Decontamination Systems Information and Research Program

**Quarterly Report
April 1 - June 30, 1998**

**By:
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Work Performed Under Contract No.: DE-FC21-92MC29467

For
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
P.O. Box 880
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**Quarterly Technical Progress Reports
2nd Calendar Quarter 1998
April 1, 1998 - June 30, 1998**

Work Performed Under
Contract Number: DE-FC21-92MC29467--33

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Office of Fossil Energy
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P.O. Box 880, 3610 Collins Ferry Road
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July 1998

EXECUTIVE SUMMARY

The following paragraphs comprise the research efforts during the second quarter of 1998 (April 1 - June 30.) These tasks have been granted a continuation until the end of August 1998. This report represents the last technical quarterly report deliverable for the WVU Cooperative Agreement - Decontamination Systems Information and Research Program. Final draft technical reports will be the next submission.

*During this period, work was completed on the Injection and Circulation of Potable Water Through PVDs on **Task 1.6 - Pilot Scale Demonstration of TCE Flushing Through PVDs at the DOE/RMI Extrusion Plant.** The data has been evaluated and representative graphs are presented. The plot of Cumulative Injected Volume vs. Cumulative Week Time show the ability to consistently inject through the two center PVDs at a rate of approximately ten (10) gallons per hour. This injection rate was achieved under a static head that varied from five (5) feet to three (3) feet. The plot of Extracted Flow Rate vs. Cumulative Week Time compares the extraction rate with and without the injection of water. The injection operation was continuous for eight hour periods while the extraction operation was executed over a pulsing schedule. Extraction rates as high as forty-five (45) gallons per hour were achieved in conjunction with injection (a 350% increase over no injection.)*

The retrieved TCE in the liquid phase varied to a considerable degree depending on the pulsing scheme, indicating a significant amount of stripping (volatilization) took place during the extraction process. A field experiment was conducted to confirm this. A liquid sample was obtained using the same vacuum system used in the pad operation and a second liquid sample was taken by a bailer. Analyzation of TCE concentration showed 99.5% volatilization when the vacuum system was used for extraction. This was also confirmed by data from the air monitoring program which indicated that 92%-99% of the retrieved TCE was being transported in the gas phase.

Data on the recovered TCE concentration for the pulsing schemes implemented in the field were collected. Based on the TCE concentration in the liquid phase, the optimum schedule for recovery during an extraction only scenario is "one hour on - seven hours off - one hour on" which allows for the recharging of the groundwater with TCE by the process of diffusion. With injection utilized, the optimum schedule for the operation is "one hour on - three hours off - one hour on," which allows for the optimum recovery of TCE in an optimized amount of liquid.

Uranium (U) was recovered in conjunction with TCE removal. Although specifically not targeted, the PVDs indiscriminately retrieved the subsurface contaminants on the order of 65-95 pCi/L. The field work was completed on surfactant augmented injection. Circulation and data reduction from this sequence of testing is ongoing.

*Several issues were addressed this quarter during work on **Task 1.7 - Technical Support for Surfactant Flushing through Prefabricated Vertical Drains (PVDs) at the RMI Ashtabula, Ohio***

Site, including surface tension readings, analytical methodology and commercial lab interaction, and operating parameters for the biodegradation of the surfactant solution. Measured surface tensions replicated at IGT were found to be in agreement with the data produced by RMIES. It was found that the water used to prepare the surfactant solution and the particular batch of surfactant products had minor effects on the surface tension.

Intentionally contaminated liquid samples containing various amounts of TCE and surfactant were prepared and sent to commercial labs (CORE and DIAL) for analysis by EPA method 5030B to verify the reliability of this method. The results showed that the 5030B purge and trap methodology yields accurate results for liquid samples containing TCE in the range of five (5) to five thousand (5,000) ppb. CORE labs reported difficulty with the antifoaming agent interfering with their GC detector, which resulted in a decreased detection limit of fifty (50) ppb TCE. DIAL reported no such difficulties and were able to accurately quantify surfactant containing samples and maintain a limit of detection of one (1) to five (5) ppb TCE. DIAL also demonstrated the viability of solid phase micro extraction (SPME) can be used as an alternative to 5030B, but this method is not EPA-approved.

Large amounts of surfactant degrading bacteria were prepared at IGT to serve as the inoculum to start the surfactant biodegradation reactor to treat the water after air stripping and ultra filtration. The reactor began operation at the end of June. A three thousand (3,000) gallon batch of surfactant solution was treated and preliminary data indicate the surfactant biodegradation reactor is operating well.

*Work this quarter on **Task 1.8a - Installation / Operation of the PVD System** by RMI Environmental Services (RMIES) involved intermittently operating the PVD system. Seven thousand, five hundred (7,500) gallons were extracted and a variety of injection / extraction modes were implemented to establish optimum operating conditions. Four hundred sixty (460) samples were collected and analyzed for various parameters including TCE, uranium, technetium-99, pH, specific conductance, solids, and surface tension. All data received was forwarded to NCSU for review. RMIES also completed the injection of surfactants expected to remove the trichloroethylene (TCE) attached to the soil. Six thousand (6,000) pounds of soil were shipped to NCSU for further laboratory studies. Tests were conducted to evaluate the volatilization of TCE during extraction operations. A variety of surfactant and non-surfactant samples were collected for volatile organics, specific conductance, pH, temperature, and surface tension analysis during PVD operations. RMIES completed work with IGT to specify the gas chromatography (GC) requirements. A purchase order was placed and the equipment arrived in early June. Pre-extraction samples were collected from the up gradient and down gradient wells and well 104. A PVD was inserted into each of the wells and extract water was sampled. Volatilization attributable to the extraction process was determined based on a comparison of the sample results. On April 7, 8, 9, and 13, the system was operated in a maximum injection / maximum extraction mode. Injection and extraction rates of fifty (50) gallons per hour were maintained throughout the eight (8) hour operating cycles. The system was operated*

in a dual venturi extraction mode for a portion of the operating time on April 7, 8, and 9. The extraction rate was not significantly influenced by the addition of the second venturi. Based on field observations, the first extract drum would fill close to capacity before the second drum would begin to fill.

On Task 1.8b - Design, Procurement, Construction and Operation of the Wastewater Treatment System, RMIES completed a DESF Field Demonstration Project Engineering Report and Project Plan which defines the design basis for the water treatment system. The Ohio Environmental Protection Agency public noticed the NPDES water permit modification on April 3, 1998. The public comment period lasted for thirty (30) days (until May 3). The permit was issued in mid May. This permit allows RMIES to treat the extracted water in the water treatment system. RMIES completed the engineering/design of the water treatment system and received various pieces of process equipment including tanks, pumps, filters, air stripper and other similar items. The wastewater treatment system was constructed and tested during this report period. Approximately nine thousand (9,000) gallons of water were processed.

QUARTERLY
TECHNICAL
PROGRESS REPORTS

FOCUS AREA 1.0

Subsurface Contaminants,
Containment & Remediation

Pilot Scale Demonstration of TCE Flushing Through PVDs at the DOE/RMI Extrusion Plant 1997 FETC Task No. 1.6

Quarterly Technical Progress Report

Reporting Period:

April -June 1998

Work Performed Under Contract

For:

U.S. Department of Energy

Office of Fossil Energy

Federal Energy Technology Center

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July 1998

ABSTRACT

Continuing development on the use of Prefabricated Vertical Drains for Enhanced Soil Flushing technology is progressing with application of the technology at a private-sector site that was a former uranium processing facility for the US Department of Energy. The site, located in Ashtabula Ohio, is owned by the RMI Titanium Corporation. It has both radiological and hazardous materials contamination in soil and groundwater mediums which are limited to a 7 acre area of a 26 acre site. The facility terminated all production operations in 1988 and since then has focused efforts on the decontamination and decommissioning of the facility which includes remediation of the soil and groundwater contaminated by low-level uranium and Trichloroethylene (TCE).

North Carolina State University Department of Civil Engineering is working with RMI Environmental Services through support from DOE's Federal Energy Technology Center - Morgantown and DOE's Ashtabula Area Office - RMI Decommissioning Project, and West Virginia University (WVU). Work during the reporting period consisted of concluding the pulsing experiments using water as permeant, implementing the surfactant injection and extraction part of the experiment, conducting laboratory volatilization tests to support field observations on TCE volatilization, reducing the data from the field experiments and preparing for the FETC annual review conference.

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EXECUTIVE SUMMARY

This project was brought on-line during the fourth quarter of 1997. The project scope is to demonstrate the effectiveness of the PVD enhanced soil flushing technology at the RMI site. This research program includes all activities associated with the design, installation, operation, data gathering and interpretation, and site closure for performing a small- scale (10 ft x 10 ft area) clean-up of TCE contaminated soils at the RMI facility. The research objectives are to investigate the performance of the prefabricated vertical drains used for enhanced soil flushing operating under an injection/extraction mode in a glacial till soil. The field work will be performed to demonstrate the TCE removal using water flushing and then demonstrate the enhanced removal with surfactant solutions at the RMI facility located in Ashtabula, Ohio. This report discusses the progress made for the current reporting period.

Data from the current reporting period indicated that the system operating in injection/extraction mode is capable of circulating a flow rate of 10gal/hr with a recovery of TCE on the order of 100 µg/l in the liquid phase. The extraction rate is significantly increased as it is implemented in conjunction with injection plan. A 95%-99% volatilization of TCE is observed during the extraction process which indicates that 95%-99% of the total TCE mass is removed in the gas phase. Uranium levels on the order of 65-95 pCi/L are retrieved from the subsurface although the scope of the flushing scheme did not target uranium.

Research planned for the next quarter includes the data reduction of the surfactant injection/extraction and removal, the planning for the 1/10 acre field implementation, the performance of laboratory experiments to discern volatilization in the presence of surfactant and the design of air extraction system for the larger scale test pad . Regular monthly project coordination meetings continue to be held between the key researchers, industry partners, and funding representatives in order to maintain project communication and progress.

INTRODUCTION

This project is a concerted effort between North Carolina State University Department of Civil Engineering, U.S. Department of Energy's (DOE) Federal Energy Technology Center - Morgantown and DOE's Ashtabula Area Office - RMI Decommissioning Project, RMI Environmental Services, and WVU's Civil and Environmental Engineering Department. The goal of the work during Phase I and Phase II efforts is to conduct a field scale implementation of the PVD technology for the flushing of TCE from an area measuring approximately 1/10 acre. The work on the Phase I of the project ended on June 30 1998. The research work in this phase encompassed the installation of a 10'x10' test pad, as shown in Figure 1, to explore the feasibility of flushing TCE from the soil and

Site Description

The RMI Extrusion Plant is located in northern Ohio. The plant sits northeast of the city of Ashtabula in Ashtabula County. The area of Ashtabula County where the plant is located is highly industrialized and sparsely populated. The plant sits on a flat upland surface. An escarpment is located directly north of the plant and is about 20 to 30 feet in height. The escarpment slopes into the flood plain of the Fields Brook creek. Fields Brook creek is located 500 feet north of the plant and flows west into the Ashtabula River. The Ashtabula River moves north ultimately reaching Lake Erie. The former evaporation pond to which the TCE was exposed is located on the north side of the facility buildings and is approximately 30 ft in length and 20 ft in width. The plant consists of 25 buildings which occupy 7 acres of a 26acre plot. The layout of the site is shown in Figure 2. The nearest residence is 1/5 of a mile east of the site. Low groundwater well yields and high salinity inhibit residence in the Ashtabula area from using the groundwater as a drinking water source (Eckenfelder, 1996).

Geologic Features

The site soil is a low permeability glacial till interpreted to be Ashtabula Till and is underlain by Devonian Chagrin shale bedrock (Dames & Moore, 1985). The till is composed of approximately 82 percent clay/silt with an average specific gravity of 2.73 (Eckenfelder, 1996). In general, zones of brown clay with varying degrees of mottled orange clay comprise the upper levels of the soil. Shale fragments, pebbles, silt, and sand were found in differing degrees in the clay matrix (Dames & Moore, 1985). The piezometric surface is 2 to 3 feet below the ground surface and moves predominately in a north-northwest flow pattern towards the Fields Brook (Dames & Moore, 1985). Groundwater moves in three zones: the till zone, the till/bedrock zone, and the bedrock zone (Eckenfelder, 1996). The north-northwest flow pattern analysis was based only on equipotential lines drawn from groundwater head observations at the site.

TCE Contamination

TCE is a chlorinated hydrocarbon (CHC) solvent primarily used for degreasing metals and as a dry cleaning agent. TCE is a carcinogen and at certain doses can be immediately dangerous to human life or health. TCE's chemical abstract number is 79-016. TCE has numerous synonyms such as Trichloroethene, Acetylene trichloride, and Triclene (Montgomery and Welkom, 1990). TCE has a specific gravity of 1.46 g/n-d and acts as a dense non-aqueous phase liquid (DNAPL) in the subsurface. Because the compound's density is greater than that of water, migration of DNAPL's is generally governed by the vertical component of lateral advective transport. Limited solubility allows the DNAPL to slowly dissolve into the groundwater making the compound a continual source of contamination (Hossain and Corapcioglu, 1988).

The DNAPL tends to accumulate as stagnant pools on lower permeability layers and acts as a long term contaminant source (Anderson et.al., 1992). Meanwhile, residual amounts of hydrocarbon deposited in the soil pores during downward migration operate as another shorter term source. The erratic infiltration of the DNAPL makes it difficult to locate and characterize (Hossain and Corapcioglu, 1988).

The US Environmental Protection Agency has issued RMI a RCRA Hazardous Waste Management

Permit with conditions mandating clean up of an existing corrective action management unit. Evaluation of various state-of-practice technologies has yielded a limited success in identifying a cost-effective and expedient remediation measure. Therefore, the need for this research on accelerated soil flushing is identified.

OBJECTIVE

As environmental remediation technologies progress through the research process, it is important to continually evaluate the research goals and determine the value-added of the developing technology. For this project, the research objectives of Phase I are three-fold: The first is to perform a limited extraction of the subsurface groundwater to establish the aquifer response to the PVD vacuum extraction system. The second is to demonstrate the injection and flushing with potable water, and the third sequence of testing is to inject the surfactant solution and demonstrate a clean-up at the site. This research is specific to addressing key issues necessary for the design, installation, and operation of a one-tenth acre field remediation of the TCE contaminated soils and groundwater.

BACKGROUND

The RMI Titanium Company (RMI) Extrusion Plant is located in Ashtabula County, Ohio. The facility consists of 25 buildings and occupies 7 acres of a 26 acre site. The facility is contaminated with both radiological and hazardous materials resulting from previous operations for the US Department of Energy. The primary function of RMI, since 1962, has been the extrusion and closed-die forging of metallic depleted, natural, and slightly enriched uranium (U) used in the production of nuclear fuel elements for defense production reactors, extrusion operations for other government agencies, and the private-sector. Extrusion operations ceased in 1990, since then the Nuclear Regulatory Commission (NRC) has required the facility to implement accelerated site clean-up pursuant to its Site Decommissioning Management Plan. The US Environmental Protection Agency has issued RMI a Resource Conservation Recovery Act (RCRA) Hazardous Waste Management Permit with conditions mandating clean-up of an existing Corrective Action

Management Unit. DOE's office of Environmental Restoration and Waste Management (EM) has contracted RMI to conduct the RMI Decommissioning Project by removing all radiological and hazardous contaminants to levels which permit the facility and adjacent areas to be released for unrestricted use.

The principal contaminant on equipment, buildings, and surrounding open space areas is uranium. In addition to the uranium, soil and groundwater are contaminated with Trichloroethylene (TCE) and Technetium 99 in limited areas of the site. Clean-up of the facility is slated to continue for the next several years due to technology limitations and the unique challenges which face RMI in handling the large physical size of the manufacturing equipment and facility.

METHODOLOGY

Phase I efforts for the Laboratory Studies and Field Testing at the RMI Extrusion Plant project involved the field demonstration of the PVD enhanced soil flushing technology. The purpose of this phase of the project focuses on the *in situ* field demonstration of the flushing system configured using with two injection and six extraction PVDs. Eight PVDs were installed in a configuration shown in Figure 1. At the time of installation of the PVDs, field borings were taken to classify the in situ soils and for the identification of physical and engineering properties of the in-place soils as well as obtaining background values of the pre-flushing TCE levels.

A food-grade surfactant with a predetermined concentrations was injected into the subsurface and then extracted and analyzed for TCE concentration changes with time as well as the number of pore volumes of extracted fluid. The pressure/vacuum system were applied and distributed via a series of supply and collector pipes. The PVDs used for this research have the standard dimensions of 100 mm in width x 4.62 mm in thickness.

Once the PVDs and the piping network were constructed, the experiment were conducted in three

stages:

- Task 1 - Extraction Only
- Task 2 - Injection of Water and Extraction
- Task 3 - Injection of Surfactant and Extraction

Task 1 : System Operation Sequence 1 - Groundwater Extraction

Operate the eight PVDS in a full extraction mode only. This entails calibrating the extraction flow rate equal to the aquifer recharge in the vicinity of the test pad. The extraction will remove only site groundwater contaminated with TCE, no injection of liquids will be performed during this phase. During this operation, a set number of pore volumes of groundwater will be passed through the site soil where desorption of the TCE contaminant into the groundwater is expected to take place. Field sampling was performed on retrieved groundwater specimens for laboratory analysis of TCE, and real-time monitoring of the discharged air from the venturi system for volatile organics.

Task 2: Injection and Circulation of Potable Water Through PVDS Sequence II

During this phase of the testing, potable water will be introduced to the injection PVDS and a flushing operation between the injection and extraction PVDS will be performed. Modifications to the PVD collector piping will be made for proper operation of the system. The groundwater sampling protocol followed for the first Task will be used during this phase. It is expected that the injection phase will run for approximately ten days. During this period liquids will not be reintroduced to the aquifer.

Task 3 : Surfactant Augmented Injection / Circulation Sequence III

This will be the final process for removal of the TCE contaminants from the soil and groundwater. A surfactant will be introduced to the groundwater for removal of the residual soil-bound contaminants using the injection/extraction mode of operation followed in Task 2. Revised operational, sampling, and analysis protocol will be developed for this phase of the work. It is expected that this task will operate for approximately 8 weeks.

WORK PERFORMED THIS PERIOD

During this period, the following tasks were completed:

Task 2: Injection and Circulation of Potable Water Through PVDS and,

Task 3: Surfactant Augmented Injection / Circulation

In addition, laboratory and field experiments were conducted to investigate the stripping of TCE as the PVD system was operating. The data for the Injection and Circulation of Potable Water have been evaluated and representative graphs are presented in Figures #2- #5. While the field work on Task 3 was completed, the data reduction from this sequence of testing task is on-going.

Data presented in Figure #2 show the injection rate versus time and indicated the ability to consistently inject through the PVDs. An injection rate of approximately 10 g/hr was achieved through the two center PVDs. This injection rate was achieved under a static head that varied from 5 ft to 3 ft. Figure 3 shows the extraction rate with and without injection of water. Injection operation was continuous for 8 hour period while extraction was executed over a pulsing schedule. As shown in Figure #3, extraction rates as high as 45 g/hr were obtained when performed in conjunction with injection. This rate represent approximately 350% increase in extracted liquid as compared with the 10 gal/hr of extraction with no injection.

The retrieved TCE in the liquid phase varied from 200 $\mu\text{g/l}$ to 30 200 $\mu\text{g/l}$ depending on the pulsing scheme as shown in Figure 4. A significant amount of stripping (volatilization) took place during the extraction process. A field experiment was conducted whereby the PVD was lower to well and a liquid sample was obtained using the same vacuum system used for the Pad operation. A second liquid samples was taken by a bailer and both samples were analyzed for TCE concentration. Results of this experiment shoed 99.5% volatilization when the vacuum system was used for extraction. This results was confirmed by analyzing the results from the air monitoring system. Data from the air monitoring program indicated that 92%-99% of the retrieved TCE was being transported in the gas phase.

Table 1 shows data on the recovered TCE concentration for the pulsing schemes implemented in the field. Based on the TCE concentration in the liquid phase, an optimum scheme for recovery during

an extraction only scenario is 1hr on, 7 hrs off, and 1 hr on. This scheme allows for the recharge of the groundwater with TCE by the process of diffusion before extraction is commenced. As injection is also utilized, the optimum scheme for operation becomes 1 hr on, 3 hrs off, and 1 hr on. This scheme allows for the optimum recovery of TCE in an optimized amount of liquid.

Figure 5 indicated the recovery of Uranium (U) in conjunction with TCE removal. Although the retrieval of U was not targeted during this phase of study, the PVD indiscriminately retrieve the subsurface contaminants. In this case U levels on the order of 65-95 pCi/L were retrieved from the subsurface.

CONCLUSIONS/WORK PLANNED FOR NEXT PERIOD

The preliminary conclusions which may be drawn from this testing phase is that the PVD system operating in injection/extraction mode is capable of circulating a flow rate of 10gal/hr with a recovery of TCE on the order of 100 µg/l in the liquid phase. The extraction rate is significantly increased as it is implemented in conjunction with injection plan. A 95%-99% volatilization was observed which indicated that 95%-99% of the total TCE mass is removed in the gas phase. U levels on the order of 65-95 pCi/L were retrieved from the subsurface.

Research planned for the next quarter includes the data reduction of the surfactant injection/extraction and removal, the planning for the 1/10 acre field implementation, the performance of laboratory experiments to discern volatilization in the presence of surfactant and the design of air extraction system for the larger scale test pad . There are no outstanding issues on this work and the project is on schedule and budget.

Table 1. Summary of Recovered TCE for Different Pulsing Schemes

	Volume Liquid Removed (L)	Mass TCE Removed (mg)
Extract Only		
1on/7off/1on	238	20
1on/3off/....	231	12
1on/1off/...	250	8
Inject/Extract		
1on/7off/1on	284	31
1on/3off/....	397	39
1on/1off/...	587	48

Cumulative Injected Volume vs Cumulative Week Time

March 2 - March 6, 1998

Task 2 Sequence 2

Figure #2. PVD Injection Rate as a Function of Time

Extracted Flow Rate vs. Cumulative Week Time

March 2 - March 6, 1998

Task 2 Sequence 2

Figure #3. Comparison of Extraction Rates With and Without Injection

TCE Concentration vs Cumulative Week Time
 March 16 - March 20, 1998
 Task 2 Sequence 4
 Injection/Extraction Pulse

jqgraphs

Figure #4.

Retrieved TCE in Liquid Phase as a Function of Pulsing Schedule

Total Uranium vs Cumulative Week Time
March 14 - March 16, 1998
Task 2 Sequence 4

Figure #5.

Extracted U^{239} as a Function of Time

Technical Support for Surfactant Flushing through Prefabricated Vertical Drains (PVDs) at the
RMI Ashtabula, Ohio Site

FETC Task No. 1.7

Quarterly Technical Progress Report
Reporting Period:

April 1, 1998 to June 30, 1998

Work Performed Under Contract
No. DE-FC21-92MC29467

For
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
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ABSTRACT

This project seeks to provide support for a novel delivery device, prefabricated Vertical Drains (PVDs), which can be used for the remediation of low permeability soils. PVDs could potentially be used to support multiple remediation objectives and the use of PVDs with surfactant flooding is just one example of how these versatile delivery tools can be applied. Because this technology is novel, results will be viewed with skepticism. Therefore, it is crucial that the highest standards for data collection and analyses are applied throughout. Accordingly, rigorous adherence to a Quality Assurance and Quality Control (QA/QC) plan will be a component of this project, so that if the project is successful others can confidently review the results and make informed decisions regarding the use of this approach at other sites. The objectives of this project are to apply IGT's expertise to support West Virginia University's/North Carolina State University's surfactant flood field experiment at the RMI site in Ashtabula, Ohio. IGT will primarily supply technical assistance on the selection and use of surfactants, and ensure that proper QA/QC procedures are followed throughout the project. An integrated process flow scheme will be developed, including material and energy balances, for the full scale implementation of this technology.

Several issues were addressed during this quarter: surface tension readings of the surfactant solution prepared at RMI, analytical methodology and commercial labs, and operating parameters for the biodegradation of surfactant solution. We measured surface tensions of the RMI solution at IGT with multiple replicates and produced standard curves that have reasonably good agreement with the data produced by RMI. The water used to prepare surfactant solutions was found to have a minor effect on the surface tension of the resulting solutions, and the particular batch of surfactant products had a minor effect as well. These issues were sorted out and surface tension data was exchanged between IGT and RMI concerning the analyses of samples prepared with various water sources and ingredients, and consistent readings were obtained at both labs.

Analytical methodology was previously selected for the analysis of samples containing surfactant/TCE mixtures, but not yet fully validated by commercial labs. Intentionally contaminated liquid samples containing various amounts of TCE and surfactant were prepared and these samples were sent to commercial labs (CORE and DIAL) for analysis by EPA method 5030B to verify the reliability of this method for the analysis of samples containing significant concentrations of surfactants. The results of these tests of intentionally spiked TCE/surfactant liquid samples showed that the 5030B purge and trap methodology yields accurate results for liquid samples containing TCE in the range of 5 to 5000 ppb. CORE labs reported having difficulty with the antifoaming agent interfering with their GC detector. This resulted in a decreased detection limit of 50 ppb TCE for analyses performed by CORE. No such difficulty was reported by DIAL and they were able to accurately quantify surfactant-containing samples and maintain a limit of detection of 1 to 5 ppb TCE. Additionally DIAL demonstrated that solid phase microextraction (SPME) can be used as an alternative to purge and trap for the analysis of samples containing surfactant/TCE mixtures. However, the 5035B purge and trap methodology is EPA-approved while the SPME method is not. It is recommended that all liquid samples generated in this project should be analyzed by method 5035B. Similar analytical validation tests are being planned for the analysis of soil samples, and those analyses will be performed in July.

Large amounts of surfactant-degrading bacteria were prepared at IGT to serve as the inoculum to start the surfactant biodegradation reactor to treat water after air stripping and ultrafiltration unit operations at the RMI site. The surfactant bioreactor began operating near the end of June. A 3000 gallon batch of surfactant solution was treated. Preliminary data indicate that this surfactant biodegradation reactor is operating well, but full results will be reported next quarter.

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1.0 Introduction

The DOE/RMI site in Ashtabula, Ohio is a former uranium processing facility whose operations resulted in significant contamination of soil and groundwater at the site. The contaminants of chief concern are trichloroethylene (TCE) and technetium, and the site soil has regions of relatively low permeability. Groundwater contamination is of particular concern due to the possibility of contaminants migrating offsite. TCE is a highly recalcitrant environmental contaminant with low aqueous solubility and a density greater than water. Because TCE is a dense non-aqueous phase liquid with low solubility it tends to sink to the bottom of aquifers and dissolve slowly serving as a source of groundwater contamination for decades. Various approaches for the remediation of aquifers contaminated with chlorinated solvents include soil vapor extraction/air sparging, bioventing/biosparging, steam injection/thermal desorption, surfactant flooding, and excavation. In situ technologies are preferred as are low cost but effective technologies. A problem common to the in situ remediation of a contaminated aquifer by any approach is the need to efficiently deliver and/or recover solutions/agents to the subsurface. The problem of efficiently delivering solutions to the subsurface is even more challenging in soils with relatively low permeability.

To address the problem of in situ remediation of the subsurface West Virginia University is developing a novel versatile technology for the delivery and withdrawal of solutions using Prefabricated Vertical Drains (PVDs). PVDs have been used for decades in the construction industry to dewater soil. PVDs consist of corrugated plastic wicks encased in permeable fabric. Water movement through the soil is facilitated by the extremely high hydraulic conductivity of the PVD material. They are typically installed by hydraulic rams to depths of 50 feet or more, and are often spaced only a few feet apart. Installation of PVDs at a one acre site can generally be accomplished within about a week. This inexpensive technology which has proven to be so successful for dewatering soils has not yet been adapted for the remediation of contaminated sites, but that will be the chief objective of the West Virginia University research and field demonstration program. PVDs will be installed at the DOE/RMI site in Ashtabula, Ohio in the vicinity of a TCE-contaminated aquifer having a hydraulic conductivity of about 10^{-5} cm/sec. These drains will then be used to inject surfactant solutions to mobilize TCE for subsequent recovery by other PVDs. Additionally the PVDs will be used to inject nutrient solutions to stimulate the in situ biodegradation of residual TCE and surfactant. The goal of this portion of the project is to supply support services for these field tests by selecting appropriate surfactants, supplying surfactants, and supplying nutrient solutions for the in situ biodegradation of residual contaminants.

2.0 Purpose

The overall objective of the project is to demonstrate the use and versatility of PVDs for the in situ remediation of contaminated aquifers. The specific objectives of this project/task are to identify and supply appropriate solutions for surfactant flooding, address analytical issues related to surfactant/TCE mixtures, provide adapted microbial cultures suitable for the biodegradation of surfactant, oversee QA/QC activities, and develop engineering and cost estimates for the full scale implementation of this technology.

3.0 Background

IGT has experience in the production and use of surfactants for removing contaminants from solids, and in the biodegradation of chlorinated solvents. West Virginia University (WVU)/North Carolina State University (NCSU) has experience in the application of prefabricated vertical drains for environmental remediation applications. IGT and WVU are collaborating on this project to combine their areas of expertise to develop improved processes for the in situ treatment of TCE contaminated soil and groundwater at the RMI Ashtabula, Ohio site.

4.0 Methodology

Biodegradation Experiments

Anaerobic digester sludge obtained from the Woodridge, IL municipal wastewater treatment plant was used as an inoculum to provide anaerobic cultures for biodegradation studies. Experimental samples were amended with mineral salts medium containing at least 20 ppm sulfate. Experimental samples were incubated statically at room temperature for various periods at which time TCE biodegradation was assessed by quantifying chloride ion concentrations. Surfactant biodegradation studies were performed under aerobic conditions and utilized microbial cultures specifically adapted to the presence of high concentrations of surfactants.

Analytical Procedures

Chloride ion concentrations are determined using a chloride specific electrode (Orion). Phase behavior experiments for surfactants are performed by mixing equal volumes of aqueous solutions and TCE in sealed test tubes. After agitation the mixtures are observed initially and after coming to equilibrium after 12 to 24 hours. The volume and appearance of aqueous phase, microemulsion and oil phase are recorded. Solutions are preincubated in water baths prior to agitation and during the equilibration period when tests were performed at temperatures other than room temperature.

Surface Tension Measurements

The surface tension of surfactant solutions were determined using a Fisher 21 tensiometer and a 6 cm circumference platinum ring. Various dilutions of surfactant solutions were prepared and their surface tension was determined according to the manufacturers instruction.

5.0 Work Performed This Period

During the past quarter several issues were addressed: surface tension readings of the surfactant solution prepared at RMI, analytical methodology and commercial labs, and operating parameters for the biodegradation of surfactant solution.

6.0 Results and Discussion

Surface tension results of samples analyzed at IGT versus RMI showed some differences. We measured surface tensions of the RMI solution at IGT with multiple replicates and produced standard curves that have reasonably good agreement with the data produced by RMI. The water used to prepare surfactant solutions was found to have a minor effect on the surface tension of the resulting solutions, and the particular batch of surfactant products had a minor effect as well. These issues were sorted out and surface tension data was exchanged between IGT and RMI concerning the analyses of samples prepared with various water sources and ingredients, and consistent readings were obtained at both labs.

Analytical methods appropriate for surfactant/TCE mixtures were determined, and several commercial analytical labs were contacted to identify labs capable of meeting the specialized analytical needs of this project. The Ashtabula/RMI site is unusual in having radionuclides (uranium and technetium) possibly present in soil and water samples in addition to TCE. Additionally, the use of surfactant flooding as a remediation treatment in this project introduces further complications. Because of the possible presence of radionuclides it is necessary to deal with labs licensed to receive such samples. The list of licensed labs includes:

Core Laboratories Inc.
420 West First Street
Casper, WY 82601
Phone 800-666-0306

Diagnostic Instrumentation and Analysis Laboratory (DIAL)
205 Research Blvd.
Starkville, MS 39759
Phone 601-325-7380

McDermott Technology Inc.
Research and Development Division
Mt. Athos Rd.
P. O. Box 11165
Lynchburg, VA 24506-1165
Phone 804-522-6755

Quanterra Environmental Services
13705 Rider Trail North
Earth City, MO 63045
Phone 314-298-8566

