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Shaw® Shaw Environmental, Inc.

August 21, 2006
Project 101960

Mr. Joseph T. Martella, II
Rhode Island Department of Environmental Management
Office of Waste Management
235 Promenade Street
Providence, RI 02908-5767

Re: Laboratory Treatability Study
Former Gorham Manufacturing Facility
333 Adelaide Avenue, Providence, RI
Site Remediation Case No. 97-030

Dear Mr. Martella:

Based on the recent site investigation activities conducted in April and May 2006 (Rhode Island Department of Environmental Management (RIDEM) status report dated June 23, 2006), Textron, Inc. and Shaw Environmental, Inc. (Shaw) are proposing to perform a laboratory treatability study to evaluate the use of enhanced bioremediation for the treatment of soil and groundwater containing tetrachloroethene (PCE) at the former Gorham Manufacturing facility in Providence, RI (the Site). This work is in support of our approach for continued remediation of groundwater at the Site.

Both biostimulation and bioaugmentation are in situ remedial biotechnologies that have been shown to be efficient and cost effective treatments for the removal of chlorinated ethenes at sites such as the former Gorham Manufacturing Facility. The purpose of laboratory testing is to verify that the complete biodegradation of PCE will occur at a reasonable rate under site-specific conditions (i.e., - in site soil and groundwater). Since recent testing of site groundwater in the source area did not indicate a significant presence of dechlorinating bacteria, only bioaugmentation testing is being considered at this time. Samples will be collected of both soil and groundwater from within the source area for performing a series of laboratory microcosm experiments.

Background of Biodegradation of Chlorinated Ethenes

PCE can be degraded under anaerobic conditions by specific bacteria through reductive dehalogenation, where PCE is sequentially reduced to trichloroethene (TCE), cis-1,2-

dichloroethen (DCE), vinyl chloride (VC), and then ethene. In each case, the reactions are mediated by bacteria that thrive under low oxidation-reduction potential, and are driven by the presence of an electron donor (carbon source or hydrogen). In order for complete biodegradation/dechlorination of PCE to occur, specific bacteria capable of facilitating this process must also be present. *Dehalococcoides* sp. (DHC), some of which are capable of degrading chlorinated ethenes to ethene, are the only microbial species known to completely dechlorinate PCE, so their abundance and distribution in a contaminated aquifer is critical for effective biodegradation of PCE.

In-situ anaerobic biostimulation involves stimulating the indigenous microbial populations to degrade chlorinated ethenes by introducing electron donor (substrate) and/or nutrients into the subsurface. These materials can be delivered to the subsurface using temporary injection probes, treatment walls, soil mixing, pneumatic fracturing, or vertical or horizontal wells. The assumption with this approach is that the indigenous microbial population contains DHC, but the native DHC are unable to maintain high levels of degradation due to unfavorable oxidation-reduction potential, insufficient nutrient (e.g., nitrogen, phosphorous) levels, insufficient microbial levels, and/or lack of electron donor. As such, the success of a biostimulation approach is dependent upon the ability to distribute amendments in the subsurface, create favorable oxidation-reduction potential in situ, enhance the growth of DHC, and ultimately stimulate microbially-enhanced reductive dehalogenation of PCE and its daughter products. As mentioned above recent testing did not indicate a significant presence of DHC in the source area and so biostimulation treatability testing will not be performed.

Bioaugmentation is similar to biostimulation, except that it involves the delivery of microorganisms (in addition to substrate and nutrients) to the subsurface to stimulate biological degradation. These organisms can be cultured directly from Site material or can be obtained from an outside source. Evidence of biological degradation found at a site, such as the presence of daughter products of the degradation of the target contaminants and suitable geochemical conditions may be indicative of an active microbial population. Site soil collected from the area of the site where degradation appears to be occurring or where these organisms appear to be present can often be enriched in the laboratory to select for the population responsible for degradation. The bacterial culture can then be grown in the laboratory to produce large batches of active microorganisms that are then added to the subsurface along with appropriate substrate and nutrient.

Alternate sources of active microbial cultures of DHC have been obtained from sites where DHC are naturally occurring. There are several cultures available to Shaw, most notably our SDC-9 culture, which has been shown to completely and rapidly degrade PCE to ethene using lactate or other suitable substrate as an electron donor.

Scope of Work

The proposed scope of work is divided into three Tasks: 1) Sample collection and Preliminary Testing, 2) Microcosm Studies, and 3) Data Evaluation and Reporting. These Tasks are further described below.

Task 1 – Sample Collection and Preliminary Testing

Soil and groundwater samples will be collected for the purpose of performing a series of laboratory microcosm experiments (Task 2). Sample collection will include collection of both soil and groundwater from within the presumed source area near MW-101S&D. A geoprobe type drill rig will be mobilized to the site to collect soil from the water table (approximately 25 feet below ground surface (bgs)) to the bottom of the sand and gravel aquifer (approximately 50 feet bgs). Continuous soil samples will be collected in 4-foot dedicated plastic sleeves approximately 2 inches in diameter.

Groundwater samples will be collected for laboratory analysis of volatile organic compounds (VOCs) (EPA Method 8260), reduced gases (EPA Method 8015), anions (EPA Method 300), and total/dissolved iron and manganese. Samples will be packed in coolers with ice and shipped overnight to Shaw's analytical laboratory in Lawrenceville, New Jersey.

A minimum of 3 kilograms of soil and 6 liters of groundwater will be collected. Soil and groundwater samples collected for the microcosm experiments will be collected under anaerobic conditions.

Upon completion of soil sample collection an approximately 1- inch diameter steel well may be installed in the borehole as a potential future remediation system injection well.

Task 2 – Microcosm Studies

Microcosms will be prepared in glass serum bottles (approximate volume, 160 milli-litters (mL)). All microcosm preparation and sampling will be performed in an anaerobic chamber. Soil and groundwater will be homogenized and subsequently sampled for VOCs. Approximately 30 grams of homogenized site soil and 110-mL of Site groundwater will be added to each of the bottles. The bottles will be sealed with Teflon®-lined butyl rubber stoppers and crimp caps.

Three additional microcosm bottles will be prepared for initial analysis. These bottles will be incubated with gentle shaking for 24 hours, and then both the soil and aqueous phases will be analyzed for VOCs via EPA Method 8260. Aqