 cm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16 ft was depth-to-water in the treatment zone.</td>
</tr>
</tbody>
</table>

- 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:** 7/11/2003
- Duration: 140 d

**Treatment Cell Design:**
- Yes
- No

**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

**Date**

<table>
<thead>
<tr>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<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: Requires known values for lb and kg.
- In vapor stream: Requires known values for lb and kg.
- **Total:** 1574 lb

**Comments:**
- N/S spacing of 27.6 ft and a SW/NE spacing of 24.0 ft.
- Treatment 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

Cost

Energy

Total Energy Used: 514120

kWh  kWh/m³  kWh/yd³

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

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: 10/15/2007
Type of treatment: _____ Conductive _____ Steam X ERH _____ Other: ________________
Type of Contaminant: X 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: Eastern Montana
Address: ____________________________________________
City, State, Zip Code: _____________________________________
OU# or Site #: _________________________________________

Primary point of contact: Galen Davis
Organization: Kennedy Jenks Consultants
Address: ____________________________________________
City, State, Zip Code: _____________________________________
Phone #: 253-874-0556 email: galen.davis@kennedyjenks.com

Other contacts or vendors who worked on site _____ None
Point of contact: David Fleming
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:** 0568

**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

**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) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
<td>50 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-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>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:**

- ______________________________________

**Attachments:**

- ______________________________________
Hydrogeologic Conceptual Model

Facility ID#: 0568

---

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 Aquifer 2 Aquifer 3

Depth to water:
- low value (ft bgs): __________
- high value (ft bgs): __________
- Unknown: __________

---

Flow direction

---

Horizontal hydraulic gradient (feet/foot):

Vertically 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: Cross out Conductive
Cross out Electrical Resistance

Steam 3 phase 6 phase AC power DC power

Steam Steam + air Steam + O2

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

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

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

Start of Thermal Test: 11/4/2006 Duration: 824

Hydraulic Control No

Thermal treatment Cell Design:

Size of target zone (ft2):
1000

Thickness of target zone (ft):
20

Depth to top of target zone (ft bg):
2

Thickness of target zone below water table (ft):
20

Number of energy delivery points:

Number of extraction points:

Temperature Profile:

Initial formation temperature (deg C):
13
Unknown

Maximum representative formation temperature (deg C):
77
Unknown

Time to reach maximum representative temperature (days):
25
Unknown

Duration of treatment at representative temperature (days):
57
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.
**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: 25,1616 \( \times \) kWh \( \times \) kWh/m\(^3\) \( \times \) 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:

- 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: 11/9/2006

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: ___Non-DOD  X DoD

Facility Name: Camp LeJeune

Address: ____________________________________________

City, State, Zip Code: Jacksonville, NC

OU# or Site #: Site 89

Primary point of contact: Ron Kenyon

Organization: Shaw

Address: ____________________________________________

City, State, Zip Code: Alpharetta, GA

Phone #: 770-663-1453  email: ronald.kenyon@shawgrp.com

Other contacts or vendors who worked on site ___None

Point of contact: Daniel Hood

Type: ___Vendor, Consultant  ___Vendor, Technical Applications  X 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: ___

- Pre-treatment: __
- Post-treatment: __

<table>
<thead>
<tr>
<th>Well Position</th>
<th>Number of wells relative to treatment zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-treatment</td>
<td>In: __</td>
</tr>
<tr>
<td>Post-treatment</td>
<td>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: __

<table>
<thead>
<tr>
<th>Well Position</th>
<th>Number of relevant soil borings with post-treatment data: __</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-treatment</td>
<td>__</td>
</tr>
<tr>
<td>Post-treatment</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>
<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>Hexane</td>
<td>Cross</td>
<td>500 mg/L</td>
<td>500 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>X</td>
<td>Jet Fuel</td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>X</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td>X</td>
<td>Benzene</td>
<td></td>
<td>100 mg/L</td>
<td>50 mg/kg</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td>X</td>
<td>Toluene</td>
<td></td>
<td>50 mg/L</td>
<td>50 mg/kg</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>X</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-Dichloroethene</td>
<td>X</td>
<td>m,p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>X</td>
<td>o-xylene</td>
<td></td>
<td>0.5 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>X</td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>50 mg/kg</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethane</td>
<td>X</td>
<td></td>
<td></td>
<td>100 mg/L</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>X</td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>TCE - Deep</td>
<td>X</td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>50 mg/kg</td>
</tr>
<tr>
<td>PCE - Deep</td>
<td>X</td>
<td></td>
<td></td>
<td>0.5 mg/L</td>
<td>None</td>
</tr>
<tr>
<td>cis-12 DCE - Deep</td>
<td>X</td>
<td></td>
<td></td>
<td>1 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>trans-12 DCE - Deep</td>
<td>X</td>
<td></td>
<td></td>
<td>0.5 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>1122 PCA - Deep</td>
<td>X</td>
<td></td>
<td></td>
<td>10 mg/L</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>VC - Deep</td>
<td>X</td>
<td></td>
<td></td>
<td>0.1 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

**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 at 0.005 mg/L, but shown as 0.01 mg/kg due to spreadsheet constraints.

**Attachments:**

- [Attachment 1](#)
- [Attachment 2](#)
- [Attachment 3](#)
### Ground surface elevation based on wells in or adjacent to treatment zone:

<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? **Yes (number):**
  - Aquifer 1
  - Aquifer 2
  - Aquifer 3
  - Unknown (assume single aquifer)

- Depth to water:
  - low value (ft bgs): 1
  - high value (ft bgs): 4
  - Unknown:

- Flow direction: SE

- Horizontal hydraulic gradient (feet/foot):
  - Measured using: Slug Test, Laboratory, Field data
  - 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
  - Unknown

**Transmissivity (ft²/day):**

- Measured using: Slug Test, Laboratory, Field data
  - Unknown

**Comments:**

**Attachments:**

---

Facility ID#: 0570
Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.

<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID#: 0570</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td></td>
</tr>
<tr>
<td>- <strong>Conductive</strong></td>
<td></td>
</tr>
<tr>
<td>- <strong>Electrical Resistance</strong></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><strong>Steam + air</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Steam + O₂</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Other (describe)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type of Test:</strong></td>
<td></td>
</tr>
<tr>
<td>- Pilot test</td>
<td></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>
<td></td>
</tr>
<tr>
<td>- Largely permeable sediments with inter-bedded layers of lower permeability material</td>
<td></td>
</tr>
<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>
</tr>
<tr>
<td>- Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
<tr>
<td><strong>Treatment Target Zone:</strong></td>
<td></td>
</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>
<td></td>
</tr>
<tr>
<td><strong>Start of Thermal Test:</strong></td>
<td></td>
</tr>
<tr>
<td>- 9/11/2003</td>
<td>Duration: 242 d</td>
</tr>
<tr>
<td><strong>Hydraulic Control:</strong></td>
<td></td>
</tr>
<tr>
<td>- Yes</td>
<td></td>
</tr>
<tr>
<td>- No</td>
<td></td>
</tr>
<tr>
<td><strong>Treatment Cell Design:</strong></td>
<td></td>
</tr>
<tr>
<td>Size of target zone (ft²):</td>
<td>15873</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>21</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>8</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>91</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>38</td>
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<tr>
<td><strong>Temperature Profile:</strong></td>
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<tr>
<td>Initial formation temperature (deg C):</td>
<td>20</td>
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<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>-156</td>
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<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>~86</td>
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<tr>
<td><strong>Formation temperature immediately post-treatment:</strong></td>
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</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>1 yr</td>
</tr>
<tr>
<td><strong>Mass of contaminant removed:</strong></td>
<td></td>
</tr>
<tr>
<td>Via liquid pumping:</td>
<td>428 lb</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td>40000 lb</td>
</tr>
<tr>
<td>Total:</td>
<td>48428 lb</td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td></td>
</tr>
<tr>
<td>Only 75% on time (~175 d).</td>
<td></td>
</tr>
<tr>
<td><strong>Attachments:</strong></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: Evaluate effectiveness of ERH at reducing DNAPL within study area.

Lessons Learned

General comments on the thermal application:

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment: 99% in treatment zone and 97% in perimeter zone.
- In Soil
  - Comment: Yes.

Energy

- Total Energy Used: 1,748,660 kWh
  - Total energy applied to treatment zone: ____________ kWh/m³ ____________ kWh/yd³
  - Other energy: ____________ kWh/m³ ____________ kWh/yd³

Cost

- Total Project Cost: 2,105,215
  - Consultant Cost: ____________
  - Thermal Vendor Cost: ____________
  - Energy Cost: ____________ m³ ____________ yd³
  - Other Cost 1: 907,400
  - Other Cost 2: 672,550
  - Other Cost 3: 525,265

Please note other cost:

- Other Cost 1: **System O & M**
  - Site prep, restoration, monitoring, and reporting (31,275, 324,410, 169,580)
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: Confidential

Address: ______________________

City, State, Zip Code: NC

OU# or Site #: __________

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
### 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>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>Chlorinated Solvents</td>
<td></td>
<td></td>
<td></td>
<td></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>
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<tr>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td>None</td>
<td>None</td>
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<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzoate</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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</tr>
<tr>
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<td>Ethylbenzene</td>
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<td>None</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>1,2-dichloroethene</td>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
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<td>None</td>
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<tr>
<td>Carbon tetrachloride</td>
<td></td>
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<td>None</td>
<td>None</td>
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<tr>
<td>Chloroform</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>Total VOC's</td>
<td></td>
<td></td>
<td>None</td>
<td>5 mg/kg</td>
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### Comments:
- __________
- __________
- __________

### Attachments:
- __________
- __________
### Geologic Setting

<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>
</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

### Hydrogeologic Setting

**Is more than 1 aquifer present?**

- No
- Yes (number): ____________
- 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>low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</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></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td>low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>high</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

**K range (ft/day)**

- Measured using: Slug Test, Laboratory, Field data

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

**Transmissivity (ft²/day)**

- Measured using: Slug Test, Laboratory, Field data

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________

### Attachments:

- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Electrical Resistance</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: 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

Treatment Cell Design:

Size of target zone (ft2): 12833 | Unknown | (90 x 155 ft)

Thickness of target zone (ft): 12 | Unknown

Depth to top of target zone (ft bgs): 2 | Unknown

Thickness of target zone below water table (ft): 10 | Unknown

Number of energy delivery points: 62 | Unknown

Number of extraction points: 22 | Unknown

Temperature Profile:

Initial formation temperature (deg C): 18 | Unknown

Maximum representative formation temperature (deg C): 91 | Unknown

Time to reach maximum representative temperature (days): 136 | Unknown

Duration of treatment at representative temperature (days): 102 | 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: 5429 | Unknown

Total: 5429 | 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:**

General comments on the thermal application:

- 95% reduction in total VOCs in GW. 80% reduction in total VOCs in soil.

Lessons Learned

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: 120 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
### General Site Assessment Data

**Facility ID:** 0075

**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>
<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>Chlorinated Solvents</td>
<td></td>
<td></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-dichloroethylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
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<td>Trichloroethylene</td>
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<td>Toluene</td>
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<td>None</td>
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<td>Vinyl Chloride</td>
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</tr>
<tr>
<td>Other</td>
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<td>Benzene</td>
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<td>Jet Fuel</td>
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<td>Xylene</td>
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**Comments:**

- __________
- __________
- __________

**Attachments:**

- __________
- __________
<table>
<thead>
<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>
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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>
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<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<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: ______ ft amsl ______ Unknown

Aquifer Characteristics:

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

<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>
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</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>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>

Comments:   

Attachments:   
**Thermal Treatment - Design**

Thermal treatment:  
- Conductive
- 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 layers of lower permeability material
- Largely permeable 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): | 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): | 105 |
| 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: | Unknown |
| Total: | 69000 | lb | kg | Unknown |

**Comments:**

23 foot spacing

**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: 186 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:
**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:** 120 d

- **Type of Site:** Non-DOD DoD

- **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:** 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
### General Site Assessment Data

**Thickmess (ft.):**

**Unknown**

**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>Tetrachloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Gasoline</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetracloroethene</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-trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
<td>TBA</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethene</td>
<td>TBA</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>
</tbody>
</table>

**Number inside treatment zone:**

**Number outside treatment zone:**

**Number of relevant monitoring wells with groundwater 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:**

**Number of relevant soil borings with pre-treatment data:**

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

**Number of relevant wells relative to treatment zone:**

- **Pre-treatment:**
  - In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

- **Post-treatment:**
  - In: __________
  - Upgradient: __________
  - Downgradient: __________
  - Crossgradient: __________

**Length (parallel to flow direction)(ft.):**

**Width (ft.):**

**Thickness (ft.):**

**Facility ID#:** 0576

**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:**

- Low: ________ ft
- High: ________ ft

**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:**
  - __________

- **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: __________

**Facility ID#:** 0576

**Comments:**

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

**Attachments:**

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal Treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
<th>Steam</th>
<th>3 phase</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
</tr>
</thead>
</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: ________  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

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:

23 foot spacing

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: 

- 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: _________
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: 10/1/2004 End of Test: 2/14/2004 Duration: 137 d
Type of Site: Non-DOD DoD

Facility Name: Cape Fear Wood Preserving
Address: 1219 South Reilly Rd
City, State, Zip Code: Fayetteville, NC
OU# or Site #: ________________

Primary point of contact: Chad Northington
Organization: WRS Infrastructure and Environment, Inc.
Address: 221 Hobs St., Suite 108
City, State, Zip Code: Tampa, FL 33619
Phone #: 813-383-0309 email: cnorthington@wrsie.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

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacted Zone</td>
<td>Length (parallel to flow direction)(ft.):</td>
</tr>
<tr>
<td>Map attachment</td>
<td>Impact zone as defined by documentation</td>
</tr>
</tbody>
</table>

### Monitor Wells

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of relevant monitoring wells with groundwater data:</td>
<td>Pre-treatment:</td>
</tr>
<tr>
<td>Number of wells relative to treatment zone:</td>
<td>Pre-treatment</td>
</tr>
<tr>
<td>Post-treatment</td>
<td>In:</td>
</tr>
</tbody>
</table>

### Soil Borings

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of relevant soil borings with pre-treatment data:</td>
<td>Number inside treatment zone:</td>
</tr>
<tr>
<td>Number of relevant soil borings with post-treatment data:</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>
<th>Average Post-treatment Concentration per Chemical</th>
</tr>
</thead>
<tbody>
<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></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphtalene</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>
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<td>1,1-dichloroethane</td>
<td>Ethylbenzene</td>
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</tr>
<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>
</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>
</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

Estimates DNAPL of 9159 to 26170 lbs
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>
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<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: | 0 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: | | |
| low | | |
| high | | |

| Transmissivity (ft²/day): | Measured using: | | |
| low | | |
| high | | |

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
</table>
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

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

Treatment Cell Design:  
- Hydraulic Control
- Yes
- No

Size of target zone (ft²):  

Thickness of target zone (ft):  

Depth to top of target zone (ft bgs):  

Thicknness 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:  

Comments:  

Attachments:  

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

**Facility ID#: 0578**

### Performance

**Remediation Goal:**
- In Groundwater: Total PAH SPLP = <100 ug/L Naphthalene, <500 ug/L Phenol, <2 times 2L std for all other compounds
- In Soil: Total PAH = 800 mg/kg

**Was the Remediation Goal Achieved:**
- In Groundwater: No
- In Soil: No

**General comments on the thermal application:**

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

**Lessons Learned**

---

### Problems associated with viscous NAPL clogging system

<table>
<thead>
<tr>
<th>Energy</th>
<th>Total Energy Used: 269481.77 kWhr</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: 310 kWhr/m³</td>
<td>kWhr/m³</td>
<td>kWhr/yd³</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other energy: Please note other energy:</td>
<td>kWhr/m³</td>
<td>kWhr/yd³</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Total Project Cost: 500000</th>
<th>Consultant Cost:</th>
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<tbody>
<tr>
<td></td>
<td>Thermal Vendor Cost: 160000</td>
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<tr>
<td></td>
<td>Energy Cost: m³ yd³</td>
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<tr>
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<td>Other Cost 1:</td>
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<td>Other Cost 2:</td>
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<td></td>
<td>Other Cost 3:</td>
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</tr>
<tr>
<td></td>
<td>Please note other cost:</td>
<td>Other Cost 1:</td>
</tr>
<tr>
<td></td>
<td>Other Cost 2:</td>
<td>Other Cost 3:</td>
</tr>
<tr>
<td>General Site Information</td>
<td>Facility ID#: 0580</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------</td>
<td></td>
</tr>
</tbody>
</table>

- **File Analyzed By:** JT PD
- **Date:** 9/28/2006
- **Type of treatment:** Conductive, Steam, ERH, Other
- **Type of Contaminant:** X Chlorinated Solvents, Petroleum Hydrocarbons, Pesticides, Wood Treating, Other
- **Treatment Status:** Active, Post
- **Type of Test:** Pilot Test, Full Scale System
- **Start of Test:** 10/3/2001
- **End of Test:** 7/8/2002
- **Duration:** 79 days

- **Facility Name:** Charleston Naval Complex
- **Address:** Charleston Naval Complex, Charleston, South Carolina 29410
- **OU# or Site #:** AOC 607 in zone F
- **Primary point of contact:** David Scaturo
  - **Organization:** SC Dept. of Health and Environmental Control
  - **Address:** SC Dept. of Health and Environmental Control, Charleston, South Carolina 29410
  - **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:** CH2M Hill, Charleston, South Carolina 29410
  - **Phone #:** 352-335-5877, ext 52280
  - **Email:** dean.williamson@ch2m.com

**QA/QC**

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

**Facility ID:** 0050

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 245
- Width (ft.): 150
- 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: 25
  - Post-treatment: 45
- Number of wells relative to treatment zone:
  - Pre-treatment upgradient: __________
  - Pre-treatment downgradient: __________
  - Pre-treatment crossgradient: __________
  - Post-treatment upgradient: __________
  - Post-treatment downgradient: __________
  - Post-treatment crossgradient: __________

**Soil Borings:**
- Number of relevant soil borings with post-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>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></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>1 mg/L</td>
<td>None</td>
<td>None</td>
<td>0.1 mg/L</td>
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<tr>
<td>Tetrachloroethene</td>
<td></td>
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<td>5 mg/L</td>
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<td>1,1-dichloroethene</td>
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<td>0.001 mg/L</td>
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<td>0.01 mg/L</td>
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<td>cis-1,2-dichloroethene</td>
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<td>0.5 mg/L</td>
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<td>0.005 mg/L</td>
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<td>0.01 mg/L</td>
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<td>1,1-dichloroethane</td>
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<td>None</td>
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<td>1,1,2-trichloroethane</td>
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<td>None</td>
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<td>None</td>
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<tr>
<td>Vinyl Chloride</td>
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<td></td>
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<td>1,2-DCI total</td>
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<td>Hydrocarbon</td>
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<td>0.001 mg/L</td>
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<td>0.1 mg/L</td>
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</table>

**Comments:**

**Attachments:**
### Hydrogeologic Conceptual Model

**Facility ID#: 0580**

<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 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>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 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:** ~8 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): 2 2 2
    - high value (ft bgs): 4 4 4
    - Unknown: _____________ _____________ _____________
  - **Flow direction** NE
  - **Horizontal hydraulic gradient (feet/foot):** 0.0107 - 0.0133 0.0133 Unknown
  - **Vertical hydraulic gradient (feet/foot):** see attachment

- **K range (ft/day):**
  - Measured using: Slug Test Laboratory Field data
  - low 0.194 0.45 0.0083 _____________ Unknown
  - high 1.89 1.25 0.027
  - **Transmissivity (ft2/day):**
    - Measured using: Slug Test Laboratory Field data
    - low _____________ _____________ _____________ X Unknown
    - 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

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conduction</th>
<th>Electrical Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td></td>
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<table>
<thead>
<tr>
<th>3 phase</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
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</table>

<table>
<thead>
<tr>
<th>Steam</th>
<th>Steam + air</th>
<th>Steam + O2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Other (describe)</th>
</tr>
</thead>
<tbody>
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</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
<th>Pilot test</th>
<th>X Full-scale System</th>
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<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Geology of Treatment Zone:</th>
<th>Relatively homogeneous and permeable unconsolidated sediments</th>
<th>Relatively homogenous and impermeable unconsolidated sediments</th>
</tr>
</thead>
<tbody>
<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>X Vadose only</th>
<th>Both (Saturated and Vadose zones)</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>10/3/2001</th>
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</thead>
<tbody>
<tr>
<td>Duration:</td>
<td>278 d</td>
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<table>
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<tr>
<th>Hydraulic Control</th>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</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>
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<tbody>
<tr>
<td></td>
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Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1: Jan-03 35.6

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>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&quot; ground rods, 66 to 12 ft and 244 to 10 ft; 12 8&quot; steel piles; 6 geoprobe electrodes (2&quot;)</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

X Performance

Remediation Goal:

X In Groundwater: 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.

In Soil:

Was the Remediation Goal Achieved:

X In Groundwater

Comment: No

In Soil

Comment:

General comments on the thermal application:

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.

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

X 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: ___________________ kWhr/m³ __________________ kWhr/yd³

X Cost

Total Project Cost: 1,274,000 total

Consultant Cost:

Thermal Vendor Cost:

Energy Cost: ___________________ m³ __________________ yd³

Other Cost 1: 50,000

Other Cost 2:

Other Cost 3:

Please note other cost: X Other Cost 1: monitoring

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
- 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

City, State, Zip Code: Fargo, ND

OU# or Site #: ______________

Primary Point of Contact: Joyce Ackerman

Organization: EPA

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

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

- **Facility ID:** 002

#### 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: __________
- 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>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>Trichloroethene</td>
<td>BTEX</td>
<td>None</td>
<td>None</td>
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<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>1,1-dichloroethene</td>
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<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>o-xylene</td>
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<td>1,1,2-trichloroethane</td>
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<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
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#### Comments:

- __________
- __________
- __________
- __________

#### Attachments:
- __________
- __________
- __________
- __________
### Hydrogeologic Conceptual Model

**Facility ID#: 0582**

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
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<tbody>
<tr>
<td>Vadose Zone:</td>
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<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>
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<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
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<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td></td>
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<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: __________ ft amsl  __________ Unknown

<table>
<thead>
<tr>
<th>Aquifer Characteristics:</th>
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</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>
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</tr>
<tr>
<td>low value (ft bgs):</td>
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<tr>
<td>high value (ft bgs):</td>
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<td>7</td>
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<tr>
<td>Unknown:</td>
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<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 |
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<thead>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>high</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

- Transmissivity (ft²/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>high</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Attachment:**

- Conductivity - 5000 uS/cm

**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  
- 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:

<table>
<thead>
<tr>
<th>Size of target zone (ft^2):</th>
<th>10300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>56</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>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>55</td>
</tr>
<tr>
<td>Number of extraction points:</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 |

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: | 5188 |

Comments:

Treated volume of 13800 yd³

Attachments:

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

Remediation Goal:

- In Groundwater: Total VOCs of 1 mg/L
- In Soil: PCE = 3 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment: 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:

- Total energy applied to treatment zone: 2.8 mW-hrs
- Other energy: ____________ 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: Accutech demo

City, State, Zip Code: Somerville, NJ

Primary point of contact: EPA 540/AR-937509 July 1993

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.): __________ 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: _______Upgrade: _______Downgrad: _______Crossgrad: _______
    - Post-treatment In: _______Upgrade: _______Downgrad: _______Crossgrad: _______

- **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>Hexane</td>
<td>Cross-49</td>
<td>10 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>1 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>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>
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<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>n-xylene</td>
<td></td>
<td>None</td>
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<td>1,1,2-trichloroethene</td>
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<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
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<td></td>
<td>DCE</td>
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<td>1 mg/L</td>
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<td></td>
<td></td>
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<td>None</td>
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</tbody>
</table>

**Comments:**

- Additional notes or details about the assessment data.

**Attachments:**

- Additional supporting documents or references related to the site assessment.
Geology:  

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

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: ___________  
- 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

**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

**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>
</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
- In vapor stream: ___ lb ___ kg
- Total: ___ 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

____________________________
____________________________
____________________________
____________________________
____________________________

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: ___________________________
<table>
<thead>
<tr>
<th>General Site Information</th>
<th>Facility ID#: 0587</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Analyzed By: JT PD</td>
<td>Date: 9/13/2006</td>
</tr>
<tr>
<td>Type of treatment: Conductive Steam ERH Other:</td>
<td></td>
</tr>
<tr>
<td>Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
<td></td>
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<tr>
<td>Treatment Status: Active Post</td>
<td></td>
</tr>
<tr>
<td>Type of Test: Pilot Test Full Scale System</td>
<td></td>
</tr>
<tr>
<td>Start of Test: 2001</td>
<td>End of Test:</td>
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<tr>
<td>Type of Site: Non-DOD DoD</td>
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</tr>
<tr>
<td>Facility Name: Northern NJ</td>
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</tr>
<tr>
<td>Address:</td>
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</tr>
<tr>
<td>City, State, Zip Code: NJ</td>
<td></td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td></td>
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<tr>
<td>Primary point of contact: Paper by Denis M. Conley, et al</td>
<td></td>
</tr>
<tr>
<td>Organization: Haley &amp; Aldrich</td>
<td></td>
</tr>
<tr>
<td>Address: 200 town Centre Drive, Suite 2</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code: Rochester, NY 14623</td>
<td></td>
</tr>
<tr>
<td>Phone #: 585-359-9000</td>
<td>email: <a href="mailto:dconley@haleyaldrich.com">dconley@haleyaldrich.com</a></td>
</tr>
<tr>
<td>Other contacts or vendors who worked on site: None</td>
<td></td>
</tr>
<tr>
<td>Point of contact:</td>
<td></td>
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<tr>
<td>Type: Vendor, Consultant Vendor, Technical Applications Other</td>
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<td>Organization:</td>
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<tr>
<td>City, State, Zip Code:</td>
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</tr>
<tr>
<td>Phone #:</td>
<td>email:</td>
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<table>
<thead>
<tr>
<th>QA/QC</th>
</tr>
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<tbody>
<tr>
<td>Characteristics of Interest</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>
</tr>
</tbody>
</table>
### General Site Assessment Data

- **Facility ID:** 0587

#### Impacted Zone

- **Length (parallel to flow direction):** __________
- **Width:** __________
- **Thickness:** __________

  - [ ] 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>Chemical</th>
<th>Chlorinated Solvents</th>
<th>Polycyclic Aromatic 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>Trichloroethylene</td>
<td>Benzene</td>
<td>Crossgradient</td>
<td>None</td>
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<td>None</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
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<tr>
<td>cis-1,2-dichloroethylene</td>
<td>Benzene</td>
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<td>None</td>
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<td>trans-1,2-dichloroethylene</td>
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<td>m,p-xylene</td>
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<td>None</td>
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<td>1,1,1-trichloroethylene</td>
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<td>None</td>
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<td>Vinyl Chloride</td>
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</table>

#### Comments:

- ____________________________________________________________________
- ____________________________________________________________________
- ____________________________________________________________________
- ____________________________________________________________________

#### Attachments:

- ____________________________________________________________________
- ____________________________________________________________________
### Hydrogeologic Conceptual Model

#### Facility ID:
0587

<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>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>Saturated Zone:</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>
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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>
<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 (assume single aquifer)

#### 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>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>high value (ft bgs):</td>
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<td>Unknown:</td>
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</tbody>
</table>

| Flow direction |  |  |  |

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
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</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>
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<tbody>
<tr>
<td>low 2.84</td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
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</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></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
<td></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:  
- 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-beded lenses of lower permeability material
- Largely impermeable sediments with inter-beded layers of higher permeability material
- Competent, but fractured rock (i.e. crystalline rock)
- Weathered bedrock, limestone, sandstone

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

Start of Thermal Test:  
- 2001
- Duration: ~100 hours (~4 days)

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>481</th>
<th>Unknown</th>
<th>( x ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>x Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>x Unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>x Unknown</td>
<td></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): | 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 |

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:  

| 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:

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.
General comments on the thermal application:

---

Was the Remediation Goal Achieved:

   In Groundwater:
   Comment: ________________________________

   In Soil:
   Comment: ________________________________

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: ________________________________

Please note other cost: ________________________________

Other Cost 1: ________________________________

Other Cost 2: ________________________________

Other Cost 3: ______________
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<th>General Site Information</th>
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<tbody>
<tr>
<td>File Analyzed By: JT PD</td>
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<tr>
<td>Type of treatment:</td>
</tr>
<tr>
<td>Conductive Steam ERH</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
</tr>
<tr>
<td>Chlorinated Solvents</td>
</tr>
<tr>
<td>Petroleum Hydrocarbons</td>
</tr>
<tr>
<td>Pesticides</td>
</tr>
<tr>
<td>Wood Treating Other:</td>
</tr>
<tr>
<td>Treatment Status:</td>
</tr>
<tr>
<td>Active Post</td>
</tr>
<tr>
<td>Type of Test:</td>
</tr>
<tr>
<td>Pilot Test Full Scale System</td>
</tr>
<tr>
<td>Start of Test:</td>
</tr>
<tr>
<td>End of Test:</td>
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<tr>
<td>Duration:</td>
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<td>Type of Site:</td>
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<tr>
<td>Non-DOD DoD</td>
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<table>
<thead>
<tr>
<th>Facility Name: Paterson, NJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>City, State, Zip Code:</td>
</tr>
<tr>
<td>OU# or Site #:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary point of contact:</th>
</tr>
</thead>
<tbody>
<tr>
<td>David Fleming</td>
</tr>
<tr>
<td>Organization: TRS</td>
</tr>
<tr>
<td>Address: 7421-A Warren SE</td>
</tr>
<tr>
<td>City, State, Zip Code: Snoqualmie, WA 98065</td>
</tr>
<tr>
<td>Phone #: 425-396-4266</td>
</tr>
<tr>
<td>email: <a href="mailto:dfleming@thermalrs.com">dfleming@thermalrs.com</a></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Other contacts or vendors who worked on site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point of contact: Mark Bowen</td>
</tr>
<tr>
<td>Type: Vendor, Consultant Other</td>
</tr>
<tr>
<td>Organization: Anderson Mulholland</td>
</tr>
<tr>
<td>Address:</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
</tr>
<tr>
<td>Phone #: 914-251-0400 x307</td>
</tr>
<tr>
<td>email: <a href="mailto:mbowen@amaiconsult.com">mbowen@amaiconsult.com</a></td>
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<thead>
<tr>
<th>QA/QC</th>
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</thead>
<tbody>
<tr>
<td>Characteristics of Interest</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

Facility ID: 099

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 Boring:
- 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>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossover</td>
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<tr>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<td>None</td>
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<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>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>
</tr>
<tr>
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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>None</td>
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<tr>
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<td>1,1,1-trichloroethane</td>
<td>α-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></td>
<td>Vinyl Chloride</td>
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<td></td>
<td>None</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Chemicals of Concern

Groundwater (mg/L) | Soil (mg/kg) | Groundwater (mg/L) | Soil (mg/kg)
--- | --- | --- | ---
50 mg/L | 100 mg/kg | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None
None | None | None | None | None | None | None | None

Chemicals of Concern

Comments:

Attachments:
### 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

### 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></td>
<td></td>
</tr>
<tr>
<td>high (ft bgs):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
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</table>

**Flow direction**

TBD

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

TBD

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

TBD

**K range (ft/day)**

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
</table>

**Transmissivity (ft²/day):**

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
</table>

**Measured using:**
- Slug Test
- Laboratory
- Field data

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

**Facility ID#:** 0593

**Unconsolidated Sediments Geology:**
- Weathered bedrock, limestone, sandstone

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

**Attachments:**

**Comments:**

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________
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

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: ___________ 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: 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: Jan-95, End of Test: Apr-95, Duration: 90 d
- Type of Site: Non-DOD, DoD
- 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

**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>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>BTEX</td>
<td>Cross</td>
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<tr>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>Upgrad</td>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
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<td></td>
<td>trans-1,2-dichloroethene</td>
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<td>Vinyl Chloride</td>
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<tr>
<td></td>
<td>Other</td>
<td>None</td>
<td></td>
<td>None</td>
</tr>
</tbody>
</table>

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

### Comments:

- [ ]
- [ ]

### Attachments:

- [ ]
### Hydrogeologic Conceptual Model

**Facility ID#: 0595**

#### Unconsolidated Sediments

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

- 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></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

- 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

[ ] 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 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-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 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: ___________________________ 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

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

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: 10/19/2006
Type of treatment: Conductive Steam ERH Other: ____________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Wood Treating Other: SVOCs
Treatment Status: Active Post
Type of Test: 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): _____
- 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: 4
- Number of relevant soil borings with post-treatment data: 4
- Number inside treatment zone: 4
- Number outside treatment zone: 0

#### 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>
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</thead>
<tbody>
<tr>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<td>Tetrachloroethene</td>
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<td>trans-1,2-dichloroethene</td>
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<tr>
<td>Vinyl Chloride</td>
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<td>None</td>
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<td>None</td>
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</table>

#### Comments:

- None

#### Attachments:

- None
### 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>
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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>
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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 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water:</td>
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<td>low value (ft bgs):</td>
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<td>high value (ft bgs):</td>
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<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
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</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: Unknown
  - 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:

<table>
<thead>
<tr>
<th>Facility ID#: 0600</th>
</tr>
</thead>
</table>

### Attachments:

- Comments: ____________________________________________________________________________________________

- Attachments: ________________________________________________________________________________________
Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
- 3 phase AC power
- 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 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

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

Hydraulic Cell Design:

Size of target zone (ft2):  
- 720
- Unknown

Thickness of target zone (ft):  
- 23
- 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:  
- 22
- Unknown

Number of extraction points:  
- 6
- Unknown

Initial formation temperature (deg C):  
- 18
- Unknown

Maximum representative formation temperature (deg C):  
- 90
- Unknown

Time to reach maximum representative temperature (days):  
- 24
- Unknown

Duration of treatment at representative temperature (days):  
- 9
- Unknown

Formation temperature immediately post-treatment:  
- 85

Formation temperature post-treatment monitoring event 1:  
- 55 days 25

Duration of post-treatment monitoring (days):  
- 55 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.
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:  
- May-95
- Duration: 29 d

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft²): 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: 20
Number of extraction points: 6

Temperature Profile:

Initial formation temperature (deg C): 22
Maximum representative formation temperature (deg C): 100
Time to reach maximum representative temperature (days): 27
Duration of treatment at representative temperature (days): 9

Formation temperature immediately post-treatment:

Date | Temperature (deg C)
--- | ---
150 |

Formation temperature post-treatment monitoring event 1:

Date | Temperature (deg C)
--- | ---
55 days | 80

Duration of post-treatment monitoring (days):

- 55 days

Mass of contaminant removed:

- Via liquid pumping: [Unknown] lb [Unknown] kg
- In vapor stream: [Unknown] lb [Unknown] kg
- Total: [Unknown] lb [Unknown] kg

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

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

Energy

Total Energy Used: 75000 kWhr x 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: 151 /cubic yard

- Consultant Cost: ____________________________
- Thermal Vendor Cost: ____________________________
- Energy Cost: 14.87 m³ x 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: Jan-91
End of Test: 
Duration: 

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: IL EPA
City, State, Zip Code: Springfield, IL 62794-9276
Phone #: 630-836-1700
email: 

Other contacts or vendors who worked on site: 
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 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: __________
- Post-treatment: __________
- Number of relevant 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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<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
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<tr>
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<td>Vinyl Chloride</td>
<td></td>
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**Groundwater (mg/L) Soil (mg/kg)**

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<th>Soil (mg/kg)</th>
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<tr>
<td>Geology: Unconsolidated Sediments</td>
<td>Zone</td>
<td>Vadose Zone:</td>
<td>Saturated Zone:</td>
<td></td>
</tr>
<tr>
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<td>Relatively homogeneous and permeable unconsolidated sediments</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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<tr>
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<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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</tr>
<tr>
<td></td>
<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>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
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<td></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>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weathered bedrock, limestone, sandstone</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

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: _______ _______ _______ _______

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
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<td></td>
</tr>
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<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

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 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:
- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: Jan-91

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:

1st Phase - initiated 1991 and expanded in 1993. The system was closed via EPA-approval

Attachments:
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:
- Other Cost 1:
- Other Cost 2:
- Other Cost 3:
- Please note other cost:

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  x  ERH  ___ Other:  ________________
Type of Contaminant:  x  Chlorinated Solvents  ___ Petroleum Hydrocarbons  ___ Pesticides
___ Wood Treating  ___ Other:  ________________
Treatment Status:  ___ Active  ___ Post
Type of Test:  ___ Pilot Test  x  Full Scale System
Type of Site:  x  Non-DOD  ___ DoD

x  Facility Name:  Former AT&T Skokie Works
City, State, Zip Code:  Skokie, IL
OU# or Site #:  __________________________

x  Primary point of contact:  Dennis Sopcich
Organization:  ENSR Corporation
City, State, Zip Code:  __________________________
Phone #:  630-836-1700  email:  __________________________

x  Other contacts or vendors who worked on site  ___ None
Point of contact:  Stan Komperda
Type:  ___ Vendor, Consultant  ___ Vendor, Technical Applications  ___ Other  ________________
Organization:  IL EPA
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.):** Unknown
- **Width (ft.):** Unknown
- **Thickness (ft.):** Unknown
- **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
- **Pre-treatment:**
  - **Number of wells relative to treatment zone:**
    - **Upgradient:**
    - **Downgradient:**
    - **Crossgradient:**
- **Post-treatment:**
  - **Number of relevant monitoring wells with groundwater data:**
    - **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></td>
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<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<td>Hexane</td>
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<td>1 mg/L</td>
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<td>Tetrachloroethene</td>
<td>Jet fuel</td>
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</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:**

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<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>
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</tr>
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<td>☒ Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
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<td>☒ Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
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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>Saturated Zone:</td>
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</tr>
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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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**Ground surface elevation based on wells in or adjacent to treatment zone:** 2 ft amsl  ☒ Unknown

**Aquifer Characteristics:**

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<th>Yes (number):</th>
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</tr>
<tr>
<td>high value (ft bgs):</td>
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<td>Flow direction</td>
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<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
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<td>Laboratory</td>
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<td>high</td>
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<td>Transmissivity (ft²/day):</td>
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<tr>
<td>high</td>
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**Comments:**

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________
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**Attachments:**

___________________________________________________________________________________________
Thermal Treatment - Design

- Thermal treatment: Conductive
  - Electrical Resistance: AC power, DC power
  - 3 phase
  - 6 phase
  - 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)
  - 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

- 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
  - In vapor stream: 27202 lb, kg
  - Total: 66850 lb, kg

- 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.
Remediation Goal:

- In Groundwater: Reach risk-based target cleanup levels (RBTCs)
  - trans-1,2-DCE - 70,000 ug/L
  - cis-1,2-DCE - 35,500 ug/L
  - 1,1,1-TCA - 9,650 ug/L
  - TCE - 17,500 ug/L
  - 1,1-DCA - 175,000 ug/L
  - Vinyl Chloride - 945 ug/L

- In Soil

Was the Remediation Goal Achieved:

- In Groundwater
- In Soil

Comment:
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________

General comments on the thermal application:

Site was closed after reaching the RBTCs via IL EPA approval.

Lessons Learned
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________

Energy

- Total Energy Used: ___ kWhr ___ kWhr/m³ ___ kWhr/yd³
- Total energy applied to treatment zone: ___ kWhr/m² ___ 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

File Analyzed By: JT PD ___ 

Type of treatment: Conductive Steam ERH Other: ______________

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

Treatment Status: ______________

Type of Test: Pilot Test 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

Primary point of contact: RT Environmental Engineering

Organization: ______________

Address: 215 W. Church Rd

City, State, Zip Code: King of Prussia, PA 19406

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

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 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

____ Good temperature profile vs. time information

____ Groundwater elevations

____ Hydraulic Conductivity information

____ Good pre- and post-treatment soil data

____ Flux assessment

____ Geologic cross-section
### 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>Crosscut</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>Jet Fuel</td>
<td>Arclor 1254</td>
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<td>Arclor 1260</td>
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<td>1,1,2-Trichloroethane</td>
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<tr>
<td>Vinyl Chloride</td>
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<tr>
<td>Trichloroethene</td>
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<td>Chlorinated Solvents</td>
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<tr>
<td>Petroleum Hydrocarbons</td>
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<td>Other</td>
<td></td>
<td>none</td>
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</tbody>
</table>

### 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 well borings with post-treatment data: __________
- Number inside treatment zone: __________
- Number outside treatment zone: __________

### General Site Assessment Data

- Chemicals of Concern
  - Benzene
  - Crosscut
  - Arclor 1254
  - Arclor 1260
  - PCBs
  - Toluene
  - Ethylbenzene
  - m,p-xylene
  - o-xylene
  - 1,1,1-Trichloroethane
  - 1,1,2-Trichloroethane
  - Vinyl Chloride
  - Trichloroethene

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

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

### Comments:

- __________
- __________
- __________

### 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>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
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<td></td>
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<tr>
<td>Saturated Zone</td>
<td>x Relatively homogeneous and permeable unconsolidated sediments</td>
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</tr>
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</tbody>
</table>

### 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): x

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<th>Aquifer</th>
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<th>Flow direction</th>
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<td>1</td>
<td>low value (ft bgs): 22</td>
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<td></td>
<td>high value (ft bgs): 24</td>
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<tr>
<td></td>
<td>Unknown:</td>
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</table>

- **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.
Thermal Treatment - Design

Facility ID: 0620

Thermal treatment:  

| Conductive |  | Thermal Blankets |  |
|  |  |  |  |

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-96  

Duration: 36 hours  

Hydraulic Control  

Yes  

No  

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  

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: 60.2  

lb  

kg  

Unknown  

Total:  

lb  

kg  

Unknown  

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 - 38 hours (2/6/96 - 2/8/96); 3B - 39 hours (2/8/96 - 2/10/96)  

Estimated & report amounts removed total  

Attachments:  

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

Remediation Goal:

___ In Groundwater:

___ 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

x Energy

Total Energy Used: _______ kWhr ______ kWhr/m³ ______ kWhr/yd³

x Total energy applied to treatment zone: 5,5 GJ* ______ kWhr/m³ ______ kWhr/yd³

___ Other energy: ______ kWhr/m³ ______ kWhr/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

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<th>Value</th>
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<td>JT PD</td>
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<tr>
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<td>11/4/2006</td>
</tr>
<tr>
<td>Type of treatment</td>
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<td>Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
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<td>Treatment Status</td>
<td>Active Post</td>
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<td>Type of Test</td>
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<tr>
<td>Start of Test</td>
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<td>End of Test</td>
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<td>Duration</td>
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<tr>
<td>Primary point of contact</td>
<td>Jon Sundquist</td>
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<td>URS</td>
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<tr>
<td>Phone #</td>
<td>716-856-5636</td>
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<tr>
<td>email</td>
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<tr>
<td>Other contacts or vendors who worked on site</td>
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<td>Remedial Bureau E, 12th Floor, 625 Broadway</td>
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<tr>
<td>City, State, Zip Code</td>
<td>Albany, NY 12233-7017</td>
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<tr>
<td>Phone #</td>
<td>518-402-9814</td>
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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
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></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>HCl</td>
<td>Creosote</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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Comments:

Attachments:
### Geology:

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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>
</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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<td>Weathered bedrock, limestone, sandstone</td>
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**Ground surface elevation based on wells in or adjacent to treatment zone:**  
Unknown (a.m.s.l)

---

### 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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<tbody>
<tr>
<td>Aquifer 1</td>
<td></td>
<td></td>
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<td>Aquifer 2</td>
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<td>Aquifer 3</td>
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<table>
<thead>
<tr>
<th>Depth to water:</th>
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<th>high value (ft bgs):</th>
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<tbody>
<tr>
<td></td>
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**Flow direction**

---

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

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

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

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

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<th>Field data</th>
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</tr>
<tr>
<td>high</td>
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**Comments:**

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**Attachments:**

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<th><strong>Thermal Treatment - Design</strong></th>
<th>Facility ID: 0625</th>
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<td><strong>Thermal treatment:</strong></td>
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<tr>
<td>Conductive</td>
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<td>Electrical Resistance</td>
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<tr>
<td>Steam</td>
<td></td>
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<tr>
<td>3 phase</td>
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<td>6 phase</td>
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<td>AC power</td>
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<td>DC power</td>
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<td>Full-scale System</td>
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<td><strong>Geology of Treatment Zone:</strong></td>
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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>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<td>Vadose only</td>
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<td><strong>Attachments:</strong></td>
<td></td>
</tr>
</tbody>
</table>

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

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

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: __________________________
<table>
<thead>
<tr>
<th><strong>General Site Information</strong></th>
<th><strong>Facility ID#: 0635</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>File Analyzed By:</strong> JT PD</td>
<td>Date: 10/26/2006</td>
</tr>
<tr>
<td><strong>Type of treatment:</strong> Conductive steam ERH Other:</td>
<td></td>
</tr>
<tr>
<td><strong>Type of Contaminant:</strong> Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
<td></td>
</tr>
<tr>
<td><strong>Treatment Status:</strong> Active Post</td>
<td></td>
</tr>
<tr>
<td><strong>Type of Test:</strong> Pilot Test Full Scale System</td>
<td></td>
</tr>
<tr>
<td><strong>Start of Test:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>End of Test:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Duration:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type of Site:</strong> Non-DOD DoD</td>
<td></td>
</tr>
</tbody>
</table>

| **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.): __________
  - 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: __________
    - 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>Average Post-treatment Concentration per Chemical:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>BTEX</td>
<td>Crosswind</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<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></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
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<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
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<td>None</td>
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<td>m/p-xylene</td>
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<td>o-xylene</td>
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<td>xylene</td>
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<td>Vinyl Chloride</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>Acetone</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Methylene chloride</td>
<td></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): __________

**5.1 acres - impacted**

**Attachments:**

- 0635

**Comments:**

1.6 acres - impacted
## Geology:

### Zone

<table>
<thead>
<tr>
<th>Vadose Zone:</th>
<th>Relatively homogeneous and permeable unconsolidated sediments</th>
<th>Relatively homogeneous and impermeable unconsolidated sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Largely permeable sediments with inter-beded lenses of lower permeability material</td>
<td>Largely permeable 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>Saturated Zone:</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>Largely permeable sediments with inter-beded lenses of lower permeability material</td>
<td>Largely permeable 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>

### 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>
</table>

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
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</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>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow direction</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
<th></th>
</tr>
</thead>
<tbody>
<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></td>
</tr>
<tr>
<td>High</td>
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<td></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>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

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____________________________________________________________________________________________

Attachments:

____________________________________________________________________________________________

____________________________________________________________________________________________

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____________________________________________________________________________________________

____________________________________________________________________________________________
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: ___________

Yes No

Hydraulic Control

Treatment Cell Design

Size of target zone (ft^2): ___________ 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

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

Comments:

Attachments:

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

**Facility ID#: 0635**

**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:
- 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 Wood Treating Other: 
Treatment Status: Active Post 
Type of Test: Pilot Test Full Scale System 
Start of Test: Jul-04 End of Test: 
Duration: 
Type of Site: Non-DOD DoD

Facility Name: Former Chemical Manufacturing Facility
Address: 
City, State, Zip Code: Brooklyn, 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.):** unknown
- **Width (ft.):** unknown
- **Thickness (ft.):** unknown
- **Impacted zone as defined by documentation:** unknown
- **Alternative method for determining size of impacted zone (See source zone definition attachments):** unknown
- **Map attachment:** unknown

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: none
- Number of relevant monitoring wells with post-treatment data: unknown
- Number of relevant monitoring wells with pre-treatment data: unknown

**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></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdike</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>
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<td>None</td>
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<td>1,2-dichloroethane</td>
<td>m/p-xylene</td>
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<td>Acetone</td>
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<td>Methylene chloride</td>
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<td>None</td>
</tr>
<tr>
<td>1.6 acres · impacted</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

1.6 acres · impacted

**Attachments:**

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

1.6 acres · impacted
### 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>
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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>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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<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>
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<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>
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<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
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#### Transmissivity (ft²/day)

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<th>Measured using</th>
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<th>Field data</th>
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</tr>
</thead>
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<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
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#### Comments:

____________________________________________________________________________________________

____________________________________________________________________________________________

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____________________________________________________________________________________________

Attachments:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________
<table>
<thead>
<tr>
<th>Facility ID#: 0638</th>
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### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>__ Conductive</th>
<th>____________________________</th>
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<tbody>
<tr>
<td></td>
<td>__ Electrical Resistance</td>
<td>____________________________</td>
</tr>
<tr>
<td></td>
<td>__ 3 phase</td>
<td>__ 6 phase</td>
</tr>
<tr>
<td></td>
<td>__Steam</td>
<td>__ Full</td>
</tr>
<tr>
<td></td>
<td>__Steam</td>
<td>__ Steam + air</td>
</tr>
<tr>
<td></td>
<td>__ Other (describe)</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>
<th>__ Largely permeable sediments with inter-bedded lenses of lower permeability material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>__ Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>__ Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>__ Largely impermeable sediments with inter-bedded layers of higher permeability material</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>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>Jul-04</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Duration:</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Hydraulic Control</th>
<th>__ Yes</th>
<th>__ No</th>
</tr>
</thead>
</table>

### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thickness of target zone (ft):</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Depth to top of target zone (ft bgs):</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thickness of target zone below water table (ft):</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Number of energy delivery points:</th>
<th>47</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Number of extraction points:</th>
<th>44</th>
<th>Unknown</th>
</tr>
</thead>
</table>

### Temperature Profile:

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Maximum representative formation temperature (deg C):</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Time to reach maximum representative temperature (days):</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Duration of treatment at representative temperature (days):</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Formation temperature immediately post-treatment:</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Formation temperature post-treatment monitoring event 1:</th>
<th>____________________________</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Duration of post-treatment monitoring (days):</th>
<th>____________________________</th>
</tr>
</thead>
</table>

### Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>In vapor stream:</th>
<th>____________________________</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Total:</th>
<th>____________________________</th>
</tr>
</thead>
</table>

### Comments:

<table>
<thead>
<tr>
<th>Attachments:</th>
<th>____________________________</th>
</tr>
</thead>
</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: ___________ ___________ ___________
- 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 Date: 5/11/2005
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: 8/26/1996 End of Test: 9/25/1996 Duration: 30 d 
Type of Site: Non-DOD DoD 

Facility Name: Niagara Falls International Airport Air Reserve

Address: 
City, State, Zip Code: Niagara Falls, NY
OU# or Site #: Site 10

Primary point of contact: Gerald Hromowyk
Organization: Air Reserve
Address: 2405 Franklin Drive
City, State, Zip Code: Niagara Falls, NY 14304-5063
Phone #: 716-236-3126 email: gerald.hromowyk@niagarafalls.af.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

#### Thickness (ft):

#### Impacted zone as defined by documentation:

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

- Map attachment

#### In:

<table>
<thead>
<tr>
<th>Chemical</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><strong>Groundwater (mg/L)</strong></td>
<td><strong>Soil (mg/kg)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>1,1,2,2-tetrachloroethane</td>
<td>Jet Fuel</td>
<td>None</td>
<td>1 mg/L</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>Chloroform</td>
<td>Hexane</td>
<td>Jet Fuel</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Toluene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>0.5 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>0.5 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,2,2-trichloroethane</td>
<td>1,1,1-trichloroethane</td>
<td>MEK (2-butanone)</td>
<td>None</td>
<td>0.05 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>acetone</td>
<td>MEK (2-butanone)</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Toluene</td>
<td>MEK (2-butanone)</td>
<td>None</td>
<td>0.05 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Toluene</td>
<td>MEK (2-butanone)</td>
<td>None</td>
<td>0.05 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
<td>Toluene</td>
<td>MEK (2-butanone)</td>
<td>None</td>
<td>0.05 mg/kg</td>
<td>None</td>
</tr>
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<td>Vinyl Chloride</td>
<td>acetone</td>
<td>MEK (2-butanone)</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Toluene</td>
<td>MEK (2-butanone)</td>
<td>None</td>
<td>0.05 mg/kg</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:

[Map attachment]

---

**Facility ID:** 0640

**Number of relevant monitoring wells with groundwater data:**

**Number of relevant monitoring wells with post-treatment data:**

**Number of relevant monitoring wells with pre-treatment data:**

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

**Number of relevant soil borings with pre-treatment data:**

**Number of relevant soil borings with respect to treatment zone:**

---

**Number of relevant wells relative to treatment zone:**

**Number of relevant soil borings with groundwater data:**

**Number of relevant soil borings with pre-treatment data:**

---

**Number of wells relative to treatment zone:**

**Number of wells relative to treatment zone:**

---

**Number of relevant wells relative to treatment zone:**

---

**Number of wells relative to treatment zone:**

---
### 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: __________ 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></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):
- 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 □ 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-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 Duration: 330 d

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>9500</td>
<td>9</td>
<td>1</td>
<td>7.5</td>
<td>20</td>
<td>5</td>
</tr>
</tbody>
</table>

Temperature Profile:

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th>Maximum representative formation temperature (deg C):</th>
<th>Time to reach maximum representative temperature (days):</th>
<th>Duration of treatment at representative temperature (days):</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>82</td>
<td>25</td>
<td>5</td>
</tr>
</tbody>
</table>

Date | Temperature (deg C) |
9/25/1996 | 75 |
10/15/1996 | 40 |

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>lb</td>
<td>lb</td>
<td>lb</td>
</tr>
<tr>
<td>kg</td>
<td>kg</td>
<td>kg</td>
</tr>
</tbody>
</table>

Duration of post-treatment monitoring (days):

Comments:

Attachments:

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

General comments on the thermal application:

Lessons Learned

Energy

Total Energy Used: 336,000 kWhr

Total energy applied to treatment zone: 140,000 kWhr

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 Date: 10/30/2006
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: __________ Duration: 6 months
Type of Site: ___ Non-DOD ___ DoD

Facility Name: Syracuse, NY
Address: __________________________________________________________________________
City, State, Zip Code: Syracuse, NY
OU# or Site #: _________________________________________________________________________

Primary point of contact: Gorm Heron
Organization: TerraTherm
Address: 10 Stevens Road
City, State, Zip Code: Fitchburg, MA 01420
Phone #: 978-343-0300 email: gheron@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

___ 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: __________

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

**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>1,1,1-trichloroethane</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Trichloroethene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>1,1-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>cis-1,2-dichloroethene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2,3-trichloroethene</td>
<td>trans-1,2-dichloroethene</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>1,1-dichloroethene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethane</td>
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<td>None</td>
</tr>
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<td>1,1,1-dichloroethene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
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<td></td>
<td></td>
<td>None</td>
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</tr>
<tr>
<td>1,2-dichloroethene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
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<td></td>
<td>None</td>
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</tr>
<tr>
<td>1,2-dichloroethene</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
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<td></td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
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<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>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>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>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>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
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<td></td>
<td></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>1,2-dichloroethene</td>
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<td>1,1-dichloroethene</td>
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<tr>
<td>1,2-dichloroethene</td>
<td></td>
<td></td>
<td></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
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: 3 ft below grade

Aquifer Characteristics:

Is more than 1 aquifer present? No

Depth to water:
- low value (ft bgs): 1
- high value (ft bgs): 2
- Unknown: 0

Flow direction: south

Horizontal hydraulic gradient (feet/foot): 0.001
Vertical hydraulic gradient (feet/foot): unknown

K range (ft/day):
- Measured using: Slug Test
- Low: 0.1
- High: 1

Transmissivity (ft²/day):
- Measured using: Slug Test
- Low:
- High:

Comments:

Attachments:
Thermal Treatment - Design

Thermal treatment:  
[ ] Conductive  [x] Electrical Resistance

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

Steam

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

[ ] Other (describe)

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 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
[ ] Yes  [ ] No

Treatment Cell Design:
Size of target zone (ft^2):  21870
Thickness of target zone (ft):  18-27
Depth to top of target zone (ft bgs):  0
Thickness of target zone below water table (ft):  17-24
Number of energy delivery points:  241
Number of extraction points:  17 horizontal collectors

Temperature Profile:
Initial formation temperature (deg C):  10  
Maximum representative formation temperature (deg C):  110  
Time to reach maximum representative temperature (days):  200
Duration of treatment at representative temperature (days):  60

Formation temperature immediately post-treatment:
Formation temperature post-treatment monitoring event 1:
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:

Attachments:

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

In Groundwater: 

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: _____________ 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: 4/12/2005
Type of treatment: ___ Conductive ___ 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

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: v84@bechtel.jacobs.org

Other contacts or vendors who worked on site: ___ None
Point of contact: John Sokol
Type: ___ 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

### Impacted Zone:
- Length (parallel to flow direction)(ft.): __600__
- 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

#### 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>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</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>
</tr>
<tr>
<td>1,1-dichloroethene</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>
</tr>
<tr>
<td>1,2,2-trichloroethane</td>
<td>None</td>
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#### Petroleum Hydrocarbons
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<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>Naphthalene</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>
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<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>
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<tr>
<td>o-xylene</td>
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<tr>
<td>Benzene</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>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- ________________________________________________________________________________________________________________________________________
- ________________________________________________________________________________________________________________________________________
- ________________________________________________________________________________________________________________________________________
- ________________________________________________________________________________________________________________________________________
- ________________________________________________________________________________________________________________________________________

## Attachments:

- ___________________________________________________________________
- ___________________________________________________________________
- ___________________________________________________________________
- ___________________________________________________________________
- ___________________________________________________________________
- ___________________________________________________________________
<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 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>
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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  x Unknown

- **Aquifer Characteristics:**
  - **Is more than 1 aquifer present?** No  Yes (number): _____________  x Unknown (assume single aquifer)
  - **Depth to water:**
    - low value (ft bgs): 10
    - high value (ft bgs): 15
    - Unknown: ________

- **Flow direction:** E

- **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:**

intrinsic permeability = 5 darcy (5e-3 cm/s)

**Attachments:**

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________
Thermal Treatment - Design

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

Steam:  
- DUS/HPO
  - 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:  
- Jul-98

Duration:  
- 1 year

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft2):  
- 17000
- Unknown

Thickness of target zone (ft):  
- 35
- Unknown

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

Thickness of target zone below water table (ft):  
- 20
- Unknown

Number of energy delivery points:  
- 19
- Unknown

Number of extraction points:  
- 2
- 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:  
- Unknown

In vapor stream:  
- Unknown

Total:  
- 400

Comments:  

Attachments:  

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Please note other energy:

SteamTech (vendor) published a final report with DOE as Document no. DOE/OR/11-3032, but I could not obtain this document.

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: >1,000,000

  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 ______ Date: 10/18/2006
Type of treatment: ______ Conductive ______ Steam x 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: 10/19/1998 End of Test: 11/20/1998 Duration: 42 d
Type of Site: x Non-DOD ______ DoD ______

x Facility Name: Confidential Midwest
Address: ___________________________________________
City, State, Zip Code: Ohio
OU# or Site #: _____________________________________

x Primary point of contact: Mark Lyverse
Organization: _____________________________________
Address: _________________________________________
City, State, Zip Code: _______________________________
Phone #: __________________________ email: ____________

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

_____ 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.): _
  - 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: _
  - Number of relevant monitoring wells with post-treatment data: _
  - Number of relevant monitoring wells with pre-treatment data: _
- **Soil Borings:**
  - Number of relevant soil borings with post-treatment data: _
  - 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>Crossgradient</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>
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<td>None</td>
<td>None</td>
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<td></td>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td>None</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</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-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>
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<td>None</td>
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<td>1,1,2,2-tetrachloroethane</td>
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<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</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): _

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

**Comments:**
- Estimated 60,000 lbs of TCE in the soil.

**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>
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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>
<tr>
<td>Saturated Zone:</td>
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</tr>
<tr>
<td></td>
<td>✗ Relatively homogeneous and impermeable unconsolidated sediments</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?** 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>-12 (above grade)</td>
<td>S to SE</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Flow direction

- **Flow direction**: S to SE

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

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

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

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

#### K range (ft/day)

<table>
<thead>
<tr>
<th>Measured using</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slug Test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

#### Transmissivity (ft²/day):

<table>
<thead>
<tr>
<th>Measured using</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slug Test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

### Facility ID#

- Facility ID#: 0670

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

- Ground surface elevation based on wells in or adjacent to treatment zone: 474 ft amsl

### Comments:

- Comments:

### Attachments:

- Attachments:

- Attachments:
Thermal Treatment - Design

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

**Steam**
- [x] Steam
- [x] Steam + air
- [x] Steam + O₂
- [x] Other (describe)

**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
- 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
- Both (Saturated and Vadose zones)

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

**Start of Thermal Test:**
- 10/19/1998
- Duration: 42 d

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

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th></th>
<th>Unknown</th>
<th>( _ _ x _ _ ft)</th>
</tr>
</thead>
</table>

| 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): | 12         | 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 |

<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>265 gal</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td>3890</td>
<td>x</td>
<td>lb</td>
<td>kg</td>
</tr>
<tr>
<td>Total:</td>
<td></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.*
Remediation Goal:

- In Groundwater: 98% removal of benzene
- In Soil: 98% removal of benzene

Was the Remediation Goal Achieved:

- In Groundwater: 
  - Comment: 

- In Soil: 
  - Comment: 

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: ___ kWh ___ kWh/m³ ___ kWh/yd³
- Other energy: ___ kWh ___ kWh/m³ ___ kWh/yd³

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: 

Other energy:
- kWhr/m³
- kWhr/yd³

Other energy:
- kWhr/m³
- kWhr/yd³
General Site Information

File Analyzed By: JT x PD _____ Date: 10/30/2006
Type of treatment: _____ Conductive _____ Steam x ERH _____ Other: ________________
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: Jul-06 End of Test: Nov-06 Duration: 138 days
Type of Site: x 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 _____ Vendor, Technical Applications _____ Other: ________________
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**

**Facility ID:** (67)

**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: ___________
- Number of wells 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>Crossdite</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetracloroethene</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>1,000 mg/kg</td>
<td>None</td>
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<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>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-Trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-Trichloroethene</td>
<td>Bromoform</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethene</td>
<td>Vinyl Chloride</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Groundwater (mg/L):**

- None
- 10 mg/kg

**Soil (mg/kg):**

- None
- 10 mg/kg

**Comments:**

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

**Attachments:**

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
### Unconsolidated Sediments

#### 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:**

<table>
<thead>
<tr>
<th></th>
<th>ft amsl</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Aquifer Characteristics:**

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

#### Depth to water:
- **low value (ft bgs):**
  - 18
- **high value (ft bgs):**
  - 24
- **Unknown:**
  - 

#### Flow direction

- ______________________

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

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<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>
<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>

#### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th></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>

---

**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-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: 
- Jul-06

Duration: 
- 138 days

Hydraulic Control: 
- Yes
- No

Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>5800</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thickness of target zone (ft):</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Depth to top of target zone (ft bgs):</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thickness of target zone below water table (ft):</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Number of energy delivery points:</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Number of extraction points:</th>
<th>Unknown</th>
</tr>
</thead>
</table>

Temperature Profile:

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th>15</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Maximum representative formation temperature (deg C):</th>
<th>92</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Time to reach maximum representative temperature (days):</th>
<th>84</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Duration of treatment at representative temperature (days):</th>
<th>28</th>
</tr>
</thead>
</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: 
  - Unknown
- In vapor stream: 
  - Unknown
- Total: 
  - 3390 lb


Date | Temperature (deg C)
--- | ---

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 benzen 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
  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: 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: 5/19/2003 End of Test: varied Duration: varied 
Type of Site: Non-DOD DoD 

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.): 60
- Thickness (ft.): 1

**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:
  - Pre-treatment: __________
  - Post-treatment: 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: 48
- Number of relevant soil borings with post-treatment data: 44
- Number inside treatment zone: 102
- 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>Trichloroethene</td>
<td>None</td>
<td>100 mg/kg</td>
<td>None</td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>1 mg/kg</td>
<td>None</td>
<td>None</td>
<td>0.5 mg/kg</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>
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<td>1,1-dichloroethene</td>
<td>None</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>
<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>
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<tr>
<td>1,2-dichloroethene</td>
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<td>Hexane</td>
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<tr>
<td>Naphthalene</td>
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</tr>
<tr>
<td>Benzene</td>
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<td>None</td>
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</tr>
<tr>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

This treatment area was known as Parking Lot Area 1.

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

- **Facility ID**: 0885

**Impacted Zone**:  
- Length (parallel to flow direction)(ft.): 45  
- Width (ft.): 70  
- Thickness (ft.): 13  
- 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: None

**Soil Borings**:  
- Number of relevant soil borings with pre-treatment data: 17  
- Number of relevant soil borings with post-treatment data: 18  
- Number of soil borings with post-treatment data: 10  
- 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>Hexane</td>
<td>Cross-gradient</td>
<td>None</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethylene</td>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethylene</td>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethylene</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>Methyl vinyl ether</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-trichloroethylene</td>
<td>n-p-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethylene</td>
<td>Vinyl chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
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<td>None</td>
<td>None</td>
<td>None</td>
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</tr>
<tr>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments**:  
This treatment area is known as Parking Lot Area 2.

**Attachments**:  
- Number outside treatment zone:
- Average Pre-treatment Concentration per Chemical: Groundwater (mg/L) Soil (mg/kg)
- Average Post-treatment Concentration per Chemical: Groundwater (mg/L) Soil (mg/kg)
General Site Assessment Data

Impacted Zone:
- Length (parallel to flow direction)(ft.): ___
- 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 relevant monitoring wells with groundwater data: ___

Number of wells relative to treatment zone:
- Pre-treatment: ___
- Post-treatment: ___

Number of wells in: ___
- Upgradient: ___
- Downgradient: ___
- Crossgradient: ___

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: ___

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>Cross</td>
<td>None</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</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>o-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Comments:

This treatment area is known as the Former waste water basin.

Attachments:
### 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>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-beded lenses of lower permeability material |
|                    | Largely impermeable sediments with inter-beded layers of higher permeability material |
|                    | Weathered bedrock, limestone, sandstone          |

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

- **Unconsolidated Sediments**
  - Low value (ft bgs): 30
  - High value (ft bgs): 5
  - Unknown: 0

#### 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): 30
  - High value (ft bgs): 5
  - Unknown: 0

- **Flow direction:** SW

- **Horizontal hydraulic gradient (feet/foot):**
  - Measured using: Slug Test, Laboratory, Field data
  - K range (ft/day): 2.83(10^-5)

- **Vertical hydraulic gradient (feet/foot):**
  - Measured using: Slug Test, Laboratory, Field data
  - K range (ft/day): Unknown

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

### Comments:

* Water was at 3 ft in a perched aquifer at Parking lot Area 1.

### Attachments:

- [Attachment 1](#)
- [Attachment 2](#)
- [Attachment 3](#)
### Thermal Treatment - Design

**Facility ID:** 0685

<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>Steam</td>
<td>Steam + air</td>
</tr>
<tr>
<td>Other (describe)</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>
</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>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated only</td>
</tr>
<tr>
<td>Vadose only</td>
</tr>
<tr>
<td>Both (Saturated and Vadose zones)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>5/19/2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration:</td>
<td>195 days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydraulic Control:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

#### Treatment Cell Design:

<table>
<thead>
<tr>
<th>Size of target zone (ft2):</th>
<th>14187</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>15</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>138</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>36</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>

| Formation temperature immediately post-treatment: |  |
| Formilation 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>

#### Comments:

______________________________
______________________________
______________________________

**Attarments:**

______________________________
______________________________
______________________________

**Note:** When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal treatment:</td>
<td>Conductive</td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot test</td>
</tr>
<tr>
<td>Geology of Treatment Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td>Treatment Target Zone:</td>
<td>Saturated only</td>
</tr>
<tr>
<td>Start of Thermal Test:</td>
<td>5/19/2003</td>
</tr>
<tr>
<td>Duration:</td>
<td>205 days</td>
</tr>
<tr>
<td>Hydraulic Control:</td>
<td>Yes</td>
</tr>
<tr>
<td>Size of target zone (ft²):</td>
<td>3115</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>15</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bg):</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>16</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>5</td>
</tr>
<tr>
<td>Initial formation temperature (deg C):</td>
<td>-13</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C):</td>
<td>atleast 100</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>70</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days):</td>
<td>x/Unknown</td>
</tr>
<tr>
<td>Formation temperature immediately post-treatment:</td>
<td>Date</td>
</tr>
<tr>
<td>Formation temperature post-treatment monitoring event 1:</td>
<td>Temperature (deg C)</td>
</tr>
<tr>
<td>Date</td>
<td>Temperature (deg C)</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>lb</td>
</tr>
<tr>
<td>In vapor stream:</td>
<td>lb</td>
</tr>
<tr>
<td>Total:</td>
<td>lb</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Facility ID#: 0685</th>
</tr>
</thead>
</table>

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

- **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:**
  - ___ Saturated only
  - ___ Vadose only
  - ___ Both (Saturated and Vadose zones)

- **Start of Thermal Test:**
  - 5/19/2003
  - Duration: 190 days

- **Hydraulic Control:**
  - x Yes
  - ___ No

- **Treatment Cell Design:**

  | Size of target zone (ft²): | ___ 2409 |
  | 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): | ___ at least 100 |
  | Time to reach maximum representative temperature (days): | ___ 135 |
  | 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>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Mass of contaminant removed:**

  | Via liquid pumping: | ___ lb | ___ kg |
  | In vapor stream: | ___ lb | ___ kg |
  | Total: | ___ lb | ___ kg |

- **Comments:**

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

| Attachments: |
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: 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 x ERH ___ Other: __________

Type of Contaminant: ___ Chlorinated Solvents ___ Petroleum Hydrocarbons ___ Pesticides ___ Wood Treating ___ Other: __________

Treatment Status: x 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: Confidential, OK

Address: ________________________________

City, State, Zip Code: OK

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: bll@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
- 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:

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>
</tr>
</thead>
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<td>Tetrachloroethene</td>
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<td>trans-1,2-dichloroethene</td>
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<td></td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,1,2-tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
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<td>1,1,2,2-tetrachloroethene</td>
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<td>1,1,2,2-tetrachloroethene</td>
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<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

Comments:

Attachments:
### Hydrogeologic Conceptual Model

<table>
<thead>
<tr>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>____ Geology:</td>
</tr>
<tr>
<td>Vadose Zone:</td>
</tr>
<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>
<tr>
<td>Saturated Zone:</td>
</tr>
<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>

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): [fill in]</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>[fill in]</td>
<td>[fill in]</td>
<td>[fill in]</td>
</tr>
<tr>
<td>- high value (ft bgs):</td>
<td>[fill in]</td>
<td>[fill in]</td>
<td>[fill in]</td>
</tr>
<tr>
<td>Unknown:</td>
<td>[fill in]</td>
<td>[fill in]</td>
<td>[fill in]</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>[fill in]</td>
<td>[fill in]</td>
<td>[fill in]</td>
</tr>
<tr>
<td>high</td>
<td>[fill in]</td>
<td>[fill in]</td>
<td>[fill in]</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>[fill in]</td>
<td>[fill in]</td>
<td>[fill in]</td>
</tr>
<tr>
<td>high</td>
<td>[fill in]</td>
<td>[fill in]</td>
<td>[fill in]</td>
</tr>
</tbody>
</table>

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

**Facility ID#: 0006**

**Comments:**

**Attachments:**

---
**Thermal Treatment - Design**

**Facility ID:** 0690

<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>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>Steam + air</td>
<td>Steam + O₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (describe)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></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 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:**

<table>
<thead>
<tr>
<th>Duration of treatment at representative temperature (days):</th>
<th>Time to reach maximum representative temperature (days):</th>
<th>Maximum representative formation temperature (deg C):</th>
<th>Initial formation temperature (deg C):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Hydraulic Control:**
- Yes
- No

**Temperature Profile:**

**Date**

<table>
<thead>
<tr>
<th>Formation temperature immediately post-treatment:</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>Total:</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</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:**

**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:

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: 

Other energy:

Remediation Goal:

Cost and Performance

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: 

Other energy:
General Site Information

File Analyzed By: JT PD ERH Date: 9/13/2006
Type of treatment: x Conductive Steam ERH Other: ____________
Type of Contaminant: Chlorinated Solvents x Petroleum Hydrocarbons Pesticides
Wood Treating Other: ____________
Treatment Status: x Active Post
Type of Test: x Pilot Test Full Scale System
Start of Test: 5/7/98 End of Test: Sep-98 Duration: 120 days
Type of Site: x Non-DOD DoD

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: x 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

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

**Impacted Zone:**
- Length (parallel to flow direction)(ft.): 125
- Width (ft.): 50
- 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
- Number of wells relative to treatment zone:
  - Pre-treatment: In: 5, Uppgradient: 2, Downgradient: 1, Crossgradient: 1
  - Post-treatment: In: 4, Uppgradient: 2, Downgradient: 1, Crossgradient: 1

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 18
- Number of relevant soil borings with post-treatment data: 18
- Number inside treatment zone: 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>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>Diesel: TPH</td>
<td>10 mg/L, 10,000 mg/kg</td>
<td>0.1 mg/L, 1,000 mg/kg</td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethene</td>
<td>Naphthalene</td>
<td>Gasoil: TPH</td>
<td>10 mg/L, 1,000 mg/kg</td>
<td>0.1 mg/L, 1,000 mg/kg</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-Dichloroethene</td>
<td>Benzen</td>
<td>Toluene</td>
<td>0.1 mg/L, 0.5 mg/kg</td>
<td>0.001 mg/L, 0.05 mg/kg</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-Dichloroethene</td>
<td>Ethylbenzene</td>
<td>0.1 mg/L, 1 mg/kg</td>
<td>0.001 mg/L, 0.05 mg/kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethene</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>1,2-Dichloroethene</td>
<td>xylenes (total)</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,2-Trichloroethane</td>
<td>MTBE</td>
<td>None</td>
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<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>Hexane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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</tbody>
</table>

### Comments:

### Attachments:

---

**Facility ID:** 0700
<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>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>
</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>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>
</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: 417 ft amsl  x Unknown |

| Aquifer Characteristics:                                                                 |
| Is more than 1 aquifer present? No x Yes (number): 2  x Unknown (assume single aquifer) |
| Depth to water:                                                                   |
| low value (ft bgs): 2  18  __________________________________________________________ |
| high value (ft bgs): 10  19  ________________________________________________________ |
| 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: 0.03  | 14  |  ___________________________ |  x Unknown          |
| high: 0.001  | 14  |  ___________________________ |

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

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 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: 5/7/1998 Duration: 120 days

Hydraulic Control: ☑ Yes ☑ No

Treatment Cell Design:

Size of target zone (ft²): 75000 ☑ Unknown ( _____ x _____ ft²)

Thickness 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: 741 ☑ Unknown

Number of extraction points: 277 ☑ 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: 1.218 x 10^5 lb x kg ☑ Unknown

Comments:

dewatered zone during treatment and removed a total of 61,345 tons

Attachments:

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

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: __________ 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: ________________________________________________________________________________

- 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>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<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>
</tr>
<tr>
<td>Wood Treating</td>
<td>Other:</td>
<td></td>
<td></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>Duration:</td>
<td>17 months</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Facility Name: ICN Pharmaceutical

| Address: | | |
| City, State, Zip Code: | Portland, OR | |
| OU# or Site #: | | |

### 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

| Type: | None |
| 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>
</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

**Facility ID:** 0720

#### 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: __________
- 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>
<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>Cross gradient</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>
</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>
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<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>α-xylene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</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

Geology:

Vadose 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

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: __________ ft amsl  X Unknown

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>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low (ft bgs):</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high (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: S

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>0.00283</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td>28.3</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:
15-60' - 10e-2 cm/s with 15-30' - being fine silts; at 60' + - 5 ft/day

Low K is upper vadose zone and high K is the saturated zone

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:  
- 5/8/2000  
- Duration: 17 months

Hydraulic Control:  
- Yes  
- No

Treatment Cell Design:

Size of target zone (ft²): 20000
Thickness of target zone (ft): 20
Depth to top of target zone (ft bgs): 20
Thickness of target zone below water table (ft): 20
Number of energy delivery points: 73
Number of extraction points: 53

Temperature Profile:

Initial formation temperature (deg C):  
- Unknown  
- Unknown

Maximum representative formation temperature (deg C):  
- Unknown  
- Unknown

Time to reach maximum representative temperature (days):  
- Unknown  
- Unknown

Duration of treatment at representative temperature (days):  
- Unknown  
- 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:

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

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:

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:
File Analyzed By: JT x PD _____ Date: 10/12/2006

Type of treatment: _____ Conductive x Steam _____ ERH _____ Other: ________________

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

_____ Wood Treating x Other: coal tar

Treatment Status: _____ Active x Post

Type of Test: _____ Pilot Test x Full Scale System


Type of Site: _____ Non-DOD _____ DoD

Facility Name: Brodhead Creek Superfund Site

Address: _______________________________________________________

City, State, Zip Code: Stroudsburg, PA

OU# or Site #: __________________________________________________

Primary point of contact: SITE doc: EPA/540/R-00/500 March 2000

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: 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>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></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>TRPH</td>
<td>None</td>
<td>1,000 mg/kg</td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>None</td>
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<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
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<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>
<tr>
<td></td>
<td>TRPH mg/kg : pre = 1830  post= 1670</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

- TRPH mg/kg:
  - pre = 1830
  - post= 1670

**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: 376 ft amsl

Aquifer Characteristics:

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>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>low value (ft bgs): 1</td>
</tr>
<tr>
<td></td>
<td>high value (ft bgs): 15</td>
</tr>
<tr>
<td>2</td>
<td>Unconnected</td>
</tr>
</tbody>
</table>

Flow direction: E

Horizontal hydraulic gradient (feet/foot): 0.005

Vertical hydraulic gradient (feet/foot): ______  x Unknown

K range (ft/day):

- Measured using: Slug Test, Laboratory, Field data
- Low: 200  Unconnected
- High:  

Transmissivity (ft²/day):

- Measured using: Slug Test, Laboratory, Field data
- Low:  Unconnected
- High: ______  x Unknown

Comments:

porosity n=0.3

K = 100 to 150 Darcies

Attachments:
Thermal Treatment - Design

- **Thermal treatment:**
  - [ ] Conductive
  - [ ] Electrical Resistance
    - [ ] 3 phase
    - [ ] 6 phase
    - [ ] AC power
    - [ ] DC power

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

- **Steam: CROW**
  - [ ] Steam
  - [ ] Steam + air
  - [ ] Steam + O2

- **Other (describe):**

- **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
  - [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: 607 d

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

- **Treatment Cell Design:**
  - **Size of target zone (ft2):** 1500
  - **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
  - **Number of extraction points:** 2

- **Temperature Profile:**
  - **Initial formation temperature (deg C):** 20
  - **Maximum representative formation temperature (deg C):** 70
  - **Time to reach maximum representative temperature (days):** 461
  - **Duration of treatment at representative temperature (days):** 1

- **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
    - [x] Unknown
  - **In vapor stream:**
    - [ ] lb
    - [ ] kg
    - [x] Unknown
  - **Total:** 1504 gal
    - [ ] lb
    - [ ] kg
    - [x] 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:**

---

**Pore volumes flushed = 25.5 (at $85000/pore volume)**

*the Pore volume size is 455,000 gallons*

---

### Lessons Learned

---

### Energy

**Total Energy Used:**

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

---

### Cost

**Total Project Cost:** 2168000

- **Consultant Cost:**
- **Thermal Vendor Cost:**
- **Energy Cost:** 60000 m³ yd³
- **Other Cost 1:**
- **Other Cost 2:**
- **Other Cost 3:**

*Please note other cost:
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By: JT PD</th>
<th>Date: 10/26/2006</th>
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<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
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<tr>
<td>Type of Contaminant:</td>
<td>Chlorinated Solvents</td>
</tr>
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<td>Treatment Status:</td>
<td>Active</td>
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<tr>
<td>Type of Test:</td>
<td>Pilot Test</td>
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<tr>
<td>Start of Test:</td>
<td>0730</td>
</tr>
<tr>
<td>End of Test:</td>
<td></td>
</tr>
<tr>
<td>Duration:</td>
<td></td>
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<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
</tr>
</tbody>
</table>

**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

**City, State, Zip Code:**

**Phone #:** 617-918-1384

**email:**

---

**Other contacts or vendors who worked on site:** None

**Point of contact:** Ian Osgerby

**Type:** Vendor, Consultant || Vendor, Technical Applications || Other

**Organization:** Navy

**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>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>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,1-trichloroethane</td>
<td>None</td>
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<td>None</td>
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<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-dichloroethene</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>1,1,2-trichloroethene</td>
<td>None</td>
<td>None</td>
<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>None</td>
</tr>
</tbody>
</table>

Comments:

Attachments:
### 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

---

### 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

---

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

---

**Facility ID#: 0730**

---

**Comments:**

---

**Attachments:**
<table>
<thead>
<tr>
<th>Thermal Treatment - Design</th>
<th>Facility ID#: 0730</th>
</tr>
</thead>
</table>

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

- **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-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

- **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>
<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: _______ 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: 

Cost and Performance

Facility ID#: 0730

Lesson Learned
General Site Information

X File Analyzed By: JT X PD _____ Date: 11/6/2006
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: X _____ Pilot Test ____ Full Scale System
Start of Test: 11/7/1993 End of Test: 12/2/1993 Duration: 25 d
Type of Site: x Non-DOD _____ DoD

X Facility Name: Savannah River Site
Address: ____________________________________________________________________
City, State, Zip Code: Aiken, SC
OU# or Site #: Site 321 - Area M

X Primary point of contact: Mark Amidon
Organization: Savannah River Site
Address: ____________________________________________________________________
City, State, Zip Code: ____________________________________________________________________
Phone #: 803-952-7781 email: mark.amidon@srs.gov

X 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.): Unknown

X: Impacted zone as defined by documentation

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

X: Map attachment

**Monitor Wells:**
- Number of relevant monitoring wells with groundwater data: Unknown

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 7
- Number of relevant soil borings with post-treatment data: 7
- Number inside treatment zone: 5
- Number outside treatment zone: 2

**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>Chlorinated Solvents</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>0.05 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>None</td>
<td>None</td>
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<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-dichloroethylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Other</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

average post treatment soils concentrations for both constituents at 0.0001 mg/Kg. From elevations 328 to 318.

### Attachments:

- [Map attachment]
- [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]
<table>
<thead>
<tr>
<th>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>

- **Vadose Zone:**
  - 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:** 355 ft amsl

**Aquifer Characteristics:**

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number): 2</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): 135
  - high value (ft bgs): 160
  - Unknown: 0

**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
  - low: Unknown
  - high: Unknown

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

**Comments:**

- Downward gradient of 2 to 8 ft/yr. Radial flow outward at 15 to 100 ft/yr.

**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:  ___ 11/7/1993  ___ Duration:  ___ 25 d

Hydraulic Control  ___ Yes  ___ No

Treatment Cell Design:

Size of target zone (ft2):  ___ 710  ___ Unknown  ___ ( 30 x 30 ft)
Thickness of target zone (ft):  ___ 21  ___ Unknown
Depth to top of target zone (ft bgs):  ___ 23  ___ Unknown
Thickness of target zone below water table (ft):  ___ 0  ___ Unknown
Number of energy delivery points:  ___ 6  ___ Unknown
Number of extraction 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):  ___ 8  ___ Unknown
Duration of treatment at representative temperature (days):  ___ 17  ___ Unknown

Formation temperature immediately post-treatment:

Date:  ___ 12/3/1993  ___ Temperature (deg C):  ___ 100

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:

1430 yd3 of heated soil

Attachments:

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

In Groundwater: ____________________________________________

In Soil: ____________________________________________

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:

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

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__________________________________________________________________________________________

Lessons Learned

Extraction well should be screened above and below clay lens.

Energy

Total Energy Used: 100,000 kWhr

Total energy applied to treatment zone: 70 kWhr/m^3 kWhr/yd^3

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

Please note other energy: ____________________________________________

Cost

Total Project Cost: 1,277,300

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 X 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: 6/15/2006 End of Test: __________ Duration: ______
Type of Site: X 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
### General Site Assessment Data

**Facility ID:** 0742

- **Impacted Zone:**
  - Length (parallel to flow direction)(ft.): ______
  - Width (ft.): ______
  - Thickness (ft.): ______
  - Unknown
  - 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: ______
  - 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>Trichloroethylene</td>
<td>X</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
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<td>None</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>
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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:
- No: __________ ft amsl
- Unknown (

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>X</th>
<th>Yes (number): 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer characteristics</td>
<td></td>
<td></td>
<td>Unknown (assume single aquifer)</td>
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</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>
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<td>Unknown:</td>
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</table>

<table>
<thead>
<tr>
<th>Flow direction</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical hydraulic gradient (feet/foot):</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:

Average K=0.4 ft/min

### 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:**
- [x] Relatively homogeneous and permeable unconsolidated sediments
- [x] Largely permeable sediments with inter-bedded layers of higher permeability material
- [x] 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:** 6/15/2006

**Duration of Thermal Test:**
- [x] Yes

**Hydraulic Control:**
- [x] Yes

**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>
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<td>Unknown</td>
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**Temperature Profile:**

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C)</th>
<th>Maximum representative formation temperature (deg C)</th>
<th>Time to reach maximum representative temperature (days)</th>
<th>Duration of treatment at representative temperature (days)</th>
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</thead>
<tbody>
<tr>
<td>18.3</td>
<td>Unknown</td>
<td>Unknown</td>
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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>In vapor stream</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>[x]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mass (lb, kg):**

<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.*
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
- **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:** 9/10/2000 End of Test: 9/28/2001 Duration: 365 d
- **Type of Site:** Non-DOD DoD

- **Facility Name:** Savannah River Site
- **Address:** __________________________
- **City, State, Zip Code:** Aiken, SC
- **OU# or Site #:** 321-M Solvent Storage Area

- **Primary point of contact:** Jim Kupar
- **Organization:** Bechtel Savannah River, Inc.
- **Address:** Bldg. 730-4B, Rm 3029
- **City, State, Zip Code:** Aiken, SC 29808
- **Phone #:** 803-952-6525 email: james.kupar@srs.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

Facility ID#: 0750

Impacted Zone:
- Length (parallel to flow direction)(ft.): 25000
- Width (ft.): 16000
- Thickness (ft.): 140

- 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:
  - Number of wells relative to treatment zone:
    - Pre-treatment In: _______
    - Upgradient: _______
    - Downgradient: _______
    - Crossgradient: _______

- Post-treatment:
  - 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>Trichloroethene</td>
<td>Hexane</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>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>
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<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>None</td>
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</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>m+p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethene</td>
<td>Creosote</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

X Geology: Zone

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

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 X Yes (number): 3 Unknown (assume single aquifer)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to water: low value (ft bgs):</td>
<td>135</td>
<td>160</td>
<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: ___ ___ ___ ___ ___ ___

Horizontal hydraulic gradient (feet/foot): ___ ___ ___ ___ ___ ___ ___ ___ Unknown
Vertical hydraulic gradient (feet/foot): ___ ___ ___ ___ ___ ___ ___ ___ Unknown

X K range (ft/day)

Measured using: ___ Slug Test ___ Laboratory X Field data

<table>
<thead>
<tr>
<th></th>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>K range (ft/day):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>low</td>
<td>576</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Transmissivity (ft2/day):

Measured using: ___ Slug Test ___ Laboratory ___ Field data

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

Field data

Comments:

Average K=0.4 ft/min

Attachments:
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0750</th>
</tr>
</thead>
</table>

- **Thermal treatment:**
  - Conductive
  - 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:**
  - 9/10/2000
  - Duration: 365 d

- **Hydraulic Control:**
  - Yes
  - No

- **Treatment Cell Design:**
  - Size of target zone (ft²): 10,000
  - Thickness of target zone (ft): 20
  - Depth to top of target zone (ft bgs): 15
  - Thickness of target zone below water table (ft): 9
  - Number of energy delivery points: 2
  - Number of extraction points: 4

- **Temperature Profile:**
  - Initial formation temperature (deg C): 20
  - Maximum representative formation temperature (deg C): 100
  - Time to reach maximum representative temperature (days): 180
  - Duration of treatment at representative temperature (days): 185

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (deg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/1/2001</td>
<td>99</td>
</tr>
<tr>
<td>11/2/2001</td>
<td>90</td>
</tr>
</tbody>
</table>

- **Mass of contaminant removed:**
  - Via liquid pumping: __________ lb __________ kg
  - In vapor stream: __________ lb __________ kg
  - Total: 31,000 lb __________ kg

- **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.
### Performance

**Remediation Goal:**

<table>
<thead>
<tr>
<th>In Groundwater</th>
<th>In Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Was the Remediation Goal Achieved:**

<table>
<thead>
<tr>
<th>In Groundwater</th>
<th>In Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comment:**

General comments on the thermal application:

Steam injected - 4.5x10E10 BTUs (13188198 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.

### Lessons Learned

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

___

### Energy

**Total Energy Used:**

<table>
<thead>
<tr>
<th>kWhr</th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total energy applied to treatment zone:** 13188198 kw-hr

<table>
<thead>
<tr>
<th>kWhr</th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Other energy:**

<table>
<thead>
<tr>
<th>kWhr</th>
<th>kWhr/m³</th>
<th>kWhr/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Please note other energy:**

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

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_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

___

### Cost

**Total Project Cost:** $29 / yd³

<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>m³</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:** 10/11/2006
- **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:** 3/25/1993
- **End of Test:** 4/26/1993
- **Duration:** 27 days
- **Type of Site:** Non-DOD, DoD

### Facility Name
- **Savannah River Site**
- **Address:**
- **City, State, Zip Code:** Aiken, SC 29801
- **OU# or Site #:** Site 321 M-Area Seepage Basin

### Primary point of contact
- **Organization:**
- **Address:**
- **City, State, Zip Code:**
- **Phone #:**
- **email:**

### 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**
**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>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>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-dichloroethene</td>
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<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>
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<td>None</td>
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<td>1,2-dichloroethene</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>
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<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>1,1-dichloroethane</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<td>None</td>
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<td>1,1,2-trichloroethane</td>
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<td>None</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>- 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>
</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:** 360 ft amsl

**Aquifer Characteristics:**

- Is more than 1 aquifer present?  No  Yes (number): 1  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></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:**

- x (Unknown)

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

- x (Unknown)

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

- x (Unknown)

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

- Measured using:  x (Slug Test)  Laboratory  Field data

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- x (Unknown)

**Transmissivity (ft²/day):**

- Measured using:  x (Slug Test)  Laboratory  Field data

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
</tr>
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</table>

- x (Unknown)

**Comments:**

- x (ln)

**Attachments:**

- x (ln)
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductive</td>
</tr>
<tr>
<td>Electrical Resistance</td>
</tr>
<tr>
<td>3 phase</td>
</tr>
<tr>
<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>
</tr>
<tr>
<td>Steam + O2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Test:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot test</td>
</tr>
<tr>
<td>Full-scale System</td>
</tr>
</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>
</tr>
</thead>
<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>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/25/1993</td>
</tr>
<tr>
<td>Duration: 27 d</td>
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<thead>
<tr>
<th>Hydraulic Control:</th>
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</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Cell Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²): 1000</td>
</tr>
<tr>
<td>Thickness of target zone (ft): 10</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs): 35</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft): Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points: 1</td>
</tr>
<tr>
<td>Number of extraction points: 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Profile:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial formation temperature (deg C): 20</td>
</tr>
<tr>
<td>Maximum representative formation temperature (deg C): 65</td>
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<tr>
<td>Time to reach maximum representative temperature (days): 27</td>
</tr>
<tr>
<td>Duration of treatment at representative temperature (days): 1</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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<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>

| Shut down for 7 days |

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:

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

Other energy: 11675 kWhr

Other energy: Please note other energy:

---

Cost

Total Project Cost: 853994

Consultant Cost:

Thermal Vendor Cost:

Energy Cost: 11020

Other Cost 1: 245867

Other Cost 2: 241390

Other Cost 3: 366737

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
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

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.): 33
- Width (ft.): 11
- Thickness (ft.): 8
- 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: 1
    - Upgradient: 4
    - Downgradient: 4
    - Crossgradient: 4
  - Post-treatment: In: 1
    - Upgradient: 4
    - Downgradient: 4
    - Crossgradient: 4

**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: 11
- Number of relevant soil borings with post-treatment data: 4
- Number inside treatment zone: 8
  - 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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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</tr>
<tr>
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<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<tr>
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<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1,2-trichloroethene</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethene</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
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<table>
<thead>
<tr>
<th>Chemical</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>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>0.005 mg/L</td>
<td>0.01 mg/kg</td>
</tr>
<tr>
<td>Trichloroethene</td>
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<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>
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<td>1,2-dichloroethene</td>
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<tr>
<td>1,1,2-trichloroethene</td>
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</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:
- 
- 
- 
- 

### Attachments:
- 
- 
- 
- 

Facility ID: 0765
Hydrogeologic Conceptual Model

Geology:

- Vadose 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
  - 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: 897 ft amsl

Aquifer Characteristics:

- Is more than 1 aquifer present? X No
- Depth to water:
  - low value (ft bgs): 55
  - high value (ft bgs): 65
- Unknown:
- Flow direction SW
- Horizontal hydraulic gradient (feet/foot): 0.03
- Vertical hydraulic gradient (feet/foot): 0.04
- K range (ft/day)
  - Measured using: Slug Test
  - Laboratory
  - Field data
  - low 0.024
  - high 0.24

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

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>Type of Test:</th>
<th>Pilot test</th>
<th>Full-scale System</th>
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</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>
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</tr>
<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
<td></td>
</tr>
<tr>
<td>Treatment Target Zone:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Saturated only</td>
<td>Vadose only</td>
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<td>Start of Thermal Test:</td>
<td>1/29/2007</td>
<td>Duration: 142</td>
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<tr>
<td>Hydraulic Control:</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Size of target zone (ft²):</td>
<td>2554</td>
<td>Unknown (33 x 78 ft)</td>
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<tr>
<td>Thickness of target zone (ft):</td>
<td>87</td>
<td>Unknown</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bg):</td>
<td>0</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>15</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>14</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>10</td>
<td>Unknown</td>
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<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>101</td>
<td>Unknown</td>
</tr>
<tr>
<td>Time to reach maximum representative temperature (days):</td>
<td>75</td>
<td>Unknown</td>
</tr>
<tr>
<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>165</td>
<td></td>
</tr>
</tbody>
</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></td>
</tr>
<tr>
<td>In vapor stream:</td>
<td>11550</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>11550</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  
Facility ID#: 0765

**Performance**

Remediation Goal:

- In Groundwater:
  - **X**

- In Soil:
  - **X**
  - 95% UCL of mean TCE concentration must be <0.060 mg/kg

Was the Remediation Goal Achieved:

- In Groundwater:
  - Comment:

- In Soil:
  - Comment:
  - 95% UCL of mean TCE concentration = 0.017 mg/kg

**General comments on the thermal application:**

Lessons Learned

**Energy**

Total Energy Used: 1860600 kWhr

- **X** kWhr/m³ kWhr/yd³

- 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

**Cost**

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

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT PD</th>
<th>Date: 10/11/2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of treatment:</td>
<td>Conductive</td>
<td>Steam ERH Other:</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>
<td></td>
</tr>
<tr>
<td>Type of Test:</td>
<td>Pilot Test Full Scale System</td>
<td></td>
</tr>
<tr>
<td>Start of Test:</td>
<td>6/13/1995</td>
<td></td>
</tr>
<tr>
<td>End of Test:</td>
<td>7/8/1995</td>
<td></td>
</tr>
<tr>
<td>Duration:</td>
<td>26 d</td>
<td></td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD DoD</td>
<td></td>
</tr>
</tbody>
</table>

### Facility Name: Oak Ridge Reservation

#### Address:

City, State, Zip Code: Oak Ridge, TN

OU# or Site #: Site K-25

### Primary point of contact:

<table>
<thead>
<tr>
<th>Organization:</th>
<th>OSTI.gov/bridge document #: DOE/OR/22160-T22 vol 1 &amp; 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<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
- 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: 

<table>
<thead>
<tr>
<th>Number of wells relative to treatment zone:</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In:</td>
<td>Upgradient:</td>
</tr>
<tr>
<td></td>
<td>Downgradient:</td>
<td>Crossgradient:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 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: 
- Number of wells relative to treatment zone: 

#### Soils:
- Number of relevant soil borings with groundwater 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>None</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>cis,1,2-Dichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>trans,1,2-Dichloroethene</td>
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<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
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<td>None</td>
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<td>0.01 mg/kg</td>
<td>None</td>
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<tr>
<td>1,1,2-Trichloroethene</td>
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<td>None</td>
<td>None</td>
<td>0.01 mg/kg</td>
<td>None</td>
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</tbody>
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#### Comments:

- Additional comments can be added here.

#### Attachments:

- Attachments for additional data or documentation can be added 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>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>
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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>Is more than 1 aquifer present?</th>
<th>No</th>
<th>Yes (number):</th>
<th>Unknown (assume single aquifer)</th>
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<tbody>
<tr>
<td></td>
<td>Depth to water:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Flow direction:</td>
<td></td>
<td></td>
<td></td>
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</table>

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

<table>
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<tr>
<th>Measured using:</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
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<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
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<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>
<td>low</td>
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<td>Unknown</td>
</tr>
<tr>
<td>high</td>
<td></td>
<td></td>
<td></td>
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</tbody>
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<p>| Comments: | |
| Attachments: | |</p>
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<thead>
<tr>
<th><strong>Thermal Treatment - Design</strong></th>
<th><strong>Facility ID#: 0768</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal treatment:</strong></td>
<td><strong>Conductive</strong></td>
</tr>
<tr>
<td><strong>x</strong> Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td><strong>Steam</strong></td>
<td><strong>Steam + air</strong></td>
</tr>
<tr>
<td><strong>Steam + O2</strong></td>
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<tr>
<td><strong>Other (describe)</strong></td>
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</tr>
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<td><strong>Type of Test:</strong></td>
<td><strong>Pilot test</strong></td>
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<tr>
<td><strong>Geology of Treatment Zone:</strong></td>
<td><strong>Relatively homogeneous and permeable unconsolidated sediments</strong></td>
</tr>
<tr>
<td><strong>Treatment Target Zone:</strong></td>
<td><strong>Saturated only</strong></td>
</tr>
<tr>
<td><strong>Start of Thermal Test:</strong></td>
<td>6/13/1995</td>
</tr>
<tr>
<td><strong>Hydraulic Control</strong></td>
<td><strong>Yes</strong></td>
</tr>
<tr>
<td><strong>Treatment Cell Design:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Initial formation temperature (deg C):</strong></td>
<td>18</td>
</tr>
<tr>
<td><strong>Maximum representative formation temperature (deg C):</strong></td>
<td>75</td>
</tr>
<tr>
<td><strong>Time to reach maximum representative temperature (days):</strong></td>
<td>25</td>
</tr>
<tr>
<td><strong>Duration of treatment at representative temperature (days):</strong></td>
<td>4</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><strong>Via liquid pumping:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>In vapor stream:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></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: 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: 

General comments on the thermal application:

Cost was $144/ton

Lessons Learned

Energy
Total Energy Used: 25900 kWh  kWh/m³  kWh/m³  kWh/yd³
  Total energy applied to treatment zone: kWh/m³  kWh/m³  kWh/yd³
  Other energy: kWh/m³  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: 11/14/2006
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: 8/7/2000 End of Test: 11/5/2000 Duration: 88d
Type of Site: ___ Non-DOD ___ 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: ___ 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

**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-gradient</td>
<td>50 mg/L</td>
<td>10 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td></td>
<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>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></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethane</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Ethylbenzene</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,2-Dichloroethane</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></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
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<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td></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:**

---

**Chemical Definitions:**

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

**Map Attachment:**

---

**Impacted Zone:**

Length (parallel to flow direction)(ft.): 1250
Width (ft): 700
Thickness (ft): 60

---

**Monitor Wells:**

Number of relevant monitoring wells with groundwater data: None

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>Post-treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**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: 1

Number outside treatment zone: 1

---

**Soil Borings:**

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>Post-treatment</td>
<td></td>
<td></td>
<td></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
- M+p-xylene
- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane
- Vinyl Chloride

---

**Average Pre-treatment Concentration per Chemical:**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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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>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
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<td></td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
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<td></td>
</tr>
<tr>
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<td></td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Average Post-treatment Concentration per Chemical:**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
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<td></td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Hydrogeologic Conceptual Model

**Facility ID#: 0770**

### 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>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>0.087</td>
<td>0.88</td>
</tr>
</tbody>
</table>

### Aquifer Characteristics:

- **Is more than 1 aquifer present?**
  - No
  - Yes (number): 3
  - 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>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)**: 0.006
- **Vertical hydraulic gradient (feet/foot)**: unknown

- **K range (ft/day)**
  - Measured using: Slug Test
  - Laboratory
  - Field data
  - Low: 13
  - High: 132

- **Transmissivity (ft2/day)**
  - Measured using: Slug Test
  - Laboratory
  - Field data
  - Low: 0.087
  - High: 0.88

### Comments:

- **Other**: Terrace alluvium aquifer
  - K=0.05 ft/day to 4.51 ft/day
  - Horizontal hydraulic gradient - 0.004

### Attachments:

- [Attachment 1](#)
- [Attachment 2](#)
- [Attachment 3](#)
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
<th>Steam</th>
<th>3 phase</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
<th>Steam + air</th>
<th>Steam + O2</th>
<th>Steam + air</th>
<th>Steam + O2</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Type of Test:**<br>• Pilot test | Full-scale System

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

**Treatment Target Zone:**<br>• Saturated only<br>• Vadose only<br>• Both (Saturated and Vadose zones)

**Start of Thermal Test:**<br>8/7/2000 | Duration: 84d

**Hydraulic Control:**<br>• Yes<br>• 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 | Unknown
- **Maximum representative formation temperature (deg C):** 110 | Unknown
- **Time to reach maximum representative temperature (days):** 40 | Unknown
- **Duration of treatment at representative temperature (days):** 20 | Unknown

### Volume treated:

<table>
<thead>
<tr>
<th>In vapor stream:</th>
<th>150</th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping:</td>
<td>2.45</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>150</td>
<td>lb</td>
<td>kg</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Mass of contaminant removed:**

- **Volume treated:** 3930 cubic yds

**Attachments:**

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
Cost and 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
  - Yes, except for WJETA062 at 10.7 mg/L
- In Soil
  - Yes

General comments on the thermal application:

Objective: Reach the boiling point of TCE at depth

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: 548306
  - Consultant Cost: ___
  - Thermal Vendor Cost: ___
  - Energy Cost: 28588 ___ m³ ___ yd³
  - 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 ERH Other: ____________
Type of Contaminant: x Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Other: ____________
Treatment Status: Active Post
Type of Test: Pilot Test Full Scale System
Start of Test: 5/13/2002 End of Test: 2/19/2002 Duration: 221 d
Type of Site: Non-DOD 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: 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
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___ Good pre- and post-treatment soil data
___ Good temperature profile vs. time information
___ Flux assessment
___ Groundwater elevations
___ Geologic cross-section
___ Hydraulic Conductivity information
<table>
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<tr>
<th>Types of Contaminants</th>
<th>Chlorinated Solvents</th>
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<th>Other</th>
<th>Average Pre-treatment Concentration per Chemical</th>
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</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>
</tr>
<tr>
<td></td>
<td>1,1-Dichloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>None</td>
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<td>1,2-Dichloroethene</td>
<td>Naphthalene</td>
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<td>trans-1,2-Dichloroethene</td>
<td>Toluene</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
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<td></td>
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<td>None</td>
</tr>
</tbody>
</table>

Comments:
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________
____________________________________________________________________________________________________________________________

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:

- Low value (ft bgs): 650
- High value (ft bgs): 70
- Unknown: 650

#### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>X</th>
<th>Yes (number)</th>
<th>2</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>27</td>
<td></td>
</tr>
<tr>
<td>high value (ft bgs):</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Unknown:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow direction</th>
<th>NE</th>
</tr>
</thead>
</table>

| Horizontal hydraulic gradient (feet/foot): | 0.006 |
| Vertical hydraulic gradient (feet/foot):   |       |

<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>13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmissivity (ft^2/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>0.087</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>0.88</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 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
  - 3 phase
  - 6 phase
  - AC power
  - DC power

Stealth

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 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:  
- 5/13/2002

Duration:  
- 211 d

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:  

<table>
<thead>
<tr>
<th>Size of target zone (ft²):</th>
<th>21780</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of target zone (ft):</td>
<td>37</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>7</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>10</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>73</td>
</tr>
</tbody>
</table>

Temperature Profile:  

| 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 |

<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>0.227 lb</th>
<th>x kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vapor stream:</td>
<td>640.9 lb</td>
<td>x kg</td>
<td>Unknown</td>
</tr>
<tr>
<td>Total:</td>
<td>641.15 lb</td>
<td>x 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:
  - 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:

Target temperature - Boiling point of TCE at depth

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.

Energy

Total Energy Used: 1899000 kWh

- Total energy applied to treatment zone: x kWh, kWh/m³, kWh/yd³
- Other energy: x kWh/m³, kWh/yd³
  - Please note other energy:

Cost

Total Project Cost: 236963

- Consultant Cost: ______________________
- Thermal Vendor Cost: ______________________

- Energy Cost: 85455 m³, yd³

- Other Cost 1: 740294

- Other Cost 2: 1506648

- Other Cost 3: 38236

Please note other cost:

- Other Cost 1: capital cost
- Other Cost 2: operation and maintenance for technology
- Other Cost 3: other technology specific cost
General Site Information

File Analyzed By: JT PD Date: 10/19/2006
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
Type of Site: Non-DOD DoD

Facility Name: Kelly AFB (ITRI)
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
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: _____ Uppgradient: _____ Downgradient: _____ Crossgradient: _____
  - Post-treatment: In: _____ Uppgradient: _____ Downgradient: _____ Crossgradient: _____

Soil Borings:

- Number of relevant soil borings with pre-treatment data: 21
- Number of relevant soil borings with post-treatment data: 21
- Number inside treatment zone: 16 / 16
- Number outside treatment zone: 5 / 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></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></td>
<td></td>
<td></td>
<td>Pre-treatment:</td>
<td>Post-treatment:</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Benzene</td>
<td>Crossxite</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</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-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>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>Chlorobenzene</td>
<td></td>
<td>None</td>
<td>5 mg/kg</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td>TEPH</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:

Attachments:
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: 690 ft amsl

Aquifer Characteristics:

- Is more than 1 aquifer present? No
- Depth to water:
  - Low value (ft bgs): 24
  - High value (ft bgs): 33
  - Unknown:
- Flow direction

Horizontal hydraulic gradient (feet/foot):
- Unknown

Vertical hydraulic gradient (feet/foot):
- Unknown

K range (ft/day)
- Measured using: Slug Test
  - Low: 15.5
  - High: Unknown

Transmissivity (ft²/day):
- Measured using: Slug Test
  - Low: Unknown
  - High: Unknown

Comments:

Attachments:
Thermal Treatment - Design

Thermal treatment:

- Conductive
- Electrical Resistance
- 3 phase AC power
- 6 phase AC power
- Steam
- Steam + air
- Steam + O2
- Other (describe) RFH (ITTR)

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:

- 4/3/1993
- Duration: 61 d

Hydraulic Control:

- Yes
- No

Treatment Cell Design:

Size of target zone (ft²):

- 141
- Unknown

Thickness of target zone (ft):

- 23.3
- 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:

- 4
- Unknown

Number of extraction points:

- 16
- Unknown

Temperature Profile:

Initial formation temperature (deg C):

- 20
- Unknown

Maximum representative formation temperature (deg C):

- 110
- Unknown

Time to reach maximum representative temperature (days):

- 56
- Unknown

Duration of treatment at representative temperature (days):

- 4
- 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:
- In vapor stream:
- Total:

<table>
<thead>
<tr>
<th></th>
<th>lb</th>
<th>kg</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></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:

Total energy applied to treatment zone:

Other energy:

___ Please note other energy:

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:
<table>
<thead>
<tr>
<th><strong>General Site Information</strong></th>
<th>Facility ID#: 0801</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>x</strong> File Analyzed By: JT PD</td>
<td>Date: 10/19/2006</td>
</tr>
<tr>
<td><strong>Type of treatment:</strong></td>
<td>Conductive Steam ERH Other: RFH</td>
</tr>
<tr>
<td><strong>Type of Contaminant:</strong></td>
<td>Chlorinated Solvents Petroleum Hydrocarbons Pesticides Wood Treating Other:</td>
</tr>
<tr>
<td><strong>Treatment Status:</strong></td>
<td>Active Post</td>
</tr>
<tr>
<td><strong>Type of Test:</strong></td>
<td>x Pilot Test Full Scale System</td>
</tr>
<tr>
<td><strong>Start of Test:</strong></td>
<td>4/26/1994</td>
</tr>
<tr>
<td><strong>End of Test:</strong></td>
<td>6/14/1994</td>
</tr>
<tr>
<td><strong>Duration:</strong></td>
<td>50 d</td>
</tr>
<tr>
<td><strong>Type of Site:</strong></td>
<td>Non-DOD DoD</td>
</tr>
</tbody>
</table>

**Facility Name:** Kelly AFB (KAI)

**Address:**

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:** 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>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>
<th>Pre-treatment:</th>
<th>Post-treatment:</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<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:  

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of relevant soil borings with post-treatment data:</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Number inside treatment zone:</td>
<td>22 / 22</td>
</tr>
<tr>
<td></td>
<td>Number outside treatment zone:</td>
<td>2 / 2</td>
</tr>
</tbody>
</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>Tetrachloroethene</td>
<td>Benzene</td>
<td>Cross gradient</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>
</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-dichloroethene</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-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>Chlorobenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethane</td>
<td>TPH</td>
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<td>None</td>
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</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

- Chemicals of Concern

---

**General Site Assessment Data**

**Chemical:**

- **Tetrachloroethene:** None
- **Trichloroethene:** None
- **1,1-dichloroethene:** None
- **cis,1,2-dichloroethene:** None
- **trans,1,2-dichloroethene:** None
- **1,1-dichloroethene:** None
- **1,2-dichloroethene:** None
- **1,1,1-trichloroethane:** None
- **1,1,2-trichloroethane:** None
- **1,1,2,2-tetrachloroethane:** None
- **Vinyl Chloride:** None

**Groundwater (mg/L) | Soil (mg/kg)**

- **Tetrachloroethene:** None
- **Trichloroethene:** None
- **1,1-dichloroethene:** None
- **cis,1,2-dichloroethene:** None
- **trans,1,2-dichloroethene:** None
- **1,1-dichloroethene:** None
- **1,2-dichloroethene:** None
- **1,1,1-trichloroethane:** None
- **1,1,2-trichloroethane:** None
- **1,1,2,2-tetrachloroethane:** None
- **Vinyl Chloride:** None

---

**Comments:**

---

**Attachments:**
Hydrogeologic Conceptual Model

x Geology:  

Zone | Unconsolidated Sediments  
--- | ---  
Vadose Zone:  
- 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:  
- Largely homogeneous and permeable unconsolidated sediments  
- Largely homogeneous and impermeable unconsolidated sediments  
- Largely permeable sediments with inter-bedded layers of lower permeability material  
- Weathered bedrock, limestone, sandstone  

x Ground surface elevation based on wells in or adjacent to treatment zone: 690 ft amsl  

x Aquifer Characteristics:  

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

Depth to water:  
- low value (ft bgs): 24  
- high value (ft bgs): 33  
- 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 (ft²/day):  
Measured using:  
- Slug Test  
- Laboratory  
- Field data  
- Unknown  

Comments:  

Attachments:  

Thermal Treatment - Design

Thermal treatment:  
- Conductive
- Electrical Resistance
  - 3 phase
  - AC power
  - DC power
- Steam
  - 6 phase
  - 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
- 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:  
- 4/26/1994
- Duration: 50 d

150 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):  

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):

0 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: __________________________
- 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: 2477216
- 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: 9/27/2006

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: 1998 End of Test: 2003 Duration: varied

Type of Site: Non-DOD DoD

Facility Name: Petro-Chemical System (AKA Turtle Bayou)

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

**Facility ID:** 0810

#### 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 groundwater data:
  - 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>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>
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<td>None</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:

**# of borings per cell for example:** 1, 2, 3, and 4

#### 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>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>
</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>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>
</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

- **Is more than 1 aquifer present?** No X 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** 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: _______ Unknown

- **Transmissivity (ft²/day):**
  - Measured using: Slug Test Laboratory Field data
    - Low below: _______ Unknown
    - High: _______ Unknown

<table>
<thead>
<tr>
<th>Unit</th>
<th>K (ft/day)</th>
<th>T (ft²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>0.0036</td>
<td>C1</td>
</tr>
<tr>
<td>S</td>
<td>0.009</td>
<td>M1</td>
</tr>
<tr>
<td>S</td>
<td>0.090</td>
<td>S1</td>
</tr>
</tbody>
</table>

- **Comments:**

- **Attachments:**

---
Thermal Treatment - Design

Thermal treatment:  

- Conductive  
- Electrical Resistance  

Main 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:  

- Dec-01  
- Duration: 27 months  

Hydraulic Control:  

- Yes  
- No  

Treatment Cell Design:  

Size of target zone (ft²):  

- Unknown  

Thickness of target zone (ft):  

- 22  

Depth to top of target zone (ft bgs):  

- 12  

Thickness of target zone below water table (ft):  

- 2  

Number of energy delivery points:  

- x  

Number of extraction points:  

- 20  

Temperature Profile:  

Initial formation temperature (deg C):  

- x  

Maximum representative formation temperature (deg C):  

- x  

Time to reach maximum representative temperature (days):  

- x  

Duration of treatment at representative temperature (days):  

- x  

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.
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: 

- Oct-98
- Duration: 43 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

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.
### Thermal Treatment - Design

<table>
<thead>
<tr>
<th><strong>Facility ID:</strong></th>
<th>0810</th>
</tr>
</thead>
</table>

#### Thermal treatment:
- Conductive
- Electrical Resistance
- Office trailer area

#### 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 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:
- Oct-98
- Duration: 39 months

#### 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></td>
</tr>
<tr>
<td>Thickness of target zone (ft)</td>
<td>22</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>12</td>
</tr>
<tr>
<td>Number of energy delivery points</td>
<td>12</td>
</tr>
<tr>
<td>Number of extraction points</td>
<td>37</td>
</tr>
</tbody>
</table>

#### Temperature Profile:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</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>
<td>Unknown</td>
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<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>

#### Mass of contaminant removed:

<table>
<thead>
<tr>
<th>Method</th>
<th>Quantity lb</th>
<th>Quantity kg</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via liquid pumping</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td>In vapor stream</td>
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<td>Unknown</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>Unknown</td>
</tr>
</tbody>
</table>

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

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

- **Type of Test**: X Pilot test
- **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**: X Oct-98
- **Duration**: 39 months
- **Hydraulic Control**: X Yes, No

- **Treatment Cell Design**:
  - **Size of target zone (ft2)**: Unknown
  - **Thickness of target zone (ft)**: 22
  - **Depth to top of target zone (ft bgs)**: 2
  - **Thickness of target zone below water table (ft)**: 12
  - **Number of energy delivery points**: 12
  - **Number of extraction points**: 25

- **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**: 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.
Thermal Treatment - Design

**Thermal treatment:**
- [x] Conductive
- [ ] Electrical Resistance

**Facility ID#:** 0810

**Easement South**
- [ ] 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
- [ ] 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
- [ ] Vadose only
- [ ] Both (Saturated and Vadose zones)

**Start of Thermal Test:** Oct-98
**Duration:** 39 months

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

**Treatment Cell Design:**

<table>
<thead>
<tr>
<th>Size of target zone (ft^2):</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>
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<td>Unknown</td>
<td>9</td>
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**Temperature Profile:**

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<th>Initial formation temperature (deg C):</th>
<th>Maximum representative formation temperature (deg C):</th>
<th>Time to reach maximum representative temperature (days):</th>
<th>Duration of treatment at representative temperature (days):</th>
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</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
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</tr>
</tbody>
</table>

**Formation temperature immediately post-treatment:**

**Formation temperature post-treatment monitoring event 1:**

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<thead>
<tr>
<th>Duration of post-treatment monitoring (days):</th>
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</thead>
<tbody>
<tr>
<td>Unknown</td>
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</table>

**Mass of contaminant removed:**

<table>
<thead>
<tr>
<th>Via liquid pumping:</th>
<th>In vapor stream:</th>
<th>Total:</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
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<td>unknown</td>
</tr>
</tbody>
</table>

**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:
General Site Information

File Analyzed By: JT PD

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

Type of Contaminant: ______ Chlorinated Solvents x 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: x Non-DOD ___ DoD

Facility Name: Shell's Gasmer Rd, R&D Facility

City, State, Zip Code: TX

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

Type of Vendor: Vendor, Consultant Vendor, Technical Applications Other __________

Organization: __________

Address: __________

City, State, Zip Code: __________ 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>
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<tbody>
<tr>
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</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>
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</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>
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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>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>
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<tr>
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### Comments:

- None

### Attachments:

- None
### Geology:

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<th>Unconsolidated Sediments</th>
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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>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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<tr>
<td>Saturated Zone:</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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<tr>
<td></td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
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<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
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</table>

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

- **ft amsl:** Unknown

###Aquifer Characteristics:

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<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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<tbody>
<tr>
<td>Depth to water:</td>
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<tr>
<td>low value (ft bgs):</td>
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<tr>
<td>high value (ft bgs):</td>
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<td></td>
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<tr>
<td>Unknown:</td>
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<tr>
<td>Flow direction:</td>
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</table>

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

<table>
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<tr>
<th>K range (ft/day)</th>
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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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<td>Transmissivity (ft2/day):</td>
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### Comments:

- Additional comments or notes on the hydrogeologic conceptual model.

### Attachments:

- Additional documents or resources related to the hydrogeologic conceptual model.
<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
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<td></td>
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<td>3 phase</td>
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</table>

**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: ____________

**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 extraction points: ____________ Unknown
- Number of energy delivery 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>
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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: ____________ 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**

**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 Date: 1/25/2007
Type of treatment: Conductive Steam ERH Other: __________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides __________
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
City, State, Zip Code: Killian, TX
OU# or Site #: ________________________________

Primary point of contact: Dr. C. Herb Ward
Organization: Rice University
Address: ________________________________
City, State, Zip Code: ________________________________
Phone #: 713-348-4086 email: wardch@rice.edu

Other contacts or vendors who worked on site: None
Point of contact: __________
Type: Vendor, Consultant Vendor, Technical Applications Other
Organization: Rice University
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

Copyright 2000 by CRC Press, LLC
Book: Steam and Electroheating Remediation of Tight Soils
### General Site Assessment Data

- **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:** __________
    - **Groundwater (mg/L):** __________
    - **Soil (mg/kg):** __________
    - **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>1,1,1-trichloroethane</td>
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### Comments:

- **Pre-treatment mass estimate:** __________
- **Cross-section on pages 9-12:** __________

---

**Attachments:**

- [Facility ID: 0620](#)
### 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>
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<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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</tbody>
</table>

### Comments:

Cross-section on page 9-12  
Pre-treatment mass estimate

of 8964.92 pounds

Attachments:

---
### 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

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

<table>
<thead>
<tr>
<th></th>
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<th>Post-treatment:</th>
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<tbody>
<tr>
<td>Number of relevant soil borings with pre-treatment data:</td>
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<td>Number of relevant soil borings with post-treatment data:</td>
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<tr>
<td>Number inside treatment zone:</td>
<td>11 / 7</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>
<th>Average Post-treatment Concentration per Chemical</th>
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<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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<td></td>
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<td>Benzene</td>
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<td>o-xylene</td>
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#### Cross-section on pag 9-12

Pre-treatment mass estimate

of 3,234.38 pounds

#### Attachments:

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<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<tr>
<td></td>
<td>Vadose Zone:</td>
<td>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
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<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>
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<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
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<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>

| 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>
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<tr>
<td></td>
<td>Aquifer 1</td>
<td>Aquifer 2</td>
<td>Aquifer 3</td>
</tr>
<tr>
<td>Depth to water:</td>
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<td></td>
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<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>
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<tr>
<td>Unknown:</td>
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</table>

| Flow direction | E | |

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

Comments: 

- K = 1e-4 cm/sec for weathered shale/limestone 
- K = 3.3e-8 to 2.1e-9 cm/sec for slug tests.
**Thermal Treatment - Design**

<table>
<thead>
<tr>
<th>Facility ID#: 0820</th>
</tr>
</thead>
</table>

- **Thermal treatment:** Conductive
- **Electrical Resistance:** Cell A
  - 3 phase
  - 6 phase
  - AC power
  - DC power
  - Steam
  - Steam + air
  - Steam + O2

- **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
- **Start of Thermal Test:** 3-1997 (ended 9/5/97)
- **Duration:** 6 months

- **TCC Design:**
  - Size of target zone (ft²): 900
  - Thickness of target zone (ft): 74
  - 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

- **Temperature Profile:**
  - 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

- **Mass of contaminant removed:**
  - Via liquid pumping: Unknown
  - In vapor stream: Unknown
  - Total: 15150 lb

- **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

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
- Both (Saturated and Vadose zones)

Treatment Target Zone:

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test:

- Apr-97
- Duration:

Hydraulic Control

- Yes
- No

Treatment Cell Design:

Size of target zone (ft2):

- 770
- Unknown
- ( 24 x 24 ft)

Thickness of target zone (ft):

- 22
- Unknown

Depth to top of target zone (ft bgs):

- Unknown

Thickness of target zone below water table (ft):

- Unknown

Number of energy delivery points:

- 4
- Unknown

Number of extraction points:

- 4
- Unknown

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:
- In vapor stream:
- Total:

- 7820
- lb
- kg
- Unknown

Hydraulic Fractures at 12, 15, 18, and 21 ft.

(SIM) was completed at 16 ft

GW recovery well was upgradient (GW-A).

Post mass of 1165.37

Attachments:

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
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<tbody>
<tr>
<td>Thermal treatment:</td>
<td>Conductive, Electrical Resistance, 3 phase, 6 phase, AC power, DC power, 6 phase AC power, Steam, Cell C, Steam, Steam + air, Steam + O₂, Other (describe)</td>
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<tr>
<td>Type of Test:</td>
<td>Full-scale System, Pilot test, 24 x 24 ft, 2766 lb, 1200 kg, 7/1/1997, ended 9/5/97, 67 days, 11, 24, 24 ft, 380 ft, 15, 18, 12 ft, 20.5, 93.3, 5800 ft², 11, 11, 24 x 24 ft, 22, 22</td>
</tr>
<tr>
<td>Geology of Treatment Zone:</td>
<td>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</td>
</tr>
<tr>
<td>Treatment Target Zone:</td>
<td>Saturated only, Vadose only, Both (Saturated and Vadose zones)</td>
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<td>Start of Thermal Test:</td>
<td>7/1/1997 (ended 9/5/97)</td>
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<tr>
<td>Duration of post-treatment monitoring event 1:</td>
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<td>Duration of treatment at representative temperature (days):</td>
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<tr>
<td>Duration of post-treatment monitoring (days):</td>
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<td>Temperature Profile:</td>
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<tr>
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<td>Temperature (deg C)</td>
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<td>Formation temperature immediately post-treatment:</td>
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<td>Mass of contaminant removed:</td>
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</tr>
<tr>
<td>Attachments:</td>
<td>Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.</td>
</tr>
</tbody>
</table>

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

Measures of success (technical): 1) determine recovery rates of vapor and liquids, 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.
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: 1997 End of Test: 1997 Duration: 
Type of Site: Non-DOD DoD 

Facility Name: Hill Air Force Base
Address: Odgen, UT
OU# or Site #: OU-1

Primary point of contact: Dr. Lloyd Stewart
Organization: 
Address: 
City, State, Zip Code: Odgen, UT
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 
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

#### 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: __________

<table>
<thead>
<tr>
<th>Number of wells relative to treatment zone:</th>
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</thead>
<tbody>
<tr>
<td>Pre-treatment</td>
</tr>
<tr>
<td>Post-treatment</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>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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#### Comments:

- ______________________________________________________________________
- ______________________________________________________________________
- ______________________________________________________________________
- ______________________________________________________________________

#### Attachments:

- ______________________________________________________________________
- ______________________________________________________________________
- ______________________________________________________________________
<table>
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<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<tbody>
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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>

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>Low</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
</table>
| Transmissivity (ft²/day): measured using: Slug Test __________ Laboratory __________ Field data __________

<table>
<thead>
<tr>
<th>Low</th>
<th>Slug Test</th>
<th>Laboratory</th>
<th>Field data</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td></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
- 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):
  - 100
- Thickness of target zone (ft):
  - 30
- 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):
- 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:
  - 14 lb
  - 7 kg
- In vapor stream:
  - 34 lb
  - 15 kg
- 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: ___ 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: ___
File Analyzed By: JT x PD _____ Date: 10/26/2006
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 x Full Scale System
Start of Test: _____ Sep-00 End of Test: ___________ Duration: 3.5 Years
Type of Site: _____ Non-DOD x 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 x Other 
Organization: Navy
City, State, Zip Code: 
Phone #: 752-322-4755 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.): ______  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>Trichloroethene</td>
<td>None</td>
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<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
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<td>1,1-dichloroethene</td>
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<td>Vinyl Chloride</td>
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<td>1,1,2,2-tetrachloroethane</td>
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<tr>
<td>Bunker Fuel</td>
<td>None</td>
<td>None</td>
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<td>None</td>
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</tbody>
</table>

Comments:

8000 L of Bunker Fuel estimated to have been released

Attachments:

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________________
### Hydrogeologic Conceptual Model

**Facility ID#: 0840**

<table>
<thead>
<tr>
<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Vadose Zone:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
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<td>Saturated Zone:</td>
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</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
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<td></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>

<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>high value (ft bgs):</td>
</tr>
<tr>
<td>Unknown:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow direction</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Vertical hydraulic gradient (feet/foot):</th>
</tr>
</thead>
</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>
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</table>

<table>
<thead>
<tr>
<th>Transmissivity (ft²/day):</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Attachments:</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

- **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-00

- **Duration of post-treatment monitoring (days):**
  - 3.5 yrs

- **Hydraulic Control:**
  - Yes
  - No

- **Size of target zone (ft²):**
  - 900

- **Thickenss of target zone (ft):**
  - 20

- **Depth to top of target zone (ft bgs):**
  - 10

- **Thickenss 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:**
  - Date
  - Temperature (deg C)

- **Duration of post-treatment monitoring (days):**
  - Unknown

- **Mass of contaminant removed:**
  - Via liquid pumping: 5000 gal / month
    - lb
    - kg
    - Unknown
  - In vapor stream: 500000 gal / month
    - lb
    - kg
    - Unknown
  - Total: Unknown

- **Comments:**

- **Attachments:**

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

Remediation Goal:

- 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

- Other Cost 1: 1000000 / yr

- Other Cost 2: 600000

- Other Cost 3:

  Please note other cost:

- Other Cost 1: O&M

- Other Cost 2: Construction

- 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: X 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: Richmond, VA
Address: __________________________________________
City, State, Zip Code: Richmond, VA
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: Art Taddeo
Type: X Vendor, Consultant _______ Vendor, Technical Applications _______ Other _______
Organization: ENSR
Address: __________________________________________
City, State, Zip Code: __________________________________
Phone #: 978-589-3095 email: ataddeo@ensr.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.): ___________
- **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: ___________
- **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>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td>Tetracloroethene</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>50 mg/L</td>
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</tr>
<tr>
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<td>cis,1,2-dichloroethene</td>
<td>Benzene</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>None</td>
</tr>
<tr>
<td></td>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<tr>
<td></td>
<td>1,2-dichloroethene</td>
<td>m+p-xylene</td>
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<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
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</tr>
<tr>
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<td>1,1,2-trichloroethene</td>
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</tr>
<tr>
<td></td>
<td>1,1,2,2-tetrachloroethene</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:

- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________

#### Attachments:

- ____________________________________________________________________________
- ____________________________________________________________________________
- ____________________________________________________________________________
## Hydrogeologic Conceptual Model

### Geology:

#### Zone

<table>
<thead>
<tr>
<th>Vadose Zone</th>
<th>Saturated Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

- 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
- 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

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Geology</th>
<th>Vadose Zone</th>
<th>Saturated Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

#### Is more than 1 aquifer present?

- No
- Yes (number): ___________
- Unknown (assume single aquifer)

#### 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):</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>high (ft bgs):</td>
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<td></td>
</tr>
<tr>
<td>Unknown:</td>
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</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>

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

### Attachments:

[Attachments]

### Comments:

[Comments]
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:  

Duration:  

Hydraulic Control:  

- Yes
- No

Treatment Cell Design:

Size of target zone (ft²): 12040  

Thickness of target zone (ft): 28  

Depth to top of target zone (ft bgs): 2  

Thickness of target zone below water table (ft): 22  

Number of energy delivery points: 60  

Number of extraction points: 60

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:  

15 foot electrode spacing

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

- In Groundwater: PCE at 5 ug/L, 99.93% reduction

- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater:

- In Soil:

General comments on the thermal application:

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Lessons Learned

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

Total energy applied to treatment zone: ____________ kWhr/m³ ____________ kWhr/yd³

Other energy:

- Please note other energy:

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

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<tr>
<td>Type of Contaminant</td>
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<td>Treatment Status</td>
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<td>Primary point of contact</td>
<td>Travis Shaw</td>
</tr>
<tr>
<td>Organization</td>
<td>USACE - Seattle</td>
</tr>
<tr>
<td>Phone #</td>
<td>206-764-3527</td>
</tr>
<tr>
<td>OU# or Site #</td>
<td>East Gate Disposal Yard NAPL Area 1</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.): __________
  - 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: ______
  - 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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<td>Benzene</td>
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<td>0.01 mg/L</td>
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<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td></td>
<td>0.001 mg/L</td>
<td>None</td>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td></td>
<td>0.5 mg/L</td>
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<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
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<td></td>
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<td>Ethylbenzene</td>
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<td>None</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></td>
<td>1,1,1-trichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>0.01 mg/L</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethane</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
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<td>Vinyl chloride - deep</td>
<td>None</td>
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<td>0.001 mg/L</td>
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</tr>
</tbody>
</table>

**Comments:**

Post-treatment samples for 1,1,1-TCA and vinyl chloride in shallow - non-detect.
Post-treatment samples in cis-1,2-DCE, PCE, TCE, vinyl chloride in deep wells - non-detect.
Pre-treatment samples in 1,1,1-TCA and vinyl chloride in deep wells - non-detect.

**Attachments:**
### 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:
- 278 ft amsl

### Aquifer Characteristics:

#### Is more than 1 aquifer present?
- No
- Yes (number): _____________

#### 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):
- Unknown

#### K range (ft/day)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Low</th>
<th>High</th>
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<tbody>
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<td>Aquifer 1</td>
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<td>Slug Test</td>
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<tr>
<td>Aquifer 2</td>
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<td></td>
<td>Laboratory</td>
</tr>
<tr>
<td>Aquifer 3</td>
<td></td>
<td></td>
<td>Field data</td>
</tr>
</tbody>
</table>

#### Transmissivity (ft2/day):

<table>
<thead>
<tr>
<th>Zone</th>
<th>Low</th>
<th>High</th>
<th>Measured using</th>
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<tbody>
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<tr>
<td>Aquifer 3</td>
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<td></td>
<td>Field data</td>
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</tbody>
</table>

### 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:** 12/17/2003
  - Duration: 741 day

- **Hydraulic Control:**
  - Yes
  - No

- **Treatment Cell Design:**
  - Size of target zone (ft2): 75400
  - Thickness of target zone (ft): 36
  - Depth to top of target zone (ft bgs): 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:**

- **Formation temperature post-treatment monitoring event 1:**

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

- **Mass of contaminant removed:**
  - Via liquid pumping: 2.0785 lb
  - In vapor stream: 431.52 lb
  - Total: 4315.4 lb

- **Comments:**

- **Attachments:**
  - Total volume - 30900 yd^3

---

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

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 ERH Date: 11/15/2006
Type of treatment: Conductive Steam ERH Other: ________________
Type of Contaminant: x Chlorinated Solvents x Petroleum Hydrocarbons __ Pesticides
x Wood Treating __ Other: ________________
Treatment Status: Active x Post
Type of Test: x Pilot Test x Full Scale System
Start of Test: 2/14/2005 End of Test: 8/5/2005 Duration: 172 day
Type of Site: Non-DOD x 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): 250
- 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: 22
  - Post-treatment: 22
- Number of wells relative to treatment zone:
  - Pre-treatment: 11
  - Upgradient: 1
  - Downgradient: 6
  - Crossgradient: 2
- Post-treatment: 11
  - Upgradient: 1
  - Downgradient: 6
  - Crossgradient: 2

**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: 15
- Number outside treatment zone: 0

**Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
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<th>Other</th>
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<tbody>
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<td>Soil (mg/kg)</td>
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<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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**Comments:**

- None

**Attachments:**

- None
**Hydrogeologic Conceptual Model**

**Facility ID#:** 0863

---

### Unconsolidated Sediments

**Environmental Geology:**

**Ground surface elevation based on wells in or adjacent to treatment zone:** 278 ft amsl

**Are more than 1 aquifer present?**

- **No**
- **Yes (number):** _____________

**Number of aquifers:**

- **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**

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

- **Unknown**

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

- **low:** 24.2
- **high:** 200

**Transmissivity (ft²/day):**

- **Measured using:**
  - ** Slug Test**
  - **Laboratory**
  - **Field data**

**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:**

---
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 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 Zone:

x Saturated only

x Vadose only

x Both (Saturated and Vadose zones)

Start of Thermal Test: 2/14/2005

Duration: 172 day

Hydraulic Control: x Yes

x No

Treatment Cell Design:

Size of target zone (ft2): 22300

x Unknown (x x ft)

Thickness of target zone (ft): 52

x Unknown

Depth to top of target zone (ft bgs): 2

x Unknown

Thickness of target zone below water table (ft): 42

x Unknown

Number of energy delivery points: 101

x Unknown

Number of extraction points: 56

x Unknown

Temperature Profile:

Initial formation temperature (deg C): 17

x Unknown

Maximum representative formation temperature (deg C): 85

x Unknown

Time to reach maximum representative temperature (days): 152

x Unknown

Duration of treatment at representative temperature (days): 30

x 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:

x Via liquid pumping: 13826 Ib 245 kg

x In vapor stream: 1340 lb 11337 kg

Total: 14025 lb 12671 kg

Comments: 1089 kg - TCE, 245 kg - cis-1,2-DCE, 11337 kg - TPH = 12671 kg

Attachments:

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

Remediation Goal:

- x In Groundwater:
  Remove CVOCs to maximum extent practicable (No strict numerical goal)

- x In Soil:
  Same as above

Was the Remediation Goal Achieved:

- x In Groundwater
  Comment: Yes

- x In Soil
  Comment: Yes

General comments on the thermal application:

Performance goals: 100C in saturated zone, 90C 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

- x Energy

  - x Total energy used: 9,547,000 kWhr
  - x Total energy applied to treatment zone: 9,181,000 kWhr

  - x Other energy: Please note other energy:

Cost

- x Total Project Cost:

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

  Please note other cost:

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

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<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</th>
<th>11/15/2006</th>
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<td>Type of treatment:</td>
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<td>Wood Treating</td>
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<td>Treatment Status:</td>
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<td>Type of Test:</td>
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<td>Type of Site:</td>
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<td>Non-DOD</td>
<td>x</td>
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Facility Name: Ft. Lewis, Washington Area 3
Address: [REDACTED]
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: [REDACTED]
City, State, Zip Code: [REDACTED]
Phone #: 206-764-6918
email: kira.p.lynch@nws02.usace.army.mil

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

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

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<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 1</td>
<td>Benzene</td>
<td>Crossgradient</td>
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</tr>
<tr>
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<td>1,1-Dichloroethene 3</td>
<td>Naphthalene</td>
<td></td>
<td></td>
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<tr>
<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-Dichloroethene 4</td>
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<td>1,2-Dichloroethene 5</td>
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<td>1,3,5-trimethylbenzene</td>
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<td>Vinyl Chloride 7</td>
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<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### 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:** _______

### Chemicals of Concern

- **Number inside treatment zone:** _______
- **Number outside treatment zone:** _______

### 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:

- **278** 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><strong>Aquifer</strong></td>
<td><strong>1</strong></td>
<td><strong>2</strong></td>
<td><strong>3</strong></td>
</tr>
<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

- NW

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

- **Unknown**

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

- **Unknown**

### K range (ft/day)

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

### Transmissivity (ft²/day):

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

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:
- Size of target zone (ft2): 16200
- Thickness of target zone (ft): 30
- Depth to top of target zone (ft bgs): 0
- Thickness of target zone below water table (ft): 21
- Number of energy delivery points: 94
- Number of extraction points: 94

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

Date
Formation temperature immediately post-treatment: 1/27/2007 68
Duration of post-treatment monitoring (days): 186

Mass of contaminant removed:
- Via liquid pumping: __________________________ 0 lb 0 kg Unknown
- In vapor stream: __________________________ 0 lb 0 kg Unknown
- Total: __________________________ 0 lb 0 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:**

**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

<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>_____</td>
<td>Conductive</td>
<td>x</td>
<td>Steam</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>_____</td>
<td>Chlorinated Solvents</td>
<td>x</td>
<td>Petroleum Hydrocarbons</td>
</tr>
<tr>
<td>Treatment Status:</td>
<td>x</td>
<td>Wood Treating</td>
<td>_____</td>
<td>Other:</td>
</tr>
<tr>
<td>Type of Test:</td>
<td>x</td>
<td>Active</td>
<td>_</td>
<td>Post</td>
</tr>
<tr>
<td>Start of Test:</td>
<td>5/24/2004</td>
<td>End of Test:</td>
<td>ongoing</td>
<td>Duration:</td>
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<tr>
<td>Type of Site:</td>
<td>x</td>
<td>Non-DOD</td>
<td>_____</td>
<td>DoD</td>
</tr>
</tbody>
</table>

### Facility Name: Lake River Industrial Site

| Address: | Ridgefield, WA |
| City, State, Zip Code: | _____ |
| OU# or Site #: | _____ |

### Primary point of contact: Steve Taylor

| Organization: | _____ |
| Address: | _____ |
| City, State, Zip Code: | _____ |
| Phone #: | _____ | email: | _____ |

### Other contacts or vendors who worked on site

| 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

#### 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>

#### 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>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
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<td>1,1-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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Comments:

*Impacted area of 4 acres and may contain 100,000 gallons of wood-treating chemicals.*
### 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>
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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>
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<td></td>
<td>- Weathered bedrock, limestone, sandstone</td>
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</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>
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<td></td>
<td></td>
</tr>
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### Flow direction

<table>
<thead>
<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
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<th></th>
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<tr>
<td>Vertical hydraulic gradient (feet/foot):</td>
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### K range (ft/day)

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<thead>
<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>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>
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<td></td>
<td>Unknown</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
- Phase I
- 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:

Depth to top of target zone (ft)

Thickness of target zone below water table (ft)

Number of extraction points

Number of energy delivery points

Thickness of target zone (ft)

Size of target zone (ft²)

Deposms:

- In vapor stream:
- Via liquid pumping:
- Total:

Mass of contaminant removed:

<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.
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: 
  - Other Cost 1: 
  - Other Cost 2: 
  - Other Cost 3: 

Please note other cost:
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 _______ Full Scale System
Type of Test: _______ Pilot Test _______ Full Scale System
Start of Test: __________ End of Test: __________ Duration: __________
Type of Site: _______ Non-DOD _______ 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 _______ Other _______ Full Scale System
Organization: Navy
Address: Engineering Field Activity Northwest, Naval Facilities Engineering Command, 19917 7th Avenue NE Poulsbo, WA 98370
City, State, Zip Code: Washington
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:**

<table>
<thead>
<tr>
<th>Impacted Zone</th>
<th>Impacted 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>

#### 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>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>Tetrachloroethene</td>
<td>Hexane</td>
<td>Cross</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</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>None</td>
<td>None</td>
</tr>
<tr>
<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>Vinyl Chloride</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>
</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 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>
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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>Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</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:
- 35 ft amsl

### Aquifer Characteristics:

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

#### Depth to water:
- Low value (ft bgs): 100
- High value (ft bgs): _____________
-Unknown: _____________

### Flow direction

- SE

### 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>
- Unknown

### 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>
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<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Unknown

### Comments:

- _____________________________
- _____________________________

### Attachments:

- _____________________________
- _____________________________
- _____________________________
- _____________________________
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Facility ID#: 0880</th>
</tr>
</thead>
</table>

**Thermal Treatment:**

- [x] Conductive
- [ ] Electrical Resistance
  - [ ] 3 phase
  - [ ] 6 phase
  - [x] AC power
  - [ ] DC power
- [x] 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
- [ ] 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
- [ ] Vadose only
- [x] Both (Saturated and Vadose zones)

**Start of Thermal Test:**
- Jul-96
- Duration: 9 months

**Hydraulic Control**
- [x] 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): 50
  - Unknown
- Thickness of target zone below water table (ft): 10
  - Unknown
- Number of extraction points: 3
  - Unknown
- Number of energy delivery points: 2
  - 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>
</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: 35,000 gal ___ lb ___ kg 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.
System was expanded in August 1997

Lessons Learned

cost during 1st nine months = $61/yd³

General comments on the thermal application:

Was the Remediation Goal Achieved:

In Groundwater

Comment:

In Soil

Comment:

Remediation Goal:

In Groundwater:

In Soil:

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: 

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 

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 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:** 0881

<table>
<thead>
<tr>
<th>Impacted Zone:</th>
<th>Length (parallel to flow direction)(ft.):</th>
<th>Width (ft.):</th>
<th>Thickness (ft.):</th>
<th>Map attachment</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)

**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

#### Chlorinated Solvents

<table>
<thead>
<tr>
<th>Chemical</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>Average Groundwater (mg/L)</td>
<td>Average Soil (mg/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average Groundwater (mg/L)</td>
<td>Average Soil (mg/kg)</td>
</tr>
</tbody>
</table>

- Trichloroethene
- Tetrachloroethene
- 1,1-dichloroethene
- cis-1,2-dichloroethene
- trans-1,2-dichloroethene
- 1,1,1-trichloroethane
- 1,1,2-trichloroethane
- 1,1,2,2-tetrachloroethane
- Vinyl Chloride

- Benzene
- Jet Fuel
- No. 6 Fuel Oil
- Diesel
- Toluene
- Ethylbenzene
- m,p-xylene
- o-xylene

**Comments:**

- Additional comments...

**Attachments:**

- Additional attachments ...

---

**Facility ID:** 0881
## Hydrogeologic Conceptual Model

### Facility ID#:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone</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:

-35 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>Depth to water:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low value (ft bgs):</td>
<td>100</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):

- 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>
<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  

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:  
- Aug-97  

Duration:  
- 2 years 1 month  

Hydraulic Control  
- Yes  
- No  

Treatment Cell Design:  
Size of target zone (ft²):  
Thickmess 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:  

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:**

The system ended in Sept. 199 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.

### 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:**
  - **Energy Cost:**
- **Other Cost 1:**
- **Other Cost 2:**
- **Other Cost 3:**
  - **Please note other cost:**
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: May-99 End of Test: Aug-99 Duration: 75 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: __________ 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:** [000]

#### 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: __________

  - 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 Groundwater (mg/L) Soil (mg/kg)</th>
<th>Average Post-treatment Concentration per Groundwater (mg/L) Soil (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>BTEX</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>
<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>
</tr>
</tbody>
</table>

- **Comments:**
  - __________
  - __________
  - __________

- **Attachments:**
  - __________
  - __________
  - __________
### Unconsolidated Sediments

<table>
<thead>
<tr>
<th>Zone</th>
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<tbody>
<tr>
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<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:

- 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></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>
</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

- Transmissivity (ft²/day):

- Measured using: Slug Test  Laboratory  Field data

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

- ft amsl

- Unknown

### Attachments:

____________________________________________________________________________________________
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### Comments:

____________________________________________________________________________________________

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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:  

May-99

Duration: 75 d

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

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:

Attachments:

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

- **In Groundwater:**
  - PCE = 5 ug/L

- **In Soil:**
  - PCE = 500 ug/kg

**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:
  - 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 X Steam ERH Other: __________
Type of Contaminant: _ Chlorinated Solvents _ Petroleum Hydrocarbons _ Pesticides
X Wood Treating Other: __________
Treatment Status: _ Active _ Post
Type of Test: X Pilot Test _ Full Scale System
Start of Test: 10/1/2002 End of Test: 4/15/2003 Duration: 6.5 months
Type of Site: _ Non-DOD X DoD

Facility Name: Wyckoff / Eagle Harbor
City, State, Zip Code: Bainbridge Island, Washington
OU# or Site #: Former Process Area

Primary point of contact: Mary Jane Nearman
Organization: EPA
City, State, Zip Code: ________________________________
Phone #: 206-553-6642 email: ________________________________

Other contacts or vendors who worked on site
Point of contact: Matt Allen
Type: X Vendor, Consultant _ Vendor, Technical Applications _ Other __________
Organization: US Army Corp of Engineers
City, State, Zip Code: ________________________________
Phone #: 206-764-3697 email: matthew.s.allen@usace.army.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.): X
  - 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: X
  - Pre-treatment: 15
  - Post-treatment: 15
  - Number of wells relative to treatment zone:
    - Pre-treatment: In: 14, Upgradient: ___, Downgradient: ___, Crossgradient: ___
    - Post-treatment: In: 14, Upgradient: ___, Downgradient: ___, Crossgradient: ___

- **Soil Borings**: Number of relevant soil borings with post-treatment data: 15
  - 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>Cross</td>
<td>None</td>
<td>None</td>
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<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>Toluene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
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<td>None</td>
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<tr>
<td></td>
<td>1,1-dichloroethane</td>
<td>m/p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,2-dichloroethane</td>
<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1,1,1-trichloroethane</td>
<td>Toluene</td>
<td></td>
<td>None</td>
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<tr>
<td></td>
<td>1,2,2-trichloroethane</td>
<td>Toluene</td>
<td></td>
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<td></td>
<td>Vinyl Chloride</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

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.*
### 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>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></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:**  
fl amsl  Unknown

### Aquifer Characteristics:

<table>
<thead>
<tr>
<th>Is more than 1 aquifer present?</th>
<th>No</th>
<th>X</th>
<th>Yes (number): 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown (assume single aquifer)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
</table>
| Depth to water:  
  low value (ft bgs): | 6 | 80 | 200 |
| high value (ft bgs): | 10 | 200 | 1500+ |
| Unknown: | | | |

### Flow direction

<table>
<thead>
<tr>
<th>Radially toward End</th>
<th>Harbor and Puget Sound</th>
</tr>
</thead>
</table>

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

| X | Unknown |

### 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>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>10</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>

**Average K=26 ft/day.  Vertical anisotropy = 4.7**

### 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:**
  - Date
  - 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):
  - Date
  - Temperature (deg C)

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

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

**Facility ID#: 0900**
Cost and Performance

Facility ID#: 0900

X Performance

Remediation Goal:

X In Groundwater: Meet Puget Sound marine water quality and surface water quality.

X 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

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General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date:</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 Site:</td>
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<td>Non-DOD</td>
<td>x</td>
<td>DoD</td>
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<tr>
<td>Treatment Status:</td>
<td>x</td>
<td>Active</td>
<td>x</td>
<td>Post</td>
</tr>
<tr>
<td>Type of Test:</td>
<td>x</td>
<td>Pilot Test</td>
<td>x</td>
<td>Full Scale System</td>
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<tr>
<td>Start of Test:</td>
<td>Nov-00</td>
<td>End of Test:</td>
<td>Mar-01</td>
<td>Duration: 4 months</td>
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<td>Organization:</td>
<td>WI Department of Natural Resources</td>
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<td></td>
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</tr>
<tr>
<td>Address:</td>
<td>Delevan Municipal Well No. 4</td>
<td>Delevan Municipal Well No. 4</td>
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<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Delevan, WI</td>
<td>Delevan, WI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onion:</td>
<td>15 Pilgram Road</td>
<td>15 Pilgram Road</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phone #:</td>
<td>920-892-8756 x 3028</td>
<td>920-892-8756 x 3028</td>
<td></td>
<td></td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:wentlt@dnr.state.wi.us">wentlt@dnr.state.wi.us</a></td>
<td><a href="mailto:wentlt@dnr.state.wi.us">wentlt@dnr.state.wi.us</a></td>
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</table>

QA/QC

<table>
<thead>
<tr>
<th>Characteristics of Interest</th>
<th>Characteristics of Interest</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

<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></td>
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</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>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
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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>
</tr>
</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Post-treatment</th>
<th>In:</th>
<th>Upgradient:</th>
<th>Downgradient:</th>
<th>Crossgradient:</th>
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<tbody>
<tr>
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<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with groundwater data:</th>
<th>Number inside treatment zone:</th>
<th>Number outside treatment zone:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

**Number of relevant soil borings with pre-treatment data:**

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

**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>
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</table>

<table>
<thead>
<tr>
<th>Post-treatment</th>
<th>In:</th>
<th>Upgradient:</th>
<th>Downgradient:</th>
<th>Crossgradient:</th>
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</thead>
<tbody>
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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>
</tr>
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<tbody>
<tr>
<td></td>
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</table>

#### Chlorinated Solvents

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Pre-treatment Concentration</th>
<th>Post-treatment Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

- **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 at 16 ft**
- **Total VOCs at 20 ft**
- **Total VOCs at 24 ft**
- **Total VOCs at 26 ft**
- **Total VOCs**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
<th>Pre-treatment Concentration</th>
<th>Post-treatment Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Average Pre-treatment Concentration per Chemical**

**Average Post-treatment Concentration per Chemical**

- **Groundwater (mg/L)**
- **Soil (mg/kg)**

**Average Pre-treatment Concentration per Chemical**

**Average Post-treatment Concentration per Chemical**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
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<th>Post-treatment Concentration</th>
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<tbody>
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<td></td>
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</table>

**Comments:**

- [Additional comments related to site assessment data]

**Attachments:**

- [Related attachments for general site assessment data]
Unconsolidated Sediments

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?  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: ___________  ___________  ___________  ___________  Unknown

Transmissivity (ft^2/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 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:**
- 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>
<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:**

1540 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:**

**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/m³  
- __kWh/yd³

**Other energy:**

- __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:**
### General Site Information

<table>
<thead>
<tr>
<th>File Analyzed By:</th>
<th>JT</th>
<th>PD</th>
<th>Date: 10/30/2006</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</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>End of Test:</td>
<td>Duration: 60 d</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>Non-DOD</td>
<td>DoD</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Confidential, Racine, WI</th>
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</thead>
<tbody>
<tr>
<td>Address:</td>
<td>____________________________</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Racine, WI</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>
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<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>Mark M. Mejac</td>
</tr>
<tr>
<td>Type:</td>
<td>Vendor, Consultant, Vendor, Technical Applications, Other</td>
</tr>
<tr>
<td>Organization:</td>
<td>STS Consulting</td>
</tr>
<tr>
<td>Address:</td>
<td>11425 West lake Park Drive</td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Milwaukee, WI 53224-3025</td>
</tr>
<tr>
<td>Phone #:</td>
<td>414-359-3030</td>
</tr>
<tr>
<td>email:</td>
<td><a href="mailto:mejac@stsconsultants.com">mejac@stsconsultants.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

**Length (parallel to flow direction)(ft.):** __________  **Width (ft.):** __________  **Thickness (ft.):** 18 to 24  **Unknown**

1. **Impacted zone as defined by documentation**
2. **Alternative method for determining size of impacted zone (See source zone definition attachments)**
3. **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>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>None</td>
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<tr>
<td></td>
<td>cis,1,2-dichloroethene</td>
<td>Benzene</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
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<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
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<td>None</td>
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<td>1,1-dichloroethylene</td>
<td>Ethylbenzene</td>
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<td>1,2-dichloroethene</td>
<td>m/p-xylene</td>
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<td>o-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>1,1,2-trichloroethylene</td>
<td>Tetrachloroethene</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 area - 10,500 ft² to depth ranging between 18 and 24 ft (ie 7200 yd³ impacted)

**Attachments:**

______________________________________________________________________________________________________________________________

______________________________________________________________________________________________________________________________

______________________________________________________________________________________________________________________________

______________________________________________________________________________________________________________________________

______________________________________________________________________________________________________________________________
## Hydrogeologic Conceptual Model

### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vadose Zone:</td>
<td>1. Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>2. Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>3. Largely permeable sediments with inter-bedded lenses of lower permeability material</td>
</tr>
<tr>
<td></td>
<td>4. Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>5. Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>6. Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td>Saturated Zone:</td>
<td>1. Relatively homogeneous and permeable unconsolidated sediments</td>
</tr>
<tr>
<td></td>
<td>2. Relatively homogeneous and impermeable unconsolidated sediments</td>
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</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 (ft bgs):</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>1</td>
<td>Low (+5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>High (+5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Measured using:**
- Slug Test
- Laboratory
- Field data

**K range (ft/day):**
- Low: __________ Unknown
- High: __________

**Transmissivity (ft²/day):**
- Low: __________ Unknown
- High: __________

### Comments:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

## Facility ID:

0915

---

*Unconsolidated Sediments Geology:

- Unknown

*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)

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</tbody>
</table>

**Measured using:**
- Slug Test
- Laboratory
- Field data

**K range (ft/day):**
- Low: __________ Unknown
- High: __________

**Transmissivity (ft²/day):**
- Low: __________ Unknown
- High: __________

---

*Unconsolidated Sediments Geology:

- Unknown

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

- __________ ft amsl
- __________ Unknown

*Aquifer Characteristics:

- **Is more than 1 aquifer present?**
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  - Yes (number): __________ Unknown (assume single aquifer)

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<td>Unknown</td>
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<td></td>
</tr>
</tbody>
</table>

**Measured using:**
- Slug Test
- Laboratory
- Field data

**K range (ft/day):**
- Low: __________ Unknown
- High: __________

**Transmissivity (ft²/day):**
- Low: __________ Unknown
- High: __________

---

*Unconsolidated Sediments Geology:

- Unknown

*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 (ft bgs):</th>
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<th>Horizontal hydraulic gradient (feet/foot):</th>
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<td>Unknown</td>
<td></td>
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</tbody>
</table>

**Measured using:**
- Slug Test
- Laboratory
- Field data

**K range (ft/day):**
- Low: __________ Unknown
- High: __________

**Transmissivity (ft²/day):**
- Low: __________ Unknown
- High: __________

---

*Unconsolidated Sediments Geology:

- Unknown

*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>
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<tr>
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<tr>
<td>3</td>
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</tbody>
</table>

**Measured using:**
- Slug Test
- Laboratory
- Field data

**K range (ft/day):**
- Low: __________ Unknown
- High: __________

**Transmissivity (ft²/day):**
- Low: __________ Unknown
- High: __________
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:  

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:

Spacing 23'

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: 215 kWhr/yd³ kWhr/m³ kWhr/yd³

Total energy applied to treatment zone: 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:
<table>
<thead>
<tr>
<th>Facility Name:</th>
<th>Volk Airfield National Guard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City, State, Zip Code:</td>
<td>Camp Douglas, WI</td>
</tr>
<tr>
<td>OU# or Site #:</td>
<td></td>
</tr>
</tbody>
</table>

| 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:                                 |     |

<table>
<thead>
<tr>
<th>QA/QC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics of Interest</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>Hydraulic Conductivity information</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>
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<tbody>
<tr>
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<td>Soil (mg/kg)</td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</td>
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<tr>
<td></td>
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<tr>
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<td>None</td>
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<td>1,1,1-trichloroethane</td>
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</tr>
<tr>
<td>Vinyl Chloride</td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

### Comments:

- [Note: Fill in comments as applicable]

### Attachments:

- [Note: Attach relevant documents as applicable]
## Geology: Unconsolidated Sediments

<table>
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<tr>
<th>Zone</th>
<th>Vadose Zone</th>
<th>Saturated Zone</th>
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<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>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>
<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>

### 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></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **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):**
  - **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:

- **ft amsl:** ___________  
- **Unknown:**

### Facility ID:

- **0920**

### Geology:

- **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**
- **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**
- **Weathered bedrock, limestone, sandstone**

### Attachments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

### Comments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

### Attachments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
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:  

Duration:  

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:  

Size of target zone (ft²): 72
Thickness of target zone (ft): 2
Depth to top of target zone (ft bgs): 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): x
Maximum representative formation temperature (deg C): 150
Time to reach maximum representative temperature (days): 8
Duration of treatment at representative temperature (days): 4

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: x lb x kg Unknown
In vapor stream: x lb x kg Unknown
Total: x lb x kg x

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:

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: ___________
General Site Information

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:  
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  
□ None

Organization:  
________________________________________________________________________

Address:  
________________________________________________________________________

City, State, Zip Code:  Great Barrington, MA 01230
Phone #:  413-528-4651  
email: rkasevich@ksnenergies.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:** 0930

#### 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: 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: ______

#### 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>
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#### Comments:

- None

#### Attachments:

- None
### Ground surface elevation based on wells in or adjacent to treatment zone:

<table>
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<th>Zone</th>
<th>Value</th>
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<tbody>
<tr>
<td>Vadose Zone</td>
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<tr>
<td>Saturated Zone</td>
<td>0 ft amsl</td>
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</tbody>
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### 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>Depth to water (ft bgs)</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
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<tbody>
<tr>
<td>Low</td>
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<tr>
<td>High</td>
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<tr>
<td>Unknown</td>
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</table>

### Flow direction

- Unknown

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

- Unknown

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

- Unknown

### K range (ft/day)

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<thead>
<tr>
<th>Measured using</th>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
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<tbody>
<tr>
<td>Slug Test</td>
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<tr>
<td>Laboratory</td>
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<tr>
<td>Field data</td>
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</tbody>
</table>

<table>
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<tr>
<th>Measured using</th>
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<td></td>
<td></td>
</tr>
<tr>
<td>Field data</td>
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### Transmissivity (ft²/day)

<table>
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<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slug Test</td>
<td></td>
<td></td>
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</tr>
<tr>
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<table>
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<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
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<tbody>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Field data</td>
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</tr>
</tbody>
</table>

### Attachments:

- None

### Comments:

- None

### Facility ID:

0930

### Unconsolidated Sediments

- Weathered bedrock, limestone, sandstone
- 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
Thermal Treatment - Design

X Thermal treatment: ______ Conductive

X Electrical Resistance

____ 3 phase ______ 6 phase ______ AC power ______ DC power

____ Steam

____ Steam ______ Steam + air ______ Steam + O2

X Other (describe) ______ RFH

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

Geology of Treatment Zone:

____ Relatively homogeneous and permeable unconsolidated sediments

____ 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

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

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

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

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  x  PD  Date:  10/18/2006
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:  x  Pilot Test  Full Scale System
Start of Test:  1-Nov  End of Test:  1-Jun  Duration:  9 months
Type of Site:  x  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:  x  Vendor, Consultant  Other
Organization:  Kaizen Environmental Services
Address:  
City, State, Zip Code:  
Phone #:  403-297-0216  (1-888-525-5902)  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><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>
</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><strong>Monitor Wells:</strong></th>
<th>Number of relevant monitoring wells with groundwater data:</th>
<th><strong>Pre-treatment:</strong></th>
<th><strong>Post-treatment:</strong></th>
</tr>
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<tbody>
<tr>
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- None

<table>
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<tr>
<th><strong>Soil Borings:</strong></th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th><strong>Pre-treatment:</strong></th>
<th><strong>Post-treatment:</strong></th>
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- None

<table>
<thead>
<tr>
<th><strong>Number relative to treatment zone:</strong></th>
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</thead>
<tbody>
<tr>
<td>Pre-treatment</td>
</tr>
<tr>
<td>Post-treatment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Chemicals of Concern</strong></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Types of Contaminants</strong></th>
</tr>
</thead>
</table>

<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>Chlorinated Solvents</td>
<td>Petroleum Hydrocarbons</td>
<td>Other</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></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>BTEX</td>
<td></td>
<td>None</td>
<td>None</td>
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<tr>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
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<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>None</td>
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<td>1,2-dichloroethene</td>
<td>m+p-xylene</td>
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<td>1,1,1-trichloroethane</td>
<td>α-xylene</td>
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</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>xylenes</td>
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<td>None</td>
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</tr>
<tr>
<td>Vinyl Chloride</td>
<td>xylenes</td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Facility ID #:** 0940

**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

### Aquifer Characteristics:

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

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

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

### Aquifer 1, Aquifer 2, Aquifer 3:

- **Depth to water:**
  - Low value (ft bgs): 13
  - High value (ft bgs): __________
  - Unknown: __________

- **Flow direction:**
  - __________

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

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

### K range (ft/day)

- **Measured using:**
  - Field data
  - Laboratory
  - Slug Test
- **K range (ft/day):**
  - Low: __________
  - High: __________

### Transmissivity (ft²/day):

- **Measured using:**
  - Field data
  - Laboratory
  - Slug Test
- **Transmissivity (ft²/day):**
  - Low: __________
  - High: __________

**Comments:**

- **K = 10E-6 cm/s**

**Attachments:**

- __________
- __________
- __________
- __________
Thermal Treatment - Design

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
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<tbody>
<tr>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Thermal Test Details*

- Type of Test: Pilot test, Full-scale System
- Geology of Treatment Zone: Relatively homogeneous and permeable unconsolidated sediments, Competent, but fractured bedrock (i.e. crystalline rock)
- Treatment Target Zone: Saturated only
- Hydraulic Control: Yes
- Start of Thermal Test: 1-Nov
- Duration: 9 months
- 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>

- Mass of contaminant removed:
  - Via liquid pumping: Unknown
  - In vapor stream: Unknown
  - Total: 204000 lb, kg

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

Facility ID#: 0940

Performance

Remediation Goal:

- In Groundwater: source reduction target >95% total recovery
- In Soil:

Was the Remediation Goal Achieved:

- In Groundwater
  Comment: >99.99% source reduction, all MCLs met
- In Soil
  Comment:

General comments on the thermal application:

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

Lessons Learned

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

Energy

Total Energy Used: ___________ 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: __________________________

- 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: 10/26/2006

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: 
End of Test: 
Duration: 

Type of Site: 
- Non-DOD
- DoD

Facility Name: Safety Kleen
Address: 
City, State, Zip Code: Breslau, Ontario, Canada
OU# or Site #: 

Primary point of contact: Lynn Longshore
Organization: Safety Kleen Environmental Health and Safety
Address: 
City, State, Zip Code: 
Phone #: 18006695740
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: None
  - 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 of relevant soil borings with post-treatment data: __________

- **Types of Contaminants**

<table>
<thead>
<tr>
<th>Chemicals of Concern</th>
<th>Average Pre-treatment Concentration per Chemical</th>
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<td>Soil (mg/kg)</td>
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<td>n-xylene</td>
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<tr>
<td>Other</td>
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</table>

- **Facility ID#:** 1000

**Comments:**

____________________________________________________________________

____________________________________________________________________

______________________________

**Attachments:**

____________________________________________________________________

____________________________________________________________________

______________________________
### Geology:

<table>
<thead>
<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>
</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>
</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>

| 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 above mean sea level (ft amsl)
- High: ________ ft amsl
- Unknown: ________ 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>
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<table>
<thead>
<tr>
<th>Aquifer 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</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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<tr>
<td>high value (ft bgs):</td>
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<td>Unknown:</td>
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<table>
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<tr>
<th>Flow direction</th>
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<table>
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<tr>
<th>Horizontal hydraulic gradient (feet/foot):</th>
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<tbody>
<tr>
<td>Measured using:</td>
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<td>Slug Test</td>
</tr>
<tr>
<td>Laboratory</td>
</tr>
<tr>
<td>Field data</td>
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<tr>
<td>low</td>
</tr>
<tr>
<td>high</td>
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<table>
<thead>
<tr>
<th>Vertical hydraulic gradient (feet/foot):</th>
</tr>
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<td>Measured using:</td>
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<table>
<thead>
<tr>
<th>K range (ft/day)</th>
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<tr>
<td>Measured using:</td>
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<td>Slug Test</td>
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<td>high</td>
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<thead>
<tr>
<th>Transmissivity (ft²/day)</th>
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<th>Comments:</th>
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<th>Attachments:</th>
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<td>-------------</td>
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<tr>
<td>-------------</td>
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</table>
Thermal Treatment - Design

Facility ID: 1000

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:  
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: 4  
Number of extraction points: 6  

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:

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

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<thead>
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<th>X</th>
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<th>PD</th>
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<td>Steam</td>
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<tr>
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<td>Type of Contaminant:</td>
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<td>Chlorinated Solvents</td>
<td>___</td>
<td>Petroleum Hydrocarbons</td>
</tr>
<tr>
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<td>Treatment Status:</td>
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<td>___</td>
<td>Post</td>
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<tr>
<td></td>
<td>Type of Test:</td>
<td>X</td>
<td>Pilot Test</td>
<td>___</td>
<td>Full Scale System</td>
</tr>
<tr>
<td></td>
<td>Start of Test:</td>
<td>Aug-99</td>
<td>End of Test:</td>
<td>1-Sep</td>
<td>Duration:</td>
</tr>
<tr>
<td></td>
<td>Type of Site:</td>
<td>X</td>
<td>Non-DOD</td>
<td>___</td>
<td>DoD</td>
</tr>
</tbody>
</table>

|   | Facility Name: | Muehlacher Germany | Address: | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ |
|   | OU# or Site #: | ___ | City, State, Zip Code: | Muehlacher Germany | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ | ___ |

|   | 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 | Type: | ___ | Vendor, Consultant | ___ | Vendor, Technical Applications | ___ | Other | ___ | ___ | ___ | ___ | ___ | ___ |
|   | 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:**

<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>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Borings:</th>
<th>Number of relevant soil borings with pre-treatment data:</th>
<th>Number outside treatment zone:</th>
</tr>
</thead>
<tbody>
<tr>
<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>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></td>
<td></td>
<td></td>
<td>Groundwater (mg/L)</td>
<td>Soil (mg/kg)</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>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td></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></td>
<td></td>
<td></td>
<td>None</td>
<td>None</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>
<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>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</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>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>None</td>
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</tr>
</tbody>
</table>

### Comments:

<table>
<thead>
<tr>
<th>Attachments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Facility ID:**

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

### 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)

### 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>

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

### Comments:

- ______________________________________________________________________________________
- ______________________________________________________________________________________
- ______________________________________________________________________________________

### Attachments:

- ______________________________________________________________________________________
- ______________________________________________________________________________________
- ______________________________________________________________________________________
### Thermal Treatment - Design

*Facility ID#: 1010*

<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>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam + air</td>
</tr>
<tr>
<td>Steam + O2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other (describe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weathered bedrock, limestone, sandstone</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 impermeable sediments with inter-bedded layers of higher permeability material</td>
</tr>
<tr>
<td></td>
<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
<td>Competent, but fractured bedrock (i.e. crystalline rock)</td>
</tr>
<tr>
<td></td>
<td>Largely permeable sediments with inter-bedded lenses of lower permeability material</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>Aug-99</td>
<td>Duration: ~2 years</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Cell Design:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of target zone (ft²):</td>
<td>4024</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone (ft):</td>
<td>26-2</td>
<td>Unknown</td>
</tr>
<tr>
<td>Depth to top of target zone (ft bgs):</td>
<td>23</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thickness of target zone below water table (ft):</td>
<td>0</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of energy delivery points:</td>
<td>1</td>
<td>Unknown</td>
</tr>
<tr>
<td>Number of extraction points:</td>
<td>6</td>
<td>Unknown</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>

**Comments:**

Treated approximately 3000 m³ (3924 yd³)

**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>In Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>______________________________</td>
<td>______________________________</td>
</tr>
</tbody>
</table>

**Was the Remediation Goal Achieved:**

<table>
<thead>
<tr>
<th>In Groundwater</th>
<th>In Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>______________________________</td>
<td>______________________________</td>
</tr>
</tbody>
</table>

**General comments on the thermal application:**

<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>

**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

**Total Energy Used:**

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

**Total energy applied to treatment zone:**

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

**Other energy:**

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

**Please note other energy:**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>______________________________</td>
</tr>
</tbody>
</table>

### Cost

**Total Project Cost:** 950,900

<table>
<thead>
<tr>
<th>Consultant Cost</th>
<th>Thermal Vendor Cost</th>
<th>Energy Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>______________________________</td>
<td>290.81 / yd³</td>
<td>______________________________</td>
</tr>
</tbody>
</table>

**Other Cost 1:**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>______________________________</td>
</tr>
</tbody>
</table>

**Other Cost 2:**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>______________________________</td>
</tr>
</tbody>
</table>

**Other Cost 3:**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>______________________________</td>
</tr>
</tbody>
</table>
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: 9/26/2001 End of Test: 4/30/2002 Duration: 217 d

Type of Site: 
- Non-DOD
- DoD

Facility Name: North Hill Manor

Address: 
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 
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

#### 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 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>Crossdye</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>0.1 mg/L</td>
<td>1 mg/kg</td>
<td>0.001 mg/L</td>
</tr>
<tr>
<td>trans,1,2-dichloroethene</td>
<td>Toluene</td>
<td></td>
<td>0.01 mg/L</td>
<td>0.5 mg/kg</td>
<td>0.001 mg/L</td>
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<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
<td></td>
<td>0.05 mg/L</td>
<td>5 mg/kg</td>
<td>0.001 mg/L</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>1,1,1-trichloroethene</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>
<td>xylenes</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,2,2-tetrachloroethene</td>
<td>TPH</td>
<td></td>
<td>1 mg/L</td>
<td>500 mg/kg</td>
<td>0.1 mg/L</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</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>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?**
  - X Unknown (assume single aquifer)

- **Depth to water:**
  - low value (ft bgs): 14.1
  - high value (ft bgs): 16.7

- **Flow direction:**
  - West

- **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
  - high

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

### Comments:

- k=10⁻⁶ cm/s

### Attachments:

- 
- 
- 
- 
- 

---

*Facility ID#: 1010*
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 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:  
9/26/2001  
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 bgs): 8  
Thickness of target zone below water table (ft): 5  
Number of energy delivery points: 10  
Number of extraction points: 35

Temperature Profile:
Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C): 78  
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: 1740 Liters  
Total:

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:

- In Groundwater:
  - 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:

- In Groundwater
  - Comment: Yes

- In Soil
  - Comment: Yes

General comments on the thermal application:

_____________________________________________________________________________________________________

_____________________________________________________________________________________________________

_____________________________________________________________________________________________________

_____________________________________________________________________________________________________

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

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: 8/14/2003 End of Test: 3/xx/04 Duration: ______

Type of Site: Non-DOD DoD

Facility Name: Rosslyn Turbo

Address: ______

City, State, Zip Code: Edmonton, Canada

OU# or Site #: ______

Primary point of contact: Randall Warren

Organization: Shell Canada Products, Ltd

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 Products, Ltd

Address: ______

City, State, Zip Code: ______

Phone #: 403-216-5558 403-560-4340 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

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

**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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<tbody>
<tr>
<td></td>
<td>Trichloroethene</td>
<td>Benzene</td>
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<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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<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>cis-1,2-dichloroethene</td>
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<td>trans-1,2-dichloroethene</td>
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<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>
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<td>1,1,2-trichloroethene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Groundwater (mg/L) Soil (mg/kg)**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Groundwater</th>
<th>Soil</th>
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<tbody>
<tr>
<td></td>
<td>Groundwater</td>
<td>Soil</td>
</tr>
<tr>
<td>Benzene</td>
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<td>None</td>
</tr>
<tr>
<td>Jet Fuel</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Benzene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Toluene</td>
<td>None</td>
<td>None</td>
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<tr>
<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>o-xylene</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Crossgradient:**
- Impacted area of 1500 m³

**Comments:**

**Attachments:**

- Impacted area of 1500 m³

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None

- None
### 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>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>

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

### Aquifer Characteristics

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

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

K=10E-6 cm/s

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>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Steam</th>
<th>3 phase</th>
<th>6 phase</th>
<th>AC power</th>
<th>DC power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<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>
</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>
<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>
</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>
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</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.
Please note other energy:

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 costs:  Other Cost 1:

   Other Cost 2:

   Other Cost 3:
General Site Information

File Analyzed By: JT x PD  
Type of treatment:  
Conductive  x Steam  ERH  Other:  RFH
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  x 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:  

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: __________
  - Post-treatment: __________
- Number of wells in treatment zone:
  - 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: __________

### Types of Contaminants

<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>Groundwater (mg/L)</th>
<th>Soil (mg/kg)</th>
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<tbody>
<tr>
<td>Tetrachloroethene</td>
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<td>Crossgradient</td>
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<tr>
<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>
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</table>

### 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>
<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)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth to water (ft bgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>high</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  
  - [ ] high  
  - [ ] Unknown

- [ ] Transmissivity (ft/day) Measured using:  
  - [ ] Slug Test  
  - [ ] Laboratory  
  - [ ] Field data  
  - [ ] low  
  - [ ] high  
  - [ ] Unknown

### Facility ID:

- [ ] 1050

#### 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

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 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:  

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):  

Size of target zone (ft²):  

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

Start of Thermal Test:  

Duration:  

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:  

In vapor stream:  

Total:  

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: 

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: 

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

Facility Name: UK Atomic Energy Authority's Harwell Site
Address: 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: 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:**

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

- Impacted zones 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: ___

#### 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>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>0.1 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrahydrocarbon</td>
<td>0.01 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>0.005 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>0.05 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>0.01 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichlorobenzene</td>
<td>0.05 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2,2-trichloroethane</td>
<td>0.01 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>0.05 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichlorobenzene</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>0.5 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>0.1 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</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>0.005 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>0.005 mg/L</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:

- ____________________________________________________________________________________

#### Attachments:

- ____________________________________________________________________________________
### 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>Relatively homogeneous and permeable unconsolidated sediments</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>
<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>
<td>Weathered bedrock, limestone, sandstone</td>
</tr>
<tr>
<td></td>
<td>Weathered bedrock, limestone, sandstone</td>
<td></td>
</tr>
</tbody>
</table>

#### Aquifer Characteristics

- **Is more than 1 aquifer present?**
  - **No**
  - **Yes (number):** 1
  - **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>16.4</td>
<td>75.5</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>low value (ft bgs):</td>
<td>high value (ft bgs):</td>
<td>Unknown:</td>
</tr>
</tbody>
</table>

#### Flow direction

- **below**

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

- **Unknown**

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

- **Unknown**

#### K range (ft/day)

- **Measured using: Slug Test**
  - **low**
  - **high**

- **Laboratory**
  - **Field data**
  - **Unknown**

#### Transmissivity (ft²/day):

- **Measured using: Slug Test**
  - **low**: 6458
  - **high**

- **Laboratory**
  - **Field data**
  - **Unknown**

### Comments:

- **Flow direction for high groundwater levels - N to NE**
- **for low groundwater levels - E to SE**

### Attachments:

- 
- 
- 
- 
- 

---

Facility ID#: 1060

---
Thermal Treatment - Design

Facility ID#: 1060

Thermal treatment: Conductive

Electrical Resistance

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)

Treatment Target Zone:

- Saturated only
- Vadose only
- Both (Saturated and Vadose zones)

Start of Thermal Test: 12/5/2005

Duration: 36d

Essential Environment:

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): Unknown

Maximum representative formation temperature (deg C): 90 Unknown

Time to reach maximum representative temperature (days): 60 Unknown

Duration of treatment at representative temperature (days): 1 Unknown

Formation temperature immediately post-treatment:

Formation temperature post-treatment monitoring event 1:

Duration of post-treatment monitoring (days): 36

Mass of contaminant removed:

Via liquid pumping: lb kg Unknown

In vapor stream: lb kg Unknown

Total: 214 lb kg Unknown

Comments:

Total volume treated - 36.2 cubic meters (46 yd³, 1243 ft³)

2.5 m spacing of heater wells (16 ft)

Attachments:

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

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>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>___ Conductive</td>
<td>x Steam</td>
<td>ERH</td>
</tr>
<tr>
<td>Type of Contaminant:</td>
<td>x 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>x Full Scale System</td>
<td></td>
</tr>
<tr>
<td>Start of Test:</td>
<td>Jan-01</td>
<td></td>
<td>End of Test:</td>
</tr>
<tr>
<td>Type of Site:</td>
<td>x Non-DOD</td>
<td>____ DoD</td>
<td></td>
</tr>
</tbody>
</table>

Facility Name: Prague, Czech

City, State, Zip Code: Czech Republic

OU# or Site #: |

Primary point of contact: Pavel Dusilek

Organization: AQUATEST

Address: |

Phone #: 420 234 607 151 email: dusilek@aquatest.cz

Other contacts or vendors who worked on site | None |

Point of contact: Petr Kvapil

Type: x Vendor, Consultant | Vendor, Technical Applications | Other |

Organization: AQUATEST

Address: |

Phone #: 420 485 152 652 email: kvapil@aquatest.cz

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) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethylene</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethylene</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DCE</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Total CHCs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100 mg/L</td>
<td>None</td>
</tr>
</tbody>
</table>

### Comments:

- Trichloroethene: None
- Tetrachloroethene: None
- 1,1-dichloroethene: None
- cis-1,2-dichloroethene: None
- trans-1,2-dichloroethene: None
- 1,1-dichloroethylene: None
- 1,2-dichloroethylene: None
- 1,1,1-trichloroethane: None
- 1,1,2-trichloroethane: None
- Vinyl Chloride: None
- DCE: None
- Total CHCs: None
Hydrogeologic Conceptual Model

x 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  

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

x Aquifer Characteristics:

<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>
<th>K range (ft/day)</th>
<th>Transmissivity (ft²/day):</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>9.84</td>
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<td></td>
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</tr>
<tr>
<td>3</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

x 2nd aquifer permeability - 10^-5 m/s  
Unknown

Contamination in first 2 aquifers

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:  
- Jan-01
- Duration: 3 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):  
- 1.5

Number of energy delivery points:  
- 6
- 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:  
  - lb
  - kg
  - Unknown

- In vapor stream:  
  - lb
  - kg
  - Unknown

Total:  
- 10000
- lb
- kg
- Unknown

Comments:

10 water and vapor extraction wells and 6 vapor extraction wells only

Attachments:

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

Remediation Goal:

x In Groundwater: 1) Facility area = total (CHCs) = 0.8 mg/L

x Environment of facility area where domestic wells are located. Total (CHCs) = 0.2 mg/L

In Soil:

Was the Remediation Goal Achieved:

____ In Groundwater

____ Comment:

____ In Soil

____ Comment:

General comments on the thermal application:

Target temperature of - 89-100°C

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 X ERH

Type of treatment: Conductive Steam ERH Other: Other:

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

Treatment Status: Active Post

Type of Test: Pilot Test Full Scale System

Start of Test: End of Test: Duration: 6 months

Type of Site: Non-DOD DoD

Facility Name: Bruel & Kjaer A/S (Project No. 552)

Address:

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

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

**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>
<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>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
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</tr>
<tr>
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<td>1,1-dichloroethene</td>
<td>Naphthalene</td>
<td>None</td>
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<td></td>
<td>cis-1,2-dichloroethene</td>
<td>Benzene</td>
<td>None</td>
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<td></td>
<td>trans-1,2-dichloroethene</td>
<td>Toluene</td>
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<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<td>1,2-dichloroethene</td>
<td>m/p-xylene</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>
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<td></td>
<td>Vinyl Chloride</td>
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<td>None</td>
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<tr>
<td></td>
<td>Sum TCE and PCE</td>
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<td>None</td>
<td>50 mg/kg</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:</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>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>
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<td>Largely impermeable sediments with inter-bedded layers of higher permeability material</td>
<td></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: \[ \text{ft amsl} \] \[ \text{Unknown} \]

**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: \[ \text{Unknown} \]

Horizontal hydraulic gradient (feet/foot): \[ \text{Unknown} \]

Vertical hydraulic gradient (feet/foot): \[ \text{Unknown} \]

K range (ft/day) Measured using: Slug Test Laboratory Field data
low \[ \text{Unknown} \]
high \[ \text{Unknown} \]

Transmissivity (ft²/day): Measured using: Slug Test Laboratory Field data
low \[ \text{Unknown} \]
high \[ \text{Unknown} \]

**Facility ID#:** 1075

**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 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: ___ months

- **Hydraulic Control:**
  - ___ Yes
  - ___ No

- **Treatment Cell Design:**
  - Size of target zone (ft^2): ___ 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:**
  - 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: ___ 3000 to 4000 x lb ___ kg ___ Unknown

- **Comments:**
  - Treated 12,000m3 (15695 yd3)

- **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: ___________ 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: ____________________________

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: Odense, Denmark
Organization: Danish EPA website
Address: Odense, Denmark
City, State, Zip Code: Denmark
OU# or Site #: ________________________________

Primary point of contact: Danish EPA website
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
### General Site Assessment Data

**Facility ID:** 1080

<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>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

**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: 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: 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)</td>
<td>Soil (mg/kg)</td>
</tr>
<tr>
<td>Chlorinated Solvents</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
<td>None</td>
<td></td>
<td></td>
<td>None</td>
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<tr>
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<td></td>
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</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethane</td>
<td>None</td>
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<td>None</td>
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<tr>
<td>1,2-dichloroethane</td>
<td>None</td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
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<td></td>
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<td>None</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Comments:**

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

**Attachments:**

____________________________________________________________________________
### Hydrogeologic Conceptual Model

#### Geology:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Options</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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<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:

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

#### Comments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

#### Attachments:

____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
**Thermal Treatment - Design**

**Facility ID#: 1080**

<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>
</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 layers of lower 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:**

- Duration: 3.5 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: 140
- 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: ____________ lb ____________ kg Unknown
- In vapor stream: ____________ lb ____________ kg Unknown
- Total: 3000 lb 0 kg Unknown

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

---

**Thermal Treatment - Design**

**Facility ID#: 1080**

<table>
<thead>
<tr>
<th>Thermal treatment:</th>
<th>Conductive</th>
<th>Electrical Resistance</th>
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</thead>
<tbody>
<tr>
<td>x</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 layers of lower 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:**

- Duration: 3.5 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: 140
- 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: ____________ lb ____________ kg Unknown
- In vapor stream: ____________ lb ____________ kg Unknown
- Total: 3000 lb 0 kg Unknown

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

Lessons Learned

Energy

Total Project Cost:

Cost
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:** 2003
- **End of Test:** 2003
- **Duration:** 3.5 months

Facility Name: United Kingdom

- **Address:**
- **City, State, Zip Code:** United Kingdom

Primary point of contact: Helen Stevens

- **Organization:** IMS Marketing Communications
- **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 Vendor, Technical Applications Other
- **Organization:** Churngold Remediation Ltd
- **Phone #:** 07881 815391 or 0117 916 0510
- **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

**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: 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>
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<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></td>
<td></td>
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<td>None</td>
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<tr>
<td>Tetrachloroethene</td>
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<tr>
<td>1,1-dichloroethene</td>
<td>Benzene</td>
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<td>cis-1,2-dichloroethene</td>
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<tr>
<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 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): ___________ ___________ ___________ ___________
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 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:

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):
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.
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: 292950 (155000 GBP)

  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: 
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
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: tse@env17.hinet.net

Other contacts or vendors who worked on site: None
Point of contact: Jerry W. H. Wang
Type: Vendor, Consultant Vendor, Technical Applications Other 
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
### Types of Contaminants

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<td>Groundwater (mg/L)</td>
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</tr>
<tr>
<td>Trichloroethene</td>
<td>Benzene</td>
<td>Crossdr</td>
<td></td>
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</tr>
<tr>
<td>Tetrachloroethene</td>
<td>Jet Fuel</td>
<td>PCP</td>
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<td>10 mg/L</td>
<td>5 mg/kg</td>
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<td>Other</td>
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<td>None</td>
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</table>

### 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: 1
  - Post-treatment: 4
  - 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: __________

### Chemicals of Concern

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<td>Other</td>
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### Comments:

- None

### Attachments:

- None
### Hydrogeologic Conceptual Model

#### Facility ID:

<table>
<thead>
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<th>Geology:</th>
<th>Zone</th>
<th>Unconsolidated Sediments</th>
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<td>Vadose Zone:</td>
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<td>Saturated Zone:</td>
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</tr>
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<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) |
|---------------------------------|----|---------------|
| Aquifer 1 | | | |
| Aquifer 2 | | | |
| Aquifer 3 | | | |

- Depth to water:
  - low value (ft bgs):
    - 1
  - high value (ft bgs):
  - Unknown:

- Flow direction: SE

- Horizontal hydraulic gradient (feet/foot):
  - 0.001 to 0.00033

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

#### K range (ft/day)

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

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:  
5/12/1999  
Duration:  5 5 months

Hydraulic Control  
- Yes  
- No

Treatment Cell Design:  

Size of target zone (ft2): 2401  
Thickness of target zone (ft): 11  
Depth to top of target zone (ft bgs): 0  
Thickness of target zone below water table (ft): 10  
Number of energy delivery points: 1  
Number of extraction points:  

Temperature Profile:  

Initial formation temperature (deg C):  
Maximum representative formation temperature (deg C): 100  
Time to reach maximum representative temperature (days): 30  
Duration of treatment at representative temperature (days): 135

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 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: _______ 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: 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: x Conductive Steam ERH Other: x
Type of Contaminant: x Chlorinated Solvents Petroleum Hydrocarbons Pesticides
x Wood Treating Other: x
Treatment Status: x Active Post x
Type of Test: x Pilot Test Full Scale System
Start of Test: Nov-02 End of Test:
Duration: 50 d
Type of Site: x Non-DOD x DoD

Facility Name: Residential Site in Holland
Address: Zwijndrecht, Netherlands
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: x Vendor, Consultant x Vendor, Technical Applications Other
Organization: TerraVista, BV
Address: 
City, State, Zip Code: Hoofdoorp, Netherlands
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

A. 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: __________

B. 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: _____

C. 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: __________

D. Types of Contaminants

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</tbody>
</table>

Comments:

- 2000 m³ impacted (2615 yd³)

Attachments:

__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

2000 m³ impacted (2615 yd³)
### 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:**

### 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)**

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<tr>
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<th>High</th>
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**Transmissivity (ft2/day):**

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</table>

**Measured using:**
- Slug Test
- Laboratory
- Field data

**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:  
- Nov-02
- Duration: 60 d

Hydraulic Control:  
- Yes
- No

Treatment Cell Design:

Size of target zone (ft²):  
- Unknown ( __ x __ ft²)

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:  
- 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:

Attachments:

- 19 ft spacing: Treated - 2.000m³

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
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: _______ 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: 10/18/2006
Type of treatment: Conductive Steam ERH Other: ______________________
Type of Contaminant: Chlorinated Solvents Petroleum Hydrocarbons Pesticides
Wood Treating Other: PAHs
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
Type of Site: Non-DOD DoD

Facility Name: Former Tarmac Plant
Address: ____________________________
City, State, Zip Code: Zoetermeer, 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: _______________________
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#:** 1210

**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

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<tr>
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<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>
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**Comments:**

- 
- 
- 

**Attachments:**

- 
- 
- 

<table>
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<tr>
<th>Zone</th>
<th>Geology:</th>
<th>Unconsolidated Sediments</th>
</tr>
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<tbody>
<tr>
<td>Vadose Zone:</td>
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<td>Relatively homogeneous and permeable unconsolidated sediments</td>
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<td>Relatively homogeneous and impermeable unconsolidated sediments</td>
</tr>
<tr>
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<tr>
<td></td>
<td></td>
<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>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: 30 ft amsl, Unknown

- Aquifer Characteristics:
  - Is more than 1 aquifer present? No, Yes (number): 2, Unknown (assume single aquifer)
  - Depth to water:
    - low value (ft bgs): 2, 6
    - high value (ft bgs): 3.6
    - 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: Unknown
    - high: Unknown
  - Transmissivity (ft²/day): Measured using: Slug Test, Laboratory, Field data
    - low: Unknown
    - high: Unknown

Comments:

Attachments:
### Thermal Treatment - Design

**Facility ID:** 1210

- **Thermal treatment:**
  - [x] Conductive
  - [x] Electrical Resistance

- **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:** Dec-03
  - **Duration:** 28 weeks

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

- **Treatment Cell Design:**

  | Size of target zone (ft²): | 10862 | [ ] Unknown | (207 x 53 ft) |
  | Thickness of target zone (ft): | 31 | [ ] Unknown |
  | Depth to top of target zone (ft bgs): | 1 | [ ] Unknown |
  | Thickness of target zone below water table (ft): | 12 | [ ] Unknown |
  | Number of energy delivery points: | 43 | [ ] 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:** [ ] lb [ ] kg [ ] Unknown
  - **In vapor stream:** [ ] lb [ ] kg [ ] Unknown
  - **Total:** [ ] lb [ ] kg [ ] Unknown

- **Comments:**

  - 28 weeks of operation with three phases of heating

- **Attachments:**

  - [ ]

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

**Remediation Goal:**

- **In Groundwater:**
  - \( \text{DCE} = 10 \text{ ppb} \); \( \text{VC} = 2.5 \text{ ppb} \)

- **In Soil:**
  - __________________

**Was the Remediation Goal Achieved:**

- **In Groundwater:**

  - **Comment:** yes

  - **In Soil:**

    - __________________

**General comments on the thermal application:**

- __________________
- __________________
- __________________
- __________________
- __________________

### Energy

**Total Energy Used:**

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<tr>
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<th>kWh/m^3</th>
<th>kWh/yd^3</th>
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</thead>
<tbody>
<tr>
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**Total energy applied to treatment zone:**

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<th>kWh/yd^3</th>
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**Other energy:**

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<td>Please note other energy:</td>
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### 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:**

<p>| Other Cost 1: | __________________ |
| Other Cost 2: | __________________ |
| Other Cost 3: | __________________ |</p>
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<tr>
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<tr>
<td>Address:</td>
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</table>
### General Site Assessment Data

**Facility ID#:** 1220

#### 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: __________
  - Post-treatment: __________

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<tr>
<th>Chemical</th>
<th>Pre-treatment: Upgradient</th>
<th>Downgradient</th>
<th>Crossgradient</th>
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<tr>
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<td>Vinyl Chloride</td>
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#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: __________

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

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Pre-treatment: Upgradient</th>
<th>Downgradient</th>
<th>Crossgradient</th>
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<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Toluene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,3-xylylene</td>
<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>
</tr>
</tbody>
</table>

#### Chlorinated Solvents

- Number inside treatment zone: __________
- Number outside treatment zone: __________

#### Petroleum Hydrocarbons

- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Post-treatment: __________

#### Other

- Number of wells relative to treatment zone:
  - Pre-treatment: __________
  - Post-treatment: __________

#### Types of Contaminants

<table>
<thead>
<tr>
<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>Groundwater (mg/L) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Benzene</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-dichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,2,2-trichloroethane</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Toluene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,3-xylylene</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>m,p-xylene</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

#### Comments:

- ________________________________________________________________________________
- ________________________________________________________________________________
- ________________________________________________________________________________
- ________________________________________________________________________________

#### Attachments:

- ________________________________________________________________________________
- ________________________________________________________________________________
- ________________________________________________________________________________
- ________________________________________________________________________________
### Hydrogeologic Conceptual Model

#### Facility ID# 1220

<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-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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<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:** 

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ft amsl</td>
</tr>
<tr>
<td></td>
<td>Unknown</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>Aquifer 1</td>
<td>low value (ft bgs):</td>
</tr>
<tr>
<td>Aquifer 2</td>
<td>high value (ft bgs):</td>
</tr>
<tr>
<td>Aquifer 3</td>
<td>Unknown:</td>
</tr>
</tbody>
</table>

**Flow direction**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **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

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
- 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: ____________

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

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:
  - Comment:

- In Soil:
  - Comment:

Was the Remediation Goal Achieved:

- In Groundwater
  - Comment:

- In Soil
  - Comment:

General comments on the thermal application:

Removed 99.9% of the VOCs

Lessons Learned

Energy

Total Energy Used: 215 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

X 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: 2/19/1999 End of Test: 6/16/1999 Duration: 108 d

Type of Site: Non-DOD DoD

Facility Name: CFB Calgary

Address: ____________________________________________________________________________________________________

City, State, Zip Code: _______________________________________________________________________________________

OU# or Site #: Calgary, Alberta, Canada

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

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:** 1230  

#### 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
- Pre-treatment: 2
- Post-treatment: 2
- Number of wells relative to treatment zone:
  - Pre-treatment: 1
  - Uppgradient: None
  - Downgradient: None
  - Crossgradient: None
  - Post-treatment: 1

#### Soil Borings:
- Number of relevant soil borings with pre-treatment data: 26
- Number of relevant soil borings with post-treatment data: 12
- Number inside treatment zone: 26
- Number outside treatment zone: 12

#### 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>Groundwater (mg/L) Soil (mg/kg) Groundwater (mg/L) Soil (mg/kg)</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>inexpensive</td>
<td>Benzene</td>
<td>None</td>
<td>0.005 mg/L 1 mg/kg 0.005 mg/L 1 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>Jet Fuel</td>
<td>Xylene</td>
<td>None</td>
<td>0.001 mg/L 0.05 mg/kg 0.001 mg/L 0.05 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Xylene</td>
<td>Ethylbenzene</td>
<td>None</td>
<td>0.005 mg/L 1 mg/kg 0.005 mg/L 1 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
<td>Toluene</td>
<td>o-xylene</td>
<td>None</td>
<td>0.005 mg/L 0.05 mg/kg 0.005 mg/L 0.05 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
<tr>
<td>trans-1,2-dichloroethene</td>
<td>Ethylbenzene</td>
<td>n-propylbenzene</td>
<td>None</td>
<td>0.005 mg/L 0.05 mg/kg 0.005 mg/L 0.05 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Xylene</td>
<td>p-xylene</td>
<td>None</td>
<td>0.005 mg/L 0.05 mg/kg 0.005 mg/L 0.05 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Xylene</td>
<td>m-xylene</td>
<td>None</td>
<td>0.005 mg/L 0.05 mg/kg 0.005 mg/L 0.05 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>Xylene</td>
<td>None</td>
<td>None</td>
<td>0.005 mg/L 0.05 mg/kg 0.005 mg/L 0.05 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Xylene</td>
<td>Xylene</td>
<td>None</td>
<td>0.005 mg/L 0.05 mg/kg 0.005 mg/L 0.05 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Xylene</td>
<td>TPH</td>
<td>None</td>
<td>0.005 mg/L 0.05 mg/kg 0.005 mg/L 0.05 mg/kg</td>
<td>0.05 mg/kg 0.05 mg/kg</td>
</tr>
</tbody>
</table>

#### 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></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>
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</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:*  
Unknown 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): __________
  - 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: __________ Unknown
  - high: __________

- **Transmissivity (ft^2/day):**
  - Measured using: Slug Test Laboratory Field data
  - low: __________ Unknown
  - high: __________

**Comments:**

**Attachments:**

---

**Facility ID#:** 1230
### Thermal Treatment - Design

**Facility ID:** 1230

<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>

- **Steam**
- **Steam + air**
- **Steam + O2**
- **Other (describe)**

<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>Largely permeable sediments with inter-bedded lenses of lower permeability material</th>
</tr>
</thead>
<tbody>
<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>

<table>
<thead>
<tr>
<th>Start of Thermal Test:</th>
<th>19-Feb-99</th>
<th>Duration: 108 d</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>3390</th>
<th>(____ x ____ ft)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thickness of target zone (ft):</th>
<th>9</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Depth to top of target zone (ft bgs):</th>
<th>5</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thickness of target zone below water table (ft):</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Number of energy delivery points:</th>
<th>6</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Number of extraction points:</th>
<th>5</th>
<th>Unknown</th>
</tr>
</thead>
</table>

### Temperature Profile:

<table>
<thead>
<tr>
<th>Initial formation temperature (deg C):</th>
<th>10</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Maximum representative formation temperature (deg C):</th>
<th>60</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Time to reach maximum representative temperature (days):</th>
<th>96</th>
<th>Unknown</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Duration of treatment at representative temperature (days):</th>
<th>12</th>
<th>Unknown</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>Formation temperature immediately post-treatment:</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Formation temperature post-treatment monitoring event 1:</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Duration of post-treatment monitoring (days):</th>
<th></th>
</tr>
</thead>
</table>

### Mass of contaminant removed:

- **Via liquid pumping:** 48.5 Liters + 117 Liters
- **In vapor stream:** 34.4 Liters
- **Total:** 199.9 Liters

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

**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.
Remediation Goal:

- **In Groundwater:** Benzene-4.2 mg/L, toluene-240 mg/L, ethylbenzene-50 mg/L, xylenes-80 mg/L.
- **In Soil:** Benzene-1.5 mg/Kg, toluene-340 mg/Kg, ethylbenzene-400 mg/Kg, xylenes-130 mg/Kg.