Each of the labs listed above are licensed to receive samples which contain radionuclides, but the analysis of surfactant/contaminant mixtures presents unique problems. The presence of relatively high concentrations of surfactants in combination with contaminants is not typically encountered and methods have not been specifically developed for such samples. Each of the labs listed above was not equally willing to discuss the unusual analytical needs of this project,

particularly as regards the analysis of surfactant/contaminant mixtures which is non-routine. The most helpful labs in this regard were Core Labs and DIAL. Core volunteered to perform preliminary analyses on soil and water samples that contained surfactants to help decide on the appropriateness of methodology. Two liquid samples were prepared using the full strength four-component surfactant mixture but spiked to contain 10 or 200 ppm TCE. Similarly two 100 g samples of clean soil from the Ashtabula site were intentionally contaminated with 200 ppm TCE in the presence of surfactant solution wetting the soil. The liquid samples were analyzed by a modified purge and trap technique in which antifoam was added directly to the liquids and GC/MS analysis of contaminants captured in the trap. Analysis showed that the sample spiked with 10 ppm contained 9 ppm, while the sample spiked with 200 ppm was found to contain 150 ppm. The soil samples were first extracted with methanol and then the methanol extract was subjected to purge and trap followed by GC/MS. The soil samples which were spiked with 200 ppm were found to contain 39 and 47 ppm TCE according to these analyses. These results are favorable as regards the analysis of liquid samples using a purge and trap technique, but an improved methodology is apparently required for the accurate analysis of soil samples. After extensive discussion with project personnel, commercial analytical labs, and regulators appropriate methods were identified. EPA SW846 Method 5030B/8260B will be used for the analysis of liquid samples, and 5035 for the analysis of soils containing surfactant/contaminant mixtures. Method 5021 which is a headspace gas analytical technique could be used for the analysis of both soil and water samples, but its accuracy is less certain than alternative methods for the analysis of difficult samples such as surfactant/contaminant mixtures. Methods 5030B and 5035 are purge and trap methods while 8260B is a GC/MS method for the analysis of material eluted from the trap. While these methods are thought to be the most appropriate choices for use in this project confirmatory tests were performed to verify this.

Replicate samples containing surfactant solutions intentionally spiked with TCE at concentrations ranging from 0 to 5000 ppb were prepared and sent to two analytical laboratories: CORE and DIAL. The analytical methods being evaluated were EPA SW-846 method 5030B which is a purge and trap GC method, versus Solid Phase MicroExtraction (SPME) coupled with GC. All samples sent to both labs were subsamples of the same stock solutions of surfactant/TCE mixtures. Triplicate samples were sent to each lab to allow more than one analyses to be performed and to allow an approximate concentration to be determined followed by a more accurate determination of concentration. All samples were preserved with hydrochloric acid and shipped on ice via overnight delivery to the analytical laboratories. The results of the analyses of these samples are summarized below.

<u>Actual TCE ppb</u>	<u>Surfactant Conc. ppm</u>	<u>CORE 5030B ppb</u>	<u>CORE %recovery</u>	<u>DIAL 5030B ppb</u>	<u>DIAL %recovery</u>	<u>DIAL SPME ppb</u>	<u>DIAL %recovery</u>
0	2,500	<50	-	< 1	-	< 5	-
4.79	2,500	<50	-	2	42%	8.1	169%
19.2	2,500	<50	-	9.1	47%	24	125%
192	2,500	100	52%	110	57%	220	115%
479	2,500	270	56%	290	61%	580	121%
4790	2,500	2960	62%	2800	58%	6000	125%
0	25,000	<50	-	< 1	-	< 5	-
4.79	25,000	<50	-	1.8	38%	4.3	90%
19.2	25,000	<50	-	8.3	43%	29	151%
192	25,000	<50	-	65	34%	220	115%
479	25,000	120	25%	250	52%	410	86%
4790	25,000	1780	37%	2600	54%	5900	123%

CORE reported having difficulty with the antifoaming agent fouling their GC and consequently have adopted a minimum sample dilution of 100 fold which increases their limit of detection for TCE from .5 ppb to 50 ppb. DIAL does not report having trouble with the antifoam agent and was able to perform the analyses with a detection limit of 1 ppb for purge and trap and 5 ppb for SPME. In general it appears that SPME is more accurate and less problematic for the analysis of samples containing surfactant/TCE mixtures than purge and trap. There was a notable difference between the accuracy of analyses solutions containing 2,500 versus 25,000 ppm surfactant using the purge and trap methodology such that samples with lower surfactant concentration yielded more accurate results for TCE analyses. The SPME method does not appear to be particularly sensitive to the concentration of surfactant present. However, the 5030B purge and trap method is EPA-approved while the SPME methodology is not. Since the majority of the samples from the project will most likely contain surfactant concentrations less than 25,000 ppm and the 5030B method yields reliable results it is recommended that all liquid samples meant for reporting/regulatory purposes be analyzed by 5030B. However, routine monitoring of the project could realize cost and turn-around-time benefits from the use of SPME.

Surfactant biodegradation experiments were also performed which indicated that complete biodegradation of the four component surfactant mix at a starting concentration of 25,000 ppm can be achieved, but the treatment time could be as long as 60 days. However, if adapted cultures are employed surfactant solutions with a starting concentration of 2,500 ppm can be biodegraded in as little as 9 days. The results of surfactant biodegradation tests clearly illustrate that a mixture of surfactant degrading microorganisms adapted to fully degrade this surfactant mixture yields superior performance as compared with unadapted microbial cultures. The adaptation procedure included the use of surfactants as sole carbon and energy sources for multiple cycles of growth in a chemostat. The chemostat was initially supplied with surfactant at 25,000 ppm and the effluent

of the chemostat was recycled as the feed until surface tension readings indicated that the entirety of the surfactant had been degraded. What was observed was that different populations of bacteria were required for the initial attack on surfactant molecules versus the final degradation of surfactants. Surfactant-adapted bacteria were grown and preserved/frozen for use to assist in the start-up of the wastewater treatment process to treat surfactant-containing water resulting from this project. If ultrafiltration is used as a component of the wastewater treatment process then the concentration of surfactant requiring biodegradation should be in the range of 10 ppm which should be easily biodegraded. On June 30, 1998 a 3000 gallon batch of surfactant-containing wastewater was inoculated with adapted surfactant-degrading bacteria developed in this project. The results of this surfactant biodegradation reactor will be reported next quarter.

7.0 Conclusions

The project is proceeding as scheduled. The source of materials, particularly water, used to prepare surfactant solutions can result in minor but measurable differences in surface tension. Reproducible methodology for the preparation of and the analysis of surfactant solutions by all of the participants in the project were demonstrated. After extensive discussion with project personnel, commercial analytical labs, and regulators appropriate methods were identified. EPA SW846 Method 5030B/8260B will be used for the analysis of liquid samples, and SW846 Method 5035 for the analysis of soils containing surfactant/contaminant mixtures. Biodegradation with adapted cultures can be used to biodegrade the surfactant mixture used in this project.

8.0 Work Planned for Next Period

Support of on-going wastewater treatment activities related to surfactant biodegradation and analysis, verifying the accuracy of TCE analysis in surfactant-containing soil samples by sending spiked samples to commercial analytical laboratories, review QA/QC information and data for the project, contribute to discussions for the design of the next field tests of surfactant flooding, and assemble data that will allow engineering and cost estimates of a full scale process to be prepared.

Installation/Operation of PVD System and
Design/Construction Support for Wastewater Treatment
Associated with the PVD Operation

1997 FETC Tasks 1.8a & 1.8b

Quarterly Technical Progress Report
Reporting Period:

April 1, 1998 to June 30, 1998

Work Performed Under Contract
No.: DE-FC21-92MC29467

For:
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
Morgantown, West Virginia

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July 9th, 1998

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ABSTRACT

RMI Environmental Services (RMIES) is working cooperatively with US Department of Energy (DOE)-Federal Energy Technology Center (FETC), US DOE, Ashtabula Area Office - RMI Decommissioning Project, West Virginia University (WVU), North Carolina State University (NCSU), and the Institute of Gas Technology (IGT) to support development and deployment of a groundwater and soil remediation technology called Drain Enhanced Soil Flushing (DESF) utilizing Prefabricated Vertical Drains (PVD). RMIES's responsibilities include providing the site for the demonstration project, providing installation and operations support for the test pad area, and the design, construction, and operation of the wastewater treatment plant to treat the extracted groundwater.

During the report period, RMIES intermittently operated the PVD system. Approximately 10,500 gallons of groundwater has been extracted from the study area to date and approximately 7500 gallons were extracted during this report period. A variety of injection/extraction modes were implemented to establish optimum operating conditions. Approximately 718 samples have been collected to date with about 460 samples collected during this report period. The samples were analyzed for various parameters during the report period including TCE, uranium, technetium-99, pH, specific conductance, solids, and surface tension. All data received was forwarded to NCSU for review. RMIES began and completed injection of the surfactants during the report period. The surfactant is expected to remove trichloroethylene (TCE) which is attached to the soil. RMIES completed a DESF Field Demonstration Project Engineering Report and Project Plan which defines the design basis for the water treatment system.

RMIES received the NPDES water permit modification from the Ohio EPA during the report period. The modification was public noticed on March 30, 1998.

RMIES completed the engineering/design of the water treatment system and received various pieces of process equipment including tanks, pumps, filters, air stripper and other similar items. The wastewater treatment system was constructed and tested during report period. Approximately 9,000 gallons of water was processed.

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1.0 Introduction

The activities presented in this quarterly report are part of the WVU Cooperative Agreement's initiative for bringing environmental remediation technologies to field scale demonstration. This project is a concerted effort between RMI Environmental Services, WVU's Civil and Environmental Engineering Department, US Department of Energy's (DOE) Federal Energy Technology Center (Morgantown), North Carolina State University (NCSU), DOE's Ashtabula Area Office and the Institute of Gas Technology (IGT). The goals of the portion of the work performed by RMIES consists of 1) providing the site to perform the Prefabricated Vertical Drain (PVD) investigations 2) providing installation and operation support for a 10' x 10' test pad area and 3) providing engineering, design, procurement, installation, and operational support for a wastewater treatment system for treatment of extracted groundwater.

This report discusses the progress made during the current reporting period.

2.0 Purpose

The overall objective of this project is to demonstrate the applicability of prefabricated vertical drains for remediation of contaminated groundwater and associated soils. The project will evaluate removal efficiency of contaminated groundwater through simple extraction, injection and extraction of potable water only, and injection and extraction of a surfactant solution.

3.0 Background

The RMI Titanium Company (RMI) Extrusion Plant is located in Ashtabula County, Ohio. The facility consists of 25 buildings and occupies 7 acres of a 32 acre site. The facility is contaminated with both radiological and hazardous materials resulting from previous operations for the US Department of Energy. The primary function of RMI, since 1962, has been the extrusion and closed-die forging of metallic depleted, natural, and slightly enriched uranium (U) used in the production of nuclear fuel elements for defense production reactors, extrusion operations for other government agencies, and the private-sector. Extrusion operations ceased in 1990, since then the Nuclear Regulatory Commission (NRC) has required the facility to implement accelerated site clean-up pursuant to its Site Decommissioning Management Plan. The US Environmental Protection Agency has issued RMI a Resource Conservation Recovery Act (RCRA) Hazardous Waste Management Permit with conditions mandating clean-up of an existing Corrective Action Management Unit. DOE's office of Environmental Restoration and Waste Management (EM) has contracted RMI to conduct the RMI Decommissioning Project by removing all radiological and hazardous contaminants to levels which permit the facility and adjacent areas to be released for unrestricted use.

The principal contaminant on equipment, buildings, and surrounding open space areas is uranium. In addition to the uranium, soil and groundwater are contaminated with Trichloroethylene (TCE) and Technetium 99 in limited areas of the site. Clean-up of the facility is slated to continue for the next several years due to technology limitations and the

unique challenges which face RMI in handling the large physical size of the manufacturing equipment and facility. The use of the PVD technology has been targeted for demonstration on the portion of the site within the CAMU which has TCE, uranium, and technetium 99 contamination.

4.0 Methodology

Task 1.8a Installation/Operation of the PVD System

RMI Environmental Services has been tasked with supporting the installation and operation of a 10' x 10' test pad area. As such there are no specific or unique methodologies required to construct this system. However, as part of the operations portion of this task, extracted groundwater was analyzed via the following methods.

Analytical Methodologies

- Volatile Organic Analysis (VOA) - EPA SW846 Method 8240 or 8010
- Total Uranium - EPA 908.1
- Technetium 99 - HASL 300 (beta scintillation)
- Suspended Solids
- Dissolved Solids
- Specific Conductance
- pH
- Temperature
- Surface Tension
- Chloride - EPA 325.3
- Hardness - SM 2340B
- COD - EPA 410.4
- Sodium - EPA 273.1
- TCE in Air - NIOSH 1022

Task 1.8b Design, Procurement, Construction and Operation of the Wastewater Treatment System

RMI Environmental Services has been tasked with design, construction, operation, and decontamination of a wastewater treatment system to treat extracted wastewater. During the report period, final design of the wastewater treatment system was completed. This included defining the problem and work scope, identifying contaminants, treatment standards, performing academic and industry research to evaluate treatment options, development of a project plan and process flow diagram. The following design criteria were established for the process:

- Equipment sized to treat water generated during the project.
- Modification to existing Wastewater Treatment Plant (WWTP) required since it is not designed to remove TCE or tolerate surfactant.