Was the Remediation Goal Achieved:

- **In Groundwater:**
  - Comment:
- **In Soil:**
  - Comment:

General comments on the thermal application:

**Objective:** Evaluate the ability and efficiency of McMillan-McGee ETDS; determine effect of heating on disorption of petroleum hydrocarbons; evaluate conditions when ERH will be an effective tool in remediation; and evaluate effect of heating on the indigenous microorganisms.

Lessons Learned

Energy

- Total Energy Used: 163,000 kWhr, 178 kWhr/m³, 25 kWhr/yd³
  - Total energy applied to treatment zone: 178 kWhr/m³, 25 kWhr/yd³
  - Other energy: (Please note other energy)

Cost

- Total Project Cost: (Please note other cost)
<table>
<thead>
<tr>
<th>General Site Information</th>
<th>Facility ID#: 1240</th>
</tr>
</thead>
</table>

- **File Analyzed By**: JT PD
- **Date**: 11/13/2006
- **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: 60 d
- **Type of Site**: Non-DOD DoD

- **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**: 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#:

**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) Soil (mg/kg)</td>
<td>Groundwater (mg/L) Soil (mg/kg)</td>
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<tr>
<td>Tetrachloroethene</td>
<td>None</td>
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</tr>
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<td>Trichloroethene</td>
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<td>Vinyl Chloride</td>
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<td>Hexane</td>
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</tr>
<tr>
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<td>None</td>
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<td>None</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Benzene</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Toluene</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>p-xylene</td>
<td>None</td>
<td>None</td>
<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>Creosote</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</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></td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated Zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<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 1</th>
<th>Aquifer 2</th>
<th>Aquifer 3</th>
</tr>
</thead>
</table>

- 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

### Ground surface elevation based on wells in or adjacent to treatment zone: ____________ ft amsl

### Facility ID#:

- 1240

### Comments:

- __________________________________________________________________________________________

### Attachments:

- __________________________________________________________________________________________
## Thermal Treatment - Design

**Facility ID:** 1240

- **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 layers of lower permeability material
  - Competent, but fractured bedrock (i.e. crystalline rock)

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

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

- **Hydraulic Control**
  - Yes
  - No

### Temperature Profile:

- **Initial formation temperature (deg C):**
  - Unknown

- **Maximum representative formation temperature (deg C):**
  - 100
  - 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:**
  - 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

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

---

**Attachments:**

19 ft electrode spacing

---

**Comments:**
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: 227 kWhr/m³ × 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: 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
City, State, Zip Code: Luxembourg

Other contacts or vendors who worked on site: None
Point of contact: Vendor, Consultant
Organization: Vendor, Technical Applications
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 of wells relative to treatment zone:
  - Pre-treatment: ______
  - Upgradient: ______
  - Downgradient: ______
  - Crossgradient: ______
- Post-treatment: ______
- 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>
</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>Crossdike</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>
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<td>None</td>
</tr>
<tr>
<td>cis-1,2-dichloroethene</td>
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<td>None</td>
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<td>Toluene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1-dichloroethene</td>
<td>Ethylbenzene</td>
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<td></td>
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<td>None</td>
</tr>
<tr>
<td>1,2-dichloroethene</td>
<td>m,p-xylene</td>
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<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1,1,1-trichloroethene</td>
<td>o-xylene</td>
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<td>None</td>
</tr>
<tr>
<td>1,1,2-trichloroethene</td>
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<tr>
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<tr>
<td>Vinyl Chloride</td>
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<td></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
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### Comments:

### Attachments:

---

**General Site Assessment Data**

**Facility ID:** 1250
### 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>
</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>

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

<table>
<thead>
<tr>
<th>Elevations</th>
</tr>
</thead>
<tbody>
<tr>
<td>ft amsl</td>
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### 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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<tbody>
<tr>
<td><strong>Depth to water:</strong></td>
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<tr>
<td>low value (ft bgs):</td>
<td>16</td>
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<td>high value (ft bgs):</td>
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<tr>
<td>Unknown:</td>
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### Flow direction

- Unknown

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

- Unknown

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

- Unknown

### K range (ft/day)

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
<th>Measured using:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>Laboratory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field data</td>
</tr>
</tbody>
</table>

### Transmissivity (ft²/day)

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
<th>Measured using:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Slug Test</td>
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<td>Laboratory</td>
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<td></td>
<td>Field data</td>
</tr>
</tbody>
</table>

### Comments:

- Unknown

### Attachments:

- Unknown
### 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

**Treatment Cell Design:**

<table>
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<tr>
<th>Size of target zone (ft²):</th>
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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 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 |

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

**Mass of contaminant removed:**

| Via liquid pumping: | Unknown |
| In vapor stream: | Unknown |
| Total: | Unknown |

**Attachments:**

- 19 ft spacing
- ____________

---

**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:

- 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:
General Site Information

File Analyzed By: JT  PD  Date: 10/30/2006
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: 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
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  x 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): __________
- 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: ______
- 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 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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<tr>
<td></td>
<td>Trichloroethene</td>
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<td>Benzene</td>
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<td>o-xylene</td>
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**Soil Borings:**
- Number of relevant soil borings with pre-treatment data: ______
- Number of relevant soil borings with post-treatment data: ______
- Number of relevant soil borings with post-treatment data:
  - Number inside treatment zone: ______
  - Number outside treatment zone: ______

**Comments:**
- Pilot test with only 4 heater wells inside larger DNAPL area - impossible to achieve low concentrations due to inflow

**Attachments:**
- __________
- __________
- __________
Hydrogeologic Conceptual Model

Facility ID#: 1260

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 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):  
  - Aquifer 1  
  - Aquifer 2  
  - Aquifer 3  
- high value (ft bgs):  
  - Aquifer 1  
  - Aquifer 2  
  - Aquifer 3  
Unknown

Flow direction

Horizontal hydraulic gradient (feet/foot):  
- 0.01  
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>Facility ID#</th>
<th>1200</th>
</tr>
</thead>
</table>

**Thermal treatment:**  
- **Conductive**  
- **Electrical Resistance**  
  - 3 phase  
  - 6 phase  
  - AC power  
  - DC power  
  - Steam  
  - Stream + air  
  - Stream + 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:**  
- Oct-06  
- Duration: 2 months  

**Hydraulic Control:**  
- Yes  
- No  

**Treatment Cell Design:**  
- Size of target zone (ft²): 200  
- Thickness of target zone (ft): 15  
- Depth to top of target zone (ft bgs): 2  
- Thickness 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  

**Duration of post-treatment monitoring event 1:**  

**Mass of contaminant removed:**  
- Via liquid pumping: 11  
- In vapor stream: 24  
- Total: 35  

**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

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

__ 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: 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:  x Non-DOD   x DoD

Facility Name: Dyrup
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
Point of contact:
Type:  x Vendor, Technical Applications   x Vendor, Consultant   x Other   x None
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

**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

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<tr>
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</tr>
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<tbody>
<tr>
<td></td>
<td>Trichloroethylene</td>
<td>BTEX</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>
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<td>None None None None None</td>
<td>None None None None</td>
</tr>
<tr>
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<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>
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<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>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>__ Weathered bedrock, limestone, sandstone</td>
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<td></td>
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<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>__ Weathered bedrock, limestone, sandstone</td>
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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>
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<td>low value (ft bgs):</td>
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<td>high value (ft bgs):</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

high

Transmissivity (ft²/day):

Measured using: Slug Test  Laboratory  Field data

low

high

**Comments:**

__________________________________________________________________________

Attachments:
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<tr>
<th><strong>Thermal Treatment - Design</strong></th>
<th>Facility ID#: 1270</th>
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</tr>
<tr>
<td><em>x</em> Conductive</td>
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<tr>
<td><em>x</em> Electrical Resistance</td>
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</tr>
<tr>
<td><em>x</em> 3 phase</td>
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<td><em>x</em> 6 phase</td>
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<tr>
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</tr>
<tr>
<td><em>x</em> DC power</td>
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<tr>
<td><em>x</em> Steam</td>
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<tr>
<td><em>x</em> Steam + air</td>
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<tr>
<td><em>x</em> Steam + O2</td>
<td></td>
</tr>
<tr>
<td><em>x</em> Other (describe)</td>
<td></td>
</tr>
</tbody>
</table>

| **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:** | Duration: |                   |
| _x_ Yes | _x_ No |                   |

| **Treatment Cell Design:** |                   |
| Size of target zone (ft²): | 500 | _x_ Unknown | ( _x_ x _x_ ft) |
| Thickness of target zone (ft): | 20 | _x_ Unknown |
| Depth to top of target zone (ft bgs): | 20 | _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: | | _x_ Unknown |

| **Temperature Profile:** |                   |
| Initial formation temperature (deg C): | | _x_ Unknown |
| Maximum representative formation temperature (deg C): | 100 | _x_ Unknown |
| Time to reach maximum representative temperature (days): | 60 | _x_ Unknown |
| Duration of treatment at representative temperature (days): | 5 | _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: | _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:** |                   |
| _x_ |                   |

| **Attachments:** |                   |
| _x_ |                   |

Note: When applicable, mass flux measurements from Groundwater Services, Inc. freeware is attached.
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: ___________________________
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
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 (bgs). The Belgrade formation (Castle Hayne confining unit) begins at a depth of approximately 8 to 15 feet bgs, and the River Bend formation (Castle Hayne aquifer) begins at a depth of approximately 14 to 20 feet bgs.

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 bgs and 48 shallow heating electrodes installed to a depth of 19 feet bgs. 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 bgs with 0.010-inch wire wrap slots. The type III wells screen section was 5-feet long extending from 20 to 25 feet bgs 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 subcontractors and subcontracts 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>
<th>Site Project Contact:  Daniel Hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Camp Lejuene, North Carolina 28542</td>
<td>Phone Number: 757-322-4630</td>
</tr>
<tr>
<td>Site Safety &amp; Health Contact: Sam Yoon Phone Number 614-424-4569/ 614-537-5658</td>
<td></td>
<td></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:

DATE(S) OF FIELD VISIT(S):

(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)

<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Confined Space</td>
<td>□ Steep/Uneven Terrain</td>
</tr>
<tr>
<td>√ Heavy Equipment</td>
<td>√ Heat Stress</td>
</tr>
<tr>
<td>□ Moving Parts</td>
<td>√ Extreme Cold</td>
</tr>
<tr>
<td>□ Heavy Lifting</td>
<td>□ Ionizing Radiation</td>
</tr>
<tr>
<td>□ Electrical</td>
<td>□ Traffic</td>
</tr>
<tr>
<td>□ Overhead Hazards</td>
<td>□ Biological Hazards</td>
</tr>
<tr>
<td>□ Fall (&gt;6; Vertical)</td>
<td>□ Surface Water (Immersion)</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Explosimeter</td>
<td>□ Eye Wash</td>
</tr>
<tr>
<td>□ Fall Protection Equipment</td>
<td>□ Emergency Shower</td>
</tr>
<tr>
<td>√ Barrier Tape</td>
<td>√ Emergency Air Horn</td>
</tr>
<tr>
<td>√ Traffic Cones</td>
<td>□ Lights</td>
</tr>
<tr>
<td>□ Stretcher</td>
<td>□ Lights – emergency</td>
</tr>
<tr>
<td>√ First Aid Kit</td>
<td>□ Ladder</td>
</tr>
<tr>
<td>□ A-B-C- Fire Extinguisher</td>
<td>√ Tick Repellant</td>
</tr>
<tr>
<td>□ Snake Bite Kit</td>
<td>□ Flotation Device (USCG Type III)</td>
</tr>
</tbody>
</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

<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>
**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.

**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**

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>

(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).

- Uncharacterized Airborne Vapors or Gases
- Characterized Airborne Gases, Vapor,
- Particulates
- Oxygen
- Flammability

<table>
<thead>
<tr>
<th>ACTION LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;Background</td>
</tr>
<tr>
<td>&gt;50% PEL, REL, TLV</td>
</tr>
<tr>
<td>&lt; 19.5; &gt;23.5</td>
</tr>
<tr>
<td>&gt; 10% LEL</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.

HAZWOPER TRAINING

<table>
<thead>
<tr>
<th>NAME</th>
<th>MEDICAL</th>
<th>INITIAL</th>
<th>REFRESHER</th>
<th>CPR/FA/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Date)</td>
<td>(Hrs/Date)</td>
<td>(Date)</td>
<td>(Dates)</td>
</tr>
<tr>
<td>Jennifer Triplett</td>
<td></td>
<td>40 hours/June 2001</td>
<td>August 7, 2005</td>
<td></td>
</tr>
<tr>
<td>Paul Dahlen</td>
<td></td>
<td>40 hours/Nov 1992</td>
<td>January, 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 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

(1) 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: Figure I.

(2) BATTELLE RESOURCES

Manager, Corporate Health and Safety (ETE Division) Site Contact: Sam Yoon: 614-424-4569
Gary Carlin, 614-424-4929

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>☑ 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
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.
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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 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 cores 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:
\[ K = \left( r_c^2 \ln \left( \frac{R_c}{R} \right) / (2L_e) \right) \times \left( \frac{1}{t} \ln \left( \frac{H_0}{H_t} \right) \right) \]

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)
- \( H_0 \) = 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 \( K = \frac{T}{b} \)

Where 
- \( K \) = hydraulic conductivity (L/T)
- \( b \) = length of sampler or screen section (L) (0.5 ft or length of screen)

(Fetter, 2000).

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.

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<table>
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<tr>
<th>GP 7</th>
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<th>GP 3</th>
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<th>GP 2</th>
<th>GP 5</th>
<th>GP 6</th>
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<td>GP 5-40</td>
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Scale
1 inch = 28 feet
VE = 1/4
### 1,1-DCE Comparison

![Graph showing 1,1-DCE Comparison](image)

Figure 6(a)

### cis-1,2-DCE Comparison

![Graph showing cis-1,2-DCE Comparison](image)

Figure 6(b)
**1,1,2,2-PCA Comparison**

Figure 6(c)

**PCE Comparison**

Figure 6(d)
1,1,2-TCA Comparison

Figure 6(e)

TCE Comparison

Figure 6(f)
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Figure 11. Trichloroethylene Direct-Push Groundwater Concentrations (µg/L)
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Figure 13. trans-1,2-Dichloroethene Direct-Push Groundwater Concentrations (μg/L)
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Figure 16. Mass Flux Toolkit Inputs
Tables
<table>
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<tr>
<th>Boring Depth (ft)</th>
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<td>Fine sandy silt with some clay</td>
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<td>6-7</td>
<td>Clayey silt with some fine sands</td>
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<tr>
<td>8</td>
<td>Silty fine sand</td>
</tr>
<tr>
<td>9</td>
<td>Clayey silt with some fine sands</td>
</tr>
<tr>
<td>10</td>
<td>Fine sand</td>
</tr>
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<td>11-13</td>
<td>Silty fine sand</td>
</tr>
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<td>Silt</td>
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<td>Sand and gravel with traces of clay</td>
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<td>Sandy clay with fine to medium sand</td>
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<td>Clay sands and gravels</td>
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<td>Sands and gravels with some clay</td>
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<td>Clayey sands with some gravel</td>
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<td>Course sand with some clay</td>
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<tr>
<td>32</td>
<td>Sands and gravels with trace silts and clay</td>
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<td>Clayey sands and gravel</td>
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<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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<tr>
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<th>Physical Assessment</th>
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<th>Dissolved Petroleum Hydrocarbon Analysis</th>
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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>
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<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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DTW - Depth-to-water  
BTOC - Below top of casing
### Table 5. Water Quality Data for Monitoring Wells (February/March 2006)

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<th>pH</th>
<th>EC (mS)</th>
<th>Temperature (°C)</th>
<th>DO (mg/L)</th>
<th>ORP (mV)</th>
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* 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>
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<tr>
<th>Monitoring Well</th>
<th>Date Analyzed</th>
<th>Concentration (ug/L)</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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<td>330</td>
<td>16000</td>
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<td>1800</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
Table 7. Chemical Concentration Data for Direct-Push Downgradient Transect Locations (February/March 2006)

<table>
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<th>Sampling Location*</th>
<th>Concentration (ug/L)</th>
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<th>1.1 DCE</th>
<th>1.1,2 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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<td>ND&lt;1</td>
<td>ND&lt;1</td>
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<td>ND&lt;1</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
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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.)

<table>
<thead>
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<th>Chemical (ug/L)</th>
<th>1,1,2-TCA</th>
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<th>Date</th>
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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)
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 Unit, 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 Unit 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
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.

<table>
<thead>
<tr>
<th>SECTION 2: PROJECT INFORMATION</th>
</tr>
</thead>
</table>

(1) SITE INFORMATION

| Site Name: | ERH Pilot Test Site near BLDG 5 |
| Address: | IR Site 5 |
| Contact: | Glenna Clark |
| Phone Number: | 619-532-0951 |

Former Naval Air Station Alameda

| Address: | Alameda Point, CA 92101 |
| Contact: | Sam Yoon |
| Phone Number: | O: 614-424-4569/ C: 614-218-0627 |

(2) SITE CLASSIFICATION (check or circle all that apply)

| Hazardous (RCRA/CERCLA/State) | Site Inspection (General) |
| Construction | Well Drilling Observation |
| Landfill (Non-Hazardous) | Sampling, Air |
| UST/LUST | Sampling, Water |
| Manufacturing | Sampling, Soil |
| Active | Other: |
| Inactive | |
| Other: | |
| military installation | |

DATE(S) OF FIELD VISIT(S): 

(3) ENTRY OBJECTIVES (check or circle all that apply)

(4) BATTELLE/ASU TASKS

B1. Groundwater Investigation

B2. Groundwater sampling

B3. Water level survey and slug tests

B4. Analytical activities

(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  
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)

- [ ] Confined Space
- [X] Steep/Uneven Terrain
- [X] Drums Handling*
- [ ] Heavy Equipment
- [ ] Heat Stress
- [ ] Noise
- [ ] Moving Parts
- [X] Extreme Cold
- [ ] Non-Ionizing Radiation
- [ ] Heavy Lifting
- [ ] Ionizing Radiation
- [ ] Other:
- [ ] Electrical
- [ ] Traffic
- [ ] Overhead Hazards
- [ ] Biological Hazards
- [ ] Fall (>6; Vertical)
- [ ] Surface Water (Immersion)

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 jackets, 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)

- [ ] Explosimeter
- [ ] Eye Wash
- [ ] Confined Space Warning Signs
- [ ] Fall Protection
- [ ] Emergency Shower
- [X] Communications – On Site
- [ ] Equipment
- [X] Emergency Air Horn
- [X] Communications – Off Site
- [X] Traffic Cones
- [ ] Lights
- [ ] Other:
- [X] Stretcher
- [ ] Lights – emergency
- [ ] A-B-C- Fire
- [X] Tick Repellant
- [ ] Ladder
- [X] Extinguisher
- [X] Flotation Device (USCG Type III)
- [ ] Snake Bite Kit

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>
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<tbody>
<tr>
<td>GW</td>
<td>Chlorinated hydrocarbons</td>
<td>VO and TO</td>
<td>Total chlorinated VOCs up to 35,000</td>
<td></td>
</tr>
</tbody>
</table>
1,1-dichloroethene, 1,1,1-
trichloroethane)

µg/L prior to the ERH
operation, recent
monitoring was at
700 µg/L.

SL Chlorinated hydrocarbons VO and TO NA

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>
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<tbody>
<tr>
<td>B1</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
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<tr>
<td>B2</td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Medium/Low</td>
<td>Level D PPE</td>
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<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>
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<td>O2 Meter</td>
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<td>FID</td>
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<td>Radiation Meter (Gamma)</td>
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<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).

| ACTION LEVEL |
|-----------------|-----------------|-----------------|-----------------|
| Uncharacterized Airborne Vapors or Gases | >Background | |
| Characterized Airborne Gases, Vapor, Particulates | >50% PEL, REL, TLV | |
| Oxygen | < 19.5; >21.5 | |
| Flammability | > 10% LEL | |
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 INITIAL</th>
<th>REFRESHER INITIAL</th>
<th>CPR/FA/ INITIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jennifer Triplett</td>
<td>40 hours/June 2001</td>
<td>August 7, 2005</td>
<td></td>
</tr>
<tr>
<td>Paul Dahlen</td>
<td>40 hours/Nov 1992</td>
<td>February 2006</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

  - 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 ______________________

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
- 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
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:

(4) The conditions resulting in the emergency have been corrected.
(5) The hazards have been reassessed by the SSO.
(6) 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

(1) LOCAL RESOURCES

<table>
<thead>
<tr>
<th>Ambulance (name):</th>
<th>Alameda Hospital</th>
<th>Phone: 911</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital (name):</td>
<td>Alameda Hospital</td>
<td>Phone: 911 or (510) 522-3700</td>
</tr>
<tr>
<td>Police (local or state):</td>
<td>Alameda City Police</td>
<td>Phone: 911 or (510) 522-2423</td>
</tr>
<tr>
<td>Fire (name):</td>
<td>Alameda Fire Department</td>
<td>Phone: 911 or (510) 337-2100</td>
</tr>
<tr>
<td>HAZ MAT Responder:</td>
<td>National Response Center,</td>
<td>Phone: 911</td>
</tr>
<tr>
<td></td>
<td>Toxic Chemicals and Oil Spills</td>
<td></td>
</tr>
<tr>
<td>On-Site CPR/FA(s):</td>
<td>Sam Yoon</td>
<td>Phone: 614-218-0627</td>
</tr>
</tbody>
</table>

* 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.

(2) BATTELLE RESOURCES

Manager, Corporate Health and Safety (ETE Division) Site Contact: Sam Yoon: 614-424-4569

Gary Carlin, 614-424-4929

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>☐ 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></td>
<td>☑ Butyl</td>
<td>☐ Steel Toe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>☑ Nitrile</td>
<td>☐ Neoprene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>☑ Leather</td>
<td>☐ Fireman/Hip</td>
<td></td>
</tr>
</tbody>
</table>

SECTION 16: SAFE WORK PRACTICES
THE FOLLOWING PRACTICES MUST BE FOLLOWED BY PERSONNEL ON SITE

12. Smoking, eating, chewing gum or tobacco, or drinking are forbidden except in clean or designated areas.
13. Ignition of flammable liquids within or through improvised heating devices (e.g., barrels) is forbidden.
14. Contact with samples, excavated materials, or other contaminated materials must be minimized.
15. Use of contact lenses is prohibited at all times.
16. Do not kneel on the ground when collecting samples.
17. If drilling equipment is involved, know where the kill switch is.
18. All electrical equipment used in outside locations, wet areas, or near water must be plugged into ground fault circuit interrupter (GFCI) protected outlets.
19. A “Buddy System” in which another worker is close enough to render immediate aid will be in effect.
20. Good housekeeping practices are to be maintained.
21. Where the eyes or body may be exposed to corrosive materials, water suitable for quick drenching or flushing shall be available for immediate use.
22. 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.

<table>
<thead>
<tr>
<th>SECTION 17: EMPLOYEE ACKNOWLEDGMENTS</th>
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</thead>
<tbody>
<tr>
<td>PLAN REVIEWED BY:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>H&amp;S Manager:</td>
</tr>
<tr>
<td>Principal Investigator:</td>
</tr>
<tr>
<td>Project Leader:</td>
</tr>
<tr>
<td>Site Safety Officer:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>FIELD PERSONNEL (Print Name)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>VISITOR (Print Name)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Organization/Agency</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Organization/Agency</td>
</tr>
</tbody>
</table>

**Appendix D**
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.
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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)
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TABLE 5. WATER QUALITY DATA FOR MONITORING WELLS (JUNE 2006)
TABLE 6. CHEMICAL CONCENTRATION DATA FOR MONITORING WELLS (JUNE 2006)
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TABLE 8. FIELD DATA AND RESULTS FOR CONSTANT DRAWDOWN AQUIFER TESTING IN DIRECT-PUSH DOWNGRAĐIENT TRANSECT LOCATIONS (JUNE 2006)
TABLE 9. MONITORING WELL CHEMICAL CONCENTRATION DATA COMPARISON
### Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<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 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:

\[ K = \frac{r^2 \ln(L_c/R)}{2L_c t_{37}} \]

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:

\[ K = \frac{r_c^2 \ln(R_e/R)}{(2L_e)} \times ((1/t) \ln(H_0/H_t)) \]

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)
- \( H_0 \) = 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).

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 (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 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:

\[ T = \frac{Q}{(2(h_2-h_1)) \cdot \ln(r_2/r_1)} \]

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 (\( L \))
- \( K = T/b \)

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
Figure 2. Direct-Push Locations

Source: Shaw (2006)
Figure 3. Hydraulic Conductivity Measurement Locations
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) Overlaid on Trichloroethylene Contour Plot
### Input Data and Grid

**Site Location and I.D.:** NAS Alameda  
**Description:** Site 5

4. **CHOOSE TRANSECT**  
   - Transect 1

5. **CHOOSE TIME PERIOD**  
   - 1

6. **ENTER TRANSECT DATA**
   1. **Distance of Transect 1 from Source**: 115 (ft)
   2. **Darcy Velocity**  
   3. **Hydraulic Conductivity**
   4. **Sampling Interval**
   5. **Mid Point of Sampling Interval**

6.3 **Hydraulic Conductivity Units**: Yes
6.4 **Uniform Hydraulic Conductivity**: No
6.5 **Uniform Hydraulic Gradient**: No

<table>
<thead>
<tr>
<th>Monitoring Point</th>
<th>Distance of Monitoring Point from Start of Transect (ft)</th>
<th>Sampling Interval (ft lbs)</th>
<th>Plume Top (ft lbs)</th>
<th>Plume Bottom (ft lbs)</th>
<th>Hydraulic Conductivity (ft.d)</th>
<th>Hydraulic Gradient (ft/l)</th>
<th>Concentration (ng/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Top</td>
<td>Bottom</td>
<td>Top</td>
<td>Bottom</td>
<td>Top</td>
<td>Bottom</td>
<td>Top</td>
</tr>
<tr>
<td><strong>Constituent A</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Constituent B</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

7. **CHOOSE GRID (OPTIONAL)**
   - Number of rows: 10
   - Number of columns: 9

8. **SELECT CONSTITUENT FOR CALCULATIONS**
   - TTC
   - 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>
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<td>4-5</td>
<td>Gravelly sands with some silt</td>
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<tr>
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<td>Medium to course sand with some gravel</td>
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<td>7-8</td>
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<td>Fine sands with some silt</td>
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<td>15-16</td>
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<tr>
<td>16-17</td>
<td>Silty clay</td>
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<tr>
<td>17-18</td>
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<td>Silty fine sands with some clay</td>
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<tr>
<td>21-22</td>
<td>Clay</td>
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Table 2. Sampling Locations and Types of Test Performed (June 2006)

<table>
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<th>Groundwater Monitoring Well or Direct-push Sampling Location</th>
<th>Physical Assessment</th>
<th>Water Quality Assessment</th>
<th>Field Parameters&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Dissolved Chlorinated Solvent Analysis</th>
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<td>Slug Testing</td>
<td>Constant Drawdown Aquifer Testing</td>
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<td>Yes</td>
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<td>Yes</td>
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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.