- Minimize use/cost of surfactant via recovery and recycling.
- Develop unit operations which can be readily scaled-up.
- Identify and develop analytical protocol required to support operation and evaluate process performance.
- Safely and efficiently treat wastewater within license and permit limits.

5.0 Work Performed This Period

Work accomplished during this period consisted of:

Task 1.8a Installation/Operation of the PVD System

- Approximately 6,000 lbs of soil was shipped in early April to NCSU for further laboratory studies.
- Tests were conducted to evaluate the volatilization of TCE during extraction operations. Pre-extraction samples were collected from the upgradient and downgradient wells and well 104. A PVD was inserted into each of the wells and extract water was sampled. Volatilization attributable to the extraction process was determined based on a comparison of the sample results.
- On April 7-9 and 13, the system was operated in a maximum injection/maximum extraction mode. Injection and extraction rates of 50 gallons per hour were maintained throughout an 8 hour operating cycle.
- The system was operated in a dual venturi extraction mode for a portion of the operating time on April 7-9. The extraction rate was not significantly influenced by the addition of the second venturi. Based on field observations, one extract drum would fill close to capacity before the second drum would begin to fill.
- A variety of surfactant and non-surfactant samples were collected for volatile organics, specific conductance, pH, temperature, and surface tension analysis during PVD operations.
- RMIES completed work with IGT to specify the gas chromatograph (GC) requirements. A purchase order was placed and the equipment arrived in early June.
- The Ohio Environmental Protection Agency public noticed the NPDES water permit modification on April 3rd, 1998. The public comment period lasted for 30 days (until May 3rd). The permit was issued in mid May. This permit allows RMIES to treat the extracted water in the water treatment system.

- RMIES submitted monthly operating reports to the OEPA Division of Drinking and Ground Waters. The PVDs are considered Class V injection wells and a permit was obtained to allow injection of the potable water and the surfactant/water mixture. The report described the injection fluids, injection rate, volume of water injected, and monitoring results.
- Surfactant injection/extraction was initiated during May. One hundred eleven gallons of surfactant (10% pore volume) were injected beginning on May 5, 1998. Surfactant breakthrough in the extracted fluids was seen within 2 hours of injection. Following injection of the surfactant, the system was operated in a water injection/extraction mode through May 22.
- RMIES hosted an all project meeting on May 4, 1998. Attendees included ODE/FETC, DOE/AB, IGT, WVU, and NCSA representatives.
- Injection of 560 gallons of surfactant (50% pore volume) was completed on June 8th. Due to surfactant breakthrough on the first day of injection (May 26), the system was operated in an injection only mode from May 27 through June 5. The system was operated in a balanced injection/extraction mode from June 8 through 12 and a maximum injection/maximum extraction mode from June 15 through 17. The system was operated in a maximum injection/optimum extraction mode from June 18 through 25. The system was operated the week of June 22 to remove additional surfactant from the subsurface.
- All data for samples collected through the first surfactant injection (111 gallons) have been received from the off-site analytical laboratory and forwarded to NCSU.
- On June 26, an experiment was performed to evaluate the effect of the surfactant on volatilization of TCE during extraction operations. This experiment was conducted by adding surfactant to the upgradient monitoring well and then extracting water from the well using the portable PVD. A variety of surface tension and TCE samples were collected as a part of this experiment.
- Phase I field operations were completed on June 26.
- Phase II field operations commenced the week of June 22.
- Soil piles present in the Phase II Test Pad location were moved and the area graded to support installation of the test pad.
- During the week of June 29, five (5) soil borings were completed within the boundaries of the Phase II Test Pad. Eight to nine samples were taken from

each boring at various depths for TCE, uranium, Tc-99 analysis and geotechnical classification.

Task 1.8b Design, Procurement, Construction and Operation of the Wastewater Treatment System

- RMIES completed the work order preparation, and the electrical and mechanical work to construct the wastewater treatment system. The work was completed with the exception of leak testing and functional testing of the system. Testing of the system was completed in May, 1998.
- Engineering prepared the Operations Plan which included the Sampling and Analysis Plan for the wastewater treatment system. The Plans were complete in mid May, 1998.
- RMIES completed the electrical and mechanical work to construct the wastewater treatment system which included leak testing and functional testing of the system. Operation of the system began June, 1998.
- RMIES purchased and received a surface tension meter to conduct on-site analysis of water to support the project. RMIES worked with IGT to calibrate the instrument using the surfactant matrix specified for the project. RMIES conducted surface tension analysis of water to support the project.
- The Spintek equipment was received, set up and tested during the report period.
- RMIES met with representatives from 3M to discuss and plan testing operations for wastewater filtration to remove technetium 99.

6.0 Results and Discussion

Task 1.8a

The PVD system was intermittently operated during April, May, and June 1998. Approximately 7500 gallons of water was extracted during the report period. A grand total of approximately 10,500 gallons of water or water/surfactant mixture has been extracted to date.

Injection of surfactant began during the week of May 26th. Approximately 110 gallons of surfactant mixture was injected. Breakthrough of surfactant was observed in the extraction of PVD's within 2 hours. A second injection of 560 gallons of surfactant solution was completed on June 8th, 1998. The system was operated through June and surfactant concentrations in extracted water were monitored daily. Samples were routinely sent out for TCE analysis. All analytical data has been forwarded to NCSU for interpretation.

Phase I field injection/extraction operations ceased on June 26, 1998.

Task 1.8b

A wastewater sampling and operations plan was completed during the report phase. The wastewater treatment system was constructed and tested for operations. Approximately 6,000 gallons of non-surfactant water was treated and released during the report period. Treatment consisted of air stripping (for TCE removal) followed by treatment with granular activated carbon as a final polishing step.

Approximately 4,500 gallons of surfactant containing water was generated during the report period. Approximately 3,000 gallons was air-stripped and then placed in the bioreactor for surfactant degradation. As of June 30th, the water was 7 days into the biodegradation cycle which is expected to last another 7-14 days.

7.0 Conclusions

Preliminary analytical data obtained from the WWTP SAP indicate proper operation of all components. Final conclusions will be addressed and summarized in the WWTP final report. This report is scheduled to be completed by August 20, 1998.

8.0 Work Planned For Next Period

Task 1.8a

- Complete outside lab analysis of remaining samples
- Close out Task 1.8A
- Begin Phase II work

Task 1.8b

- Complete treatment of extracted water.
- Complete treatment of surfactant containing water.
- Complete work with Spintek for surfactant recycling tests.
- Complete work with 3M for technetium 99 removal.
- Complete final report on wastewater treatment operations.
- Begin Phase II work

9.0 Technical Difficulties

None identified during the report period.

10.0 Drawings

None developed during the report period.