Field parameters include: pH, electrical conductivity, temperature, dissolved oxygen, and oxidation reduction potential.
Table 3. Slug Test Results (June 2006)

<table>
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<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>
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<td>18-21</td>
<td>6.20E-04</td>
<td>1.76</td>
<td>6.12E-04</td>
<td>1.73</td>
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<td>4.43E-03</td>
<td>12.56</td>
<td>2.19E-03</td>
<td>6.21</td>
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<tr>
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<td>6.20E-04</td>
<td>1.76</td>
<td>4.12E-04</td>
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<td>1.46E-04</td>
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## Table 4. Depth-to-Groundwater and Groundwater Elevations for Monitoring Wells (June 2006)

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<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>1.61</td>
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<td>1.45</td>
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<td>1.85</td>
<td>6.07</td>
<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(^a)</th>
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<tbody>
<tr>
<td></td>
<td>pH</td>
<td>EC (mS)</td>
<td>Temperature (°C)</td>
<td>DO (mg/L)</td>
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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 6. Chemical Concentration Data for Monitoring Wells (June 2006)

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<th>1,1-DCE</th>
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<th>1,1-DCA</th>
<th>cis-1,2-DCE</th>
<th>1,2-DCA</th>
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<th>TCE</th>
<th>1,1,2-TCA</th>
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**Notes:****

- 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 7. Chemical Concentration Data for Direct-Push Downgradient Transect Locations (June 2006)

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<sup>a</sup> GP: Groundwater Pathway; REP: Replicate
Table 7. Chemical Concentration Data for Direct-Push Downgradient Transect Locations (Continued)

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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
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

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145

3

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9.5E-06

5.2E-04

1.5E+00

GP 5-18.5

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215

1

30

90

8.4E-05

2.8E-05

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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

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2.0E-06

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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

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5

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3.2E-06

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5.0E-01

0.583

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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

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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 - 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, 1,1,1-trichloroethene, 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).
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<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

<table>
<thead>
<tr>
<th>CLIENT NAME: Environmental Security Technology Certification Program (ESTCP)</th>
<th>PROJECT NAME: ESTCP Thermal Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINCIPAL INVESTIGATORS: Eric Foote (Battelle) and Paul Johnson (Arizona State University)</td>
<td></td>
</tr>
<tr>
<td>PROJECT LEADER: Paul Dahlen</td>
<td></td>
</tr>
<tr>
<td>PREPARED BY: Sam Yoon DATE: 10/09/2006</td>
<td></td>
</tr>
</tbody>
</table>

**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: ERH Test Site at AF Plant 4</th>
<th>Site Project Contact: Richard Wice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address: Building 181, Air Force Plant 4</td>
<td>Phone Number: 412-858-3309</td>
</tr>
<tr>
<td>Fort Worth, TX 76108</td>
<td>Site Safety &amp; Health Contact: Shane Williams</td>
</tr>
<tr>
<td>Phone Number:</td>
<td>O: 614-424-5792/ C: 614-348-4437</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>Groundwater Investigation</th>
<th>TASK PERFORMED BY OTHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2. IDW disposal</td>
<td>B2. Groundwater sampling</td>
</tr>
<tr>
<td>B3. Slug tests</td>
<td>B3. Water level survey and slug tests</td>
</tr>
<tr>
<td>B4. Analytical activities</td>
<td>B4. Analytical activities</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: 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)

<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>Checkmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confined Space</td>
<td></td>
</tr>
<tr>
<td>Steep/Uneven Terrain</td>
<td>✓</td>
</tr>
<tr>
<td>Drums Handling</td>
<td></td>
</tr>
<tr>
<td>Heavy Equipment</td>
<td></td>
</tr>
<tr>
<td>Heat Stress</td>
<td>✓</td>
</tr>
<tr>
<td>Noise</td>
<td></td>
</tr>
<tr>
<td>Moving Parts</td>
<td>✓</td>
</tr>
<tr>
<td>Extreme Cold</td>
<td></td>
</tr>
<tr>
<td>Non-Ionizing Radiation</td>
<td></td>
</tr>
<tr>
<td>Heavy Lifting</td>
<td></td>
</tr>
<tr>
<td>Ionizing Radiation</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>✓</td>
</tr>
<tr>
<td>Traffic</td>
<td></td>
</tr>
<tr>
<td>Overhead Hazards</td>
<td></td>
</tr>
<tr>
<td>Biological Hazards</td>
<td></td>
</tr>
<tr>
<td>Fall (&gt;6; Vertical)</td>
<td></td>
</tr>
<tr>
<td>Surface Water (Immersion)</td>
<td></td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Checkmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explosimeter</td>
<td></td>
</tr>
<tr>
<td>Eye Wash</td>
<td></td>
</tr>
<tr>
<td>Confined Space Warning Signs</td>
<td></td>
</tr>
<tr>
<td>Fall Protection Equipment</td>
<td></td>
</tr>
<tr>
<td>Emergency Shower</td>
<td>✓</td>
</tr>
<tr>
<td>Communications – On Site</td>
<td></td>
</tr>
<tr>
<td>Barrier Tape</td>
<td>✓</td>
</tr>
<tr>
<td>Emergency Air Horn</td>
<td>✓</td>
</tr>
<tr>
<td>Communications – Off Site</td>
<td></td>
</tr>
<tr>
<td>Traffic Cones</td>
<td>✓</td>
</tr>
<tr>
<td>Lights</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Stretcher</td>
<td></td>
</tr>
<tr>
<td>Lights – emergency</td>
<td></td>
</tr>
<tr>
<td>First Aid Kit</td>
<td></td>
</tr>
<tr>
<td>Ladder</td>
<td></td>
</tr>
<tr>
<td>A-B-C- Fire Extinguisher</td>
<td></td>
</tr>
<tr>
<td>Tick Repellant</td>
<td></td>
</tr>
<tr>
<td>Flotation Device (USCG Type III)</td>
<td></td>
</tr>
</tbody>
</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>
<th>PEL</th>
</tr>
</thead>
</table>
GW Chlorinated hydrocarbons (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, Vinyl chloride, 1,1,1-TCA, 1,1-DCE) VO and TO 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 VO and TO 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></td>
<td>Inhal/Ingest/Contact/Absorb</td>
<td>High/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B1</td>
<td>Inh/Ingest/Contact/Absorb</td>
<td>High/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B2</td>
<td>Inh/Ingest/Contact/Absorb</td>
<td>High/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B3</td>
<td>Inh/Ingest/Contact/Absorb</td>
<td>High/Low</td>
<td>Level D PPE</td>
</tr>
<tr>
<td>B4</td>
<td>Inh/Ingest/Contact/Absorb</td>
<td>High/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-dichloroethene (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).

| Uncharacterized Airborne Vapors or Gases | Background |
| Characterized Airborne Gases, Vapor, Particulates | >50% REL, TLV |
| Oxygen | < 19.5; >23.5 |
| Flammability | > 10% LEL |
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 1910.62.

<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/1993</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</td>
</tr>
<tr>
<td>Jennifer Triplett</td>
<td>April 2006</td>
<td>40 hours/June 2001</td>
<td>August 7, 2005</td>
<td>(good for 3 years)</td>
</tr>
<tr>
<td>Paul Dahlen</td>
<td>November 1992</td>
<td>40 hours/November 2001</td>
<td>February, 2006</td>
<td></td>
</tr>
<tr>
<td>Paul Johnson</td>
<td>June 2001</td>
<td>40 hours/1987</td>
<td>August 12, 2005</td>
<td>(Refresher sched. For Jan. 2007)</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: 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

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

Designation of emergency signals is as follows:
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:**

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**

**LOCAL RESOURCES**

1. **Ambulance (name):** LM Aero Emergency Services  
   **Phone:** 911 or (817) 777-3473
2. **Hospital (name):** Harris Methodist Hospital  
   **Phone:** 911 or (817) 250-3333
3. **Police (local or state):** LM Aero Security  
   **Phone:** 911 or (817) 777-2567
4. **Fire (name):** LM Aero Fire Department  
   **Phone:** 911 or (817) 777-2163
5. **HAZ MAT Responder:** National Response Center, Toxic Chemicals and Oil Spills  
   **Phone:** 911 or (800)424-8802
6. **On-Site CPR/FA(s):** Shane Williams  
   **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:**

**BATTELLE RESOURCES**

1. **Manager, Corporate Health and Safety (ETE Division)**  
   **Site Contact:** Eric Foote: 614-424-7939
   Gary Carlin, 614-424-4929

2. **Battelle Security Office**  
   **(614) 424-4444**
## SECTION 15: PERSONAL PROTECTIVE EQUIPMENT (check or circle all that apply)

<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>Hearing Protection</td>
</tr>
</tbody>
</table>

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.

## 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: [Signature] [Date]

H&S Manager: [Signature] [Date]
Principal Investigator: [Signature] [Date]
Project Leader: [Signature] [Date]
Site Safety Officer: [Signature] [Date]

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 [Signature] [Date]
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
Draft Final

Data Analysis Report of
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 Memorial Institute

February 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.
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Acronyms and Abbreviations

AFP     Air Force Plant
bgs     below ground surface
DCA     1,1-dichloroethane
DCE     1,2-dichloroethene
DNAPL   dense non-aqueous phase liquid
DO      dissolved oxygen
DELCD   dry electrolytic conductivity detector
EC      electrical conductivity
ERH     electrical resistance heating
ESTCP   Environmental Security Technology Certification Program
FID     flame-ionization detector
GC      gas chromatography
ORP     oxidation reduction potential
PID     photo-ionization detector
TCA     trichloroethane
TCE     trichloroethylene
VOA     volatile organic analysis
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:

\[ K = \left( \frac{r^2 \ln(L_c/R)}{2L_c t_{37}} \right) \]

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:

\[ K = \left( r_c^2 \ln\frac{R_c}{R} / (2L_c) \right) \ast \left( \frac{1}{t} \ln\frac{H_o}{H_t} \right) \]

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)
\( R_c \) = effective radial distance over which head is dissipated (L)
\( L_c \) = length of well screen (L) (4.5, 5, 6, 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).

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:

\[ K = \left( r_{ce}^2 \ln\frac{R_{ce}}{R} / (2L_{ce}) \right) \ast \left( \frac{1}{t} \ln\frac{H_o}{H_i} \right) \]

Where \( r_{ce}^2 \) = \( r_c^2 + S_y (R^2-r_c^2) \)
\( S_y \) = \( \frac{V_{wc}/V_s}{(r_c^2 (H_{oc}-H_i)) / ((R^2-r_c^2)H_i} \)
\( V_{wc} = \pi r_c^2 (H_{oc}-H_i) \)
\( V_s = \pi (R^2-r_c^2)H_i \)
\( H_{oc} = \frac{V_{sr}}{(\pi r_c^2)} \)

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)
\( V_{wc} \) = volume drained into casing (L³)
\( S_y \) = specific yield
\( r_{ce} \) = effective casing radius (L)
\( r_c \) = 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) (saturated thickness of screened interval)
\( H_0 \) = 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)

(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


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Figure 3. Slug Test Locations
Figure 4. Sampling Locations
Figure 5. Interpolated Groundwater Elevation Map
### Appendix D

<table>
<thead>
<tr>
<th>GP-9^</th>
<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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<td></td>
<td></td>
<td></td>
<td>25 ft below ground surface</td>
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</tbody>
</table>

Legend:
- ^ No water
- * Composite sample taken

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
Note:
* Composite sample of the open borehole

Figure 9. 1,1-DCE Direct-Push Groundwater Concentrations (μg/L)
Note:
* Composite sample of the open borehole

Figure 10. cis-1,2-DCE Direct-Push Groundwater Concentrations (μg/L)
Appendix D

Width (ft)

Expected text content: 143

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
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Figure 22. Aerial Contour Map of PCE Groundwater Concentrations (μg/L) for Monitoring Wells and Composite Direct-Push Sampling Locations
Tables
Table 1. Geologic Descriptions of Continuous Soil Cores (December 2006)

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<thead>
<tr>
<th>Boring Depth (ft)</th>
<th>Subsurface Features</th>
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<td>Silty clay with gravels</td>
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<td><strong>Continuous Soil Core GP6</strong></td>
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<td>Silty clay</td>
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<td>30.5-33.5</td>
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<td>33.5-34</td>
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Table 2. Sampling Locations and Types of Test Performed (December 2006)

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<th>Water Quality Assessment</th>
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<sup>a</sup> Monitoring well was dry.

<sup>b</sup> 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).

<sup>c</sup> Depth to water measurements are approximate and not intended for groundwater elevation calculations.

<sup>d</sup> 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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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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<th>ORP (mV)</th>
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<sup>a</sup> Indicates no water quality parameters were taken due to lack of water.
<sup>b</sup> Monitoring well was dry

EC = electrical conductivity
D.O. = dissolved oxygen
ORP = oxidation-reduction potential

All measurements were made with a Horiba U-22 meter.
## Table 6. Chemical Concentration Data for Monitoring Wells (December 2006)

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DUP - Duplicate sample
REP - Quality control sample (second analysis of same water sample)
DCA – Dichloroethane
TCE - Trichloroethene
PCE - Tetrachloroethene
DCE – Dichloroethene
Table 7. Survey Data for Direct-Push Downgradient Transect Locations

<table>
<thead>
<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>
<thead>
<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>
<th>ORP (mV)</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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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.

a Monitoring wells were installed 2-weeks prior to the December 2006 field investigation, therefore historical analytical data was not available.
Table 11. Monitoring Well Chemical Concentration Data Comparison Continued

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<th>Sample Location</th>
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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
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<th>Hydraulic Conductivity Method</th>
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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 (µg/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:

a. 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.

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 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.

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).

4.0 References


Figure 1. Site Map
Figure 2. Electrical Resistance Heating Layout and Configuration
Figure 3. Sampling Locations

Legend
- P2-MW32: Abandoned Monitoring Wells
- P2-MW32: Monitoring Wells
- E91: Electrodes
- E32: Dual Vapor Extraction Electrodes
- SV16: Dual vapor/Soil Vapor Wells
- TMP: Temperature Monitoring Points
- Collection of depth to water, aquifer specific-capacity test, and groundwater sample
- Direct Push Sampling Location
- Soil core and Direct Push Sampling Location

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 Dahlan

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

| Site Name: | Hunter Army Airfield |
| Address: | Savannah, Georgia |

| Site Project Contact: | Alpana Stevenson |
| Phone Number: | 912-315-4238 |
| Site Safety & Health Contact: | Shana Williams |
| Phone Number: | 912-315-4238 |

(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, Waste
- Sampling, Soil
- Other:

DATE(S) OF FIELD VISIT(S):

(4) BATTELLE/ASU TASKS

- B1. Groundwater Investigation
- B2. Groundwater sampling
- B3. Water level survey and ring tests
- B4. Analytical activities

TASK PERFORMED BY OTHERS

- 01. Direct push activities for gw sample collection
- 02. BID disposal
- 03.
- 04.

(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

- Eric Foote-Paul Johnson

SITE SAFETY OFFICER

- Shana Williams

ALTERNATIVE SITE SAFETY OFFICER(S)

- Jennifer Triplet/Paul Dahlan
- N/A

PUBLIC INFORMATION OFFICER

- Paul Dahlan/Jennifer Triplet

SITE RECORD KEEPER

- Shana Williams

SITE PERSONNEL WITH CPR/FA

- Paul Dahlan

FIELD TEAM LEADER(S)

- Paul Dahlan

OTHER FIELD TEAM MANAGERS

- Shana Williams
(6) **ON SITE CONTROL**

*Sasha 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 has been established at the previous ERH 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 north and east 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
- Slope/Uneven Terrain
- Heat Stress
- Noise
- Moving Parts
- Extreme Cold
- Ionizing Radiation
- Non-Ionizing Radiation
- Heavy Lifting
- Traffic
- Electrical
- Overhead Hazards
- Biological Hazards
- Fall (4-6, 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 protection 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
- Fall Protection Equipment
- Eye Wash
- Emergency Shower
- Emergency Air Horn
- Communications - On Site
- Communications - Off Site
- Traffic Cone
- Lights
- Other:
- Stretcher
- Lights - emergency
- First Aid Kit
- Ladder
- A-B-C-Fire Extinguisher
- Tick Repellent
- Snake Bite Kit
- 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 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>BTEX (benzene, toluene, ethylbenzene, xylenes), Polyaromatic hydrocarbons (PAHs)</td>
<td>VO and TO</td>
<td>Not Available</td>
<td></td>
</tr>
<tr>
<td>SL</td>
<td>BTEX 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), ETO (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, 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
- Liquimer®

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 (Sensor: 10.6 eV)</td>
<td>daily/hourly/continuous/other</td>
<td>3 times per day</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</td>
<td>daily/hourly/continuous/other</td>
<td>3 times per day</td>
</tr>
<tr>
<td>GC/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.

<table>
<thead>
<tr>
<th>ACTION LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncharacterized Airborne Gases or Gases</td>
</tr>
<tr>
<td>Characterized Airborne Gases, Vapor, Particulates</td>
</tr>
<tr>
<td>Oxygen</td>
</tr>
<tr>
<td>Flammability</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. Perimeter monitoring (support zone) will be conducted, as 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 1910.137.

<table>
<thead>
<tr>
<th>NAME</th>
<th>MEDICAL (Date)</th>
<th>INITIAL (Hrs/Date)</th>
<th>REFRESHER (Date)</th>
<th>CPR/FA/ (Date) (good for years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eric Foster</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>Shane Williams</td>
<td>February 2006</td>
<td>40 hours/April 1994</td>
<td>July 14, 2006</td>
<td></td>
</tr>
<tr>
<td>Jennifer Triplett</td>
<td>40 hours/June 2001</td>
<td>August 7, 2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paul Dahlem</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 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

- 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:

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/Trash
- Wet Brushes
- Other Decontamination Solution
- Buckets
- Water

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 shall 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 person shall re-enter 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 re-enter 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

\[\checkmark\] 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): | Emergency Services | Phone: 911 |
| Ambulance (name): | St. Joseph's Candler Hospital | Phone: 911 or (912) 819-6000 |
| Hospital (name): | Savannah Police Department | Phone: 911 or (912) 232-4141 |
| Police (local or state): | Savannah Fire & Emergency Services | Phone: 911 or (912) 651-6758 |
| HAZ MAT Responder: | Savannah Special Operations Division | Phone: 911 or (912) 651-6758 |
| On-Site CPR/FA(s): | Shana Williams | Phone: 414-348-4437 |

* For life-threatening emergencies or emergency trauma care.
  The above hospital is approximately 4.6 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) **BATTENELLE RESOURCES**

Health and Safety Representative (BSTI)
Stephanie Halgren, CSP.
614-424-7385

Site Contact: Eric Ford: 614-374-2729

Battelle Security Office
(614) 424-4444

ER-0314 182 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>Covers all</td>
<td>Cotton</td>
<td>Safety</td>
<td>Hard Hat</td>
</tr>
<tr>
<td>Tyvek</td>
<td>Leather</td>
<td>Fireman/Ship</td>
<td>Safety Glasses</td>
</tr>
<tr>
<td>Saranex</td>
<td>Nitrile</td>
<td>Neoprene</td>
<td>(with side shields)</td>
</tr>
<tr>
<td>PE Tyvek</td>
<td>Butyl</td>
<td>Steel Toe</td>
<td>Goggles</td>
</tr>
<tr>
<td>Other</td>
<td>Neoprene</td>
<td></td>
<td>Face shield</td>
</tr>
<tr>
<td></td>
<td>Viton</td>
<td></td>
<td>Hearing Protection</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 the 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 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:  

<table>
<thead>
<tr>
<th>H&amp;S Representative</th>
<th>Principal Investigator</th>
<th>Project Leader</th>
<th>Site Safety Officer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stephanie Heiser</td>
<td>Eric Foot</td>
<td>Paul Dahlen</td>
<td>Stana Williams</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.

FIELD PERSONNEL (Print Name):  SIGNATURE:  DATE:  

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VISITOR (Print Name):  SIGNATURE:  DATE:  

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Organization/Agency:  

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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.
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## Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<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>
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<tr>
<td>ORP</td>
<td>oxidation reduction potential</td>
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<tr>
<td>PID</td>
<td>photo-ionization detector</td>
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<tr>
<td>temp</td>
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<tr>
<td>VOA</td>
<td>volatile organic analysis</td>
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<td>yr</td>
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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:

\[ T = \frac{Q}{(2(h_2-h_1))} \times \ln \left( \frac{r_2}{r_1} \right) \]

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)

\[ K = T/b \]

Where \( K \) = hydraulic conductivity (L/T)
- \( b \) = length of sampler or screen section (L) (0.5 ft or length of screen)

(Fetter, 2000).

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:
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.

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.

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.

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

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Figure 1. Site Map
Figure 2. Direct-Push Locations

Source: EPA (2005)
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
<table>
<thead>
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<th>GP 4</th>
<th>GP 3</th>
<th>GP 2</th>
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**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 18. m/p Xylenes Contour Plot
Figure 19. O Xylenes Contour Plot
Figure 20. Naphthalene Contour Plot
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Figure 22. Interpolated Benzene Concentration Grid
Figure 23. Interpolated Hydraulic Conductivity Grid
Figure 24. Benzene Mass Flux Results
Table 1. Geologic Descriptions of Continuous Soil Cores (March/April 2007)

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<td>Fine Sand</td>
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Table 2. Sampling Locations and Types of Test Performed (March/April 2007)

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<th>Water Quality Assessment</th>
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</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)

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<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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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>
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<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>
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<td>2</td>
<td>9</td>
<td>129</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>DTW (ft BTOC)</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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<sup>(a)</sup> 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)

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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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See Figure 1
DUP = Duplicate sample,  REP = Quality control sample (second analysis of same water sample)
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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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<th>Volume purged (ml)</th>
<th>Time (min)</th>
<th>Time (sec)</th>
<th>Total Time (sec)</th>
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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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</table>

N/A – No Data Available
Dup – Duplicate Sample
REP – Quality Control Sample (second analysis of same sample)
Draft Final

Data Analysis Report for
Ft. Lewis, Washington – Area 3

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.
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# Acronyms and Abbreviations

<table>
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<th>Acronym</th>
<th>Description</th>
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<td>dry electrolytic conductivity detector</td>
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<td>ERH</td>
<td>electrical resistance heating</td>
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<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>ft</td>
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<td>gas chromatography</td>
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<td>kg</td>
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<td>VOA</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.
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
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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
M08 - Treatment Zone Well

Figure 18. Monitoring Well M08 Data
Figure 19. Monitoring Well P05 Data
Tables
Table 1. Groundwater Sampling Locations

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**Notes:**
- Pre-treatment concentration data
- During treatment concentration data
- Post-treatment concentration data

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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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)

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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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Table 5. Mass Flux Analysis

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<th>Hydraulic Gradient (ft/ft)</th>
<th>Hydraulic Conductivity and Gradient Measurements</th>
<th>Discharge (kg/yr)</th>
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<td>Low hydraulic conductivity and gradient</td>
<td>1.42E-01</td>
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<td>0.0034</td>
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<td>0.0042</td>
<td>High hydraulic conductivity and gradient</td>
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Appendix E

Quality Assurance Project Plan
(see electronic attachment)
APPENDIX E

QUALITY ASSURANCE PROJECT PLAN
(Reproduced here from the Demonstration Plan)

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:
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<tr>
<th>Performance Criteria</th>
<th>Description</th>
<th>Primary or Secondary</th>
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</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>
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</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:

\[
\% \text{ Accuracy} = \frac{100(X - X_a)}{X_a} \tag{B-1}
\]

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:

\[
\% \text{ Completeness} = 100 \frac{D_o}{D_s} \tag{B-2}
\]

where

- \( D_o \) = quantity of data obtained
- \( D_s \) = 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>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
## RESULTS

<table>
<thead>
<tr>
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<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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## Interpolation Error Results

### TCE Interpolation Methods
- Hydraulic Conductivity: 1) Vertical: Linear  2) Horizontal: Linear
- Concentration: 1) Vertical: Linear  2) Horizontal: Linear
- Hydraulic Gradient: 1) Vertical: Linear  2) Horizontal: Linear

### Total Mass Flux Including All Points

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**Back to Mass Flux Result**  
**Back to Data Input**  
**Print**  
**HELP**  

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**Select Time Period to View:**
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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

### Site Location and ID:
- **CAMP LEJEUNE**
- **SITE 80 - DIRECT PUSH SAMPLING**

**Description:**

**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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End of Transect
Start of Transect
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GP 7
GP 7
GP 7
GP 7
GP 7
End of Transect

Top of
Sampling
Interval

Bottom of
Sampling
Interval

9
13
17
17
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20
24

Parameter
Examined

Parameter
Value
Removed For
Analysis

Parameter
Units

Total Mass Flux
Excluding Selected
Point and
Interpolating
(g/day)

Conductivity
Concentration
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2.80E+00
0.00E+00
7.60E+04
7.40E+04
4.40E+04
6.60E+02
3.80E+02
1.00E+00
1.50E+05
1.60E+05
5.80E+04
4.50E+02
4.60E+02
6.60E+02
2.00E+04
8.70E+02
6.40E+01
2.90E+02
8.50E+01
1.10E+03
5.80E+02
1.20E+02
1.30E+02
4.90E+01
6.40E+01
2.90E+02
7.50E+02
1.20E+03
6.20E+02
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2.00E+01
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1.40E+02
3.20E+01
0.00E+00

ft/d
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9.10E+01
9.12E+01
8.99E+01
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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

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<th>Bottom of Sampling Interval</th>
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<th>Parameter Value Removed For Analysis</th>
<th>Parameter Units</th>
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<th>Contribution of Selected Point to Total Mass Flux (%)</th>
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Total Mass Flux Including All Points: **4.31E+00** (g/day)
### Interpolation Error Results

**Site Location and ID:** Ft. Lewis NAPL Area 3  
**Description:**

#### TCE Interpolation Methods
- **Hydraulic Conductivity:** Uniform  
- **Concentration:** 1) Vertical: Linear  2) Horizontal: Linear  
- **Hydraulic Gradient:** Uniform

#### Total Mass Flux Including All Points

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**RESULTS**

- Total Mass Flux Including All Points: **3.90E-01 (g/day)**
### TCE Interpolation Methods

- **Hydraulic Conductivity:** Uniform
- **Concentration:** 1) Vertical: Linear  2) Horizontal: Linear
- **Hydraulic Gradient:** Uniform

### Total Mass Flux Including All Points

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### Parameter Examined

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**Ft. Lewis NAPL Area 3**

**RESULTS**

**Next Step:**
- Mass Flux Summary
- Print

**End of Transect**

**Description:**

- **Site Location and ID:** Ft. Lewis NAPL Area 3
- **TCE Interpolation Methods**
  - **Concentration:** 1) Vertical: Linear  2) Horizontal: Linear
  - **Hydraulic Conductivity:** Uniform
  - **Hydraulic Gradient:** Uniform
### 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

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**Total Mass Flux Including All Points:** 1.03E-01 (g/day)
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<td>-17.3</td>
</tr>
<tr>
<td>95</td>
<td>GP 8</td>
<td>20</td>
<td>20.5</td>
<td>Concentration</td>
<td>6.50E+01 ug/L</td>
<td>8.12E-02</td>
<td>20.0</td>
</tr>
<tr>
<td>96</td>
<td>GP 9</td>
<td>12</td>
<td>16</td>
<td>Concentration</td>
<td>5.00E-07 ug/L</td>
<td>1.00E-01</td>
<td>0.3</td>
</tr>
<tr>
<td>97</td>
<td>GP 9</td>
<td>16</td>
<td>20</td>
<td>Concentration</td>
<td>5.00E-07 ug/L</td>
<td>1.01E-01</td>
<td>0.7</td>
</tr>
<tr>
<td>98</td>
<td>End of Transect</td>
<td></td>
<td></td>
<td>Concentration</td>
<td>0.00E+00 ug/L</td>
<td>1.00E-01</td>
<td>-0.1</td>
</tr>
</tbody>
</table>
## Interpolation Error Results

### Site Location and I.D.: NAS Bakersfield
### Description: Site 5

**Next Step:** Mass Flux Summary

**Back to Mass Flux Result**

**Print**

**SELECT TRANSECT TO VIEW**

**SELECT TIME PERIOD TO VIEW**

### TCE Interpolation Methods

- Hydraulic Conductivity: 1) Vertical: Linear 2) Horizontal: Linear
- Concentration: 1) Vertical: Linear 2) Horizontal: Linear
- Hydraulic Gradient: 1) Vertical: Linear 2) Horizontal: Linear

### Total Mass Flux Including All Points

![Graph](image)

### Results

| End of Transect | Top of Sampling Interval | Bottom of Sampling Interval | Parameter | Parameter Value | Parameter Value Removed For Analysis | Parameter | Units | interpolation

| Transect 1 | 1.79E-01 |

| Transect 2 | 1.77E-01 |

| Transect 3 | 1.72E-01 |

| Transect 4 | 1.71E-01 |

| Transect 5 | 1.69E-01 |

| Transect 6 | 1.64E-01 |

| Transect 7 | 1.63E-01 |

| Transect 8 | 1.61E-01 |

| Transect 9 | 1.59E-01 |

| Transect 10 | 1.57E-01 |

| Transect 11 | 1.55E-01 |

| Transect 12 | 1.53E-01 |

| Transect 13 | 1.51E-01 |

| Transect 14 | 1.49E-01 |

| Transect 15 | 1.47E-01 |

| Transect 16 | 1.45E-01 |

| Transect 17 | 1.43E-01 |

| Transect 18 | 1.41E-01 |

| Transect 19 | 1.39E-01 |

| Transect 20 | 1.37E-01 |

| Transect 21 | 1.35E-01 |

| Transect 22 | 1.33E-01 |

| Transect 23 | 1.31E-01 |

| Transect 24 | 1.29E-01 |

| Transect 25 | 1.27E-01 |

| Transect 26 | 1.25E-01 |

| Transect 27 | 1.23E-01 |

| Transect 28 | 1.21E-01 |

| Transect 29 | 1.19E-01 |

| Transect 30 | 1.17E-01 |

| Transect 31 | 1.15E-01 |

| Transect 32 | 1.13E-01 |

| Transect 33 | 1.11E-01 |

| Transect 34 | 1.09E-01 |

| Transect 35 | 1.07E-01 |

| Transect 36 | 1.05E-01 |

| Transect 37 | 1.03E-01 |

| Transect 38 | 1.01E-01 |

| Transect 39 | 9.9E-02 |

| Transect 40 | 9.7E-02 |

| Transect 41 | 9.5E-02 |

| Transect 42 | 9.3E-02 |

| Transect 43 | 9.1E-02 |

| Transect 44 | 8.9E-02 |

| Transect 45 | 8.7E-02 |

| Transect 46 | 8.5E-02 |

| Transect 47 | 8.3E-02 |

| Transect 48 | 8.1E-02 |

| Transect 49 | 7.9E-02 |

| Transect 50 | 7.7E-02 |

| Transect 51 | 7.5E-02 |

| Transect 52 | 7.3E-02 |

| Transect 53 | 7.1E-02 |

| Transect 54 | 6.9E-02 |

| Transect 55 | 6.7E-02 |

| Transect 56 | 6.5E-02 |

| Transect 57 | 6.3E-02 |

| Transect 58 | 6.1E-02 |

| Transect 59 | 5.9E-02 |

| Transect 60 | 5.7E-02 |

| Transect 61 | 5.5E-02 |

| Transect 62 | 5.3E-02 |

| Transect 63 | 5.1E-02 |

| Transect 64 | 4.9E-02 |

| Transect 65 | 4.7E-02 |

| Transect 66 | 4.5E-02 |

| Transect 67 | 4.3E-02 |

---

1. The table below shows all concentration and, if applicable, non-uniform conductivity/Darcy velocity and gradient input data. 2. 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 NASA internal written note.
<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 Excluding Selected Point and Interpolating Selected Point (g/day)</th>
<th>Total Mass Flux (g/day)</th>
<th>Contribution of Selected Point to Total Mass Flux (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GP 5</td>
<td>16.5</td>
<td>16</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.86E-01</td>
</tr>
<tr>
<td>GP 5</td>
<td>16.5</td>
<td>16</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.86E-01</td>
</tr>
<tr>
<td>GP 5</td>
<td>20.5</td>
<td>21</td>
<td>Gradient</td>
<td>1.00E+00</td>
<td>ft/ft</td>
<td>1.84E-01</td>
</tr>
<tr>
<td>GP 5</td>
<td>20.5</td>
<td>21</td>
<td>Gradient</td>
<td>1.00E+00</td>
<td>ft/ft</td>
<td>1.84E-01</td>
</tr>
<tr>
<td>GP 6</td>
<td>6.5</td>
<td>7</td>
<td>Concentration</td>
<td>1.00E+00</td>
<td>ug/L</td>
<td>1.81E-01</td>
</tr>
<tr>
<td>GP 6</td>
<td>10.5</td>
<td>11</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.87E-01</td>
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<tr>
<td>GP 6</td>
<td>12.5</td>
<td>13</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.86E-01</td>
</tr>
<tr>
<td>GP 6</td>
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<td>19</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.84E-01</td>
</tr>
<tr>
<td>GP 6</td>
<td>20.5</td>
<td>21</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.84E-01</td>
</tr>
<tr>
<td>GP 6</td>
<td>7</td>
<td>7.5</td>
<td>Gradient</td>
<td>1.00E+00</td>
<td>ft/ft</td>
<td>1.82E-01</td>
</tr>
<tr>
<td>GP 6</td>
<td>7</td>
<td>7.5</td>
<td>Gradient</td>
<td>1.00E+00</td>
<td>ft/ft</td>
<td>1.82E-01</td>
</tr>
<tr>
<td>GP 8</td>
<td>6.5</td>
<td>16</td>
<td>Concentration</td>
<td>1.00E+00</td>
<td>ug/L</td>
<td>1.81E-01</td>
</tr>
<tr>
<td>GP 8</td>
<td>12.5</td>
<td>13</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.86E-01</td>
</tr>
<tr>
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<td>18.5</td>
<td>19</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.84E-01</td>
</tr>
<tr>
<td>GP 8</td>
<td>20.5</td>
<td>21</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.84E-01</td>
</tr>
<tr>
<td>Start of Transect</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.86E-01</td>
<td>5.0</td>
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</tr>
<tr>
<td>End of Transect</td>
<td>Concentration</td>
<td>0.00E+00</td>
<td>ug/L</td>
<td>1.86E-01</td>
<td>5.0</td>
<td></td>
</tr>
</tbody>
</table>

RESULTS

- **Total Mass Flux**
  - Excluding Selected Point and Interpolating Point
  - Selected Point to Total Mass Flux (%)

- **Parameter Examined**
  - Concentration
  - Gradient

- **Parameter Value**
  - Excluding Selected Point and Interpolating Point
  - Selected Point to Total Mass Flux (%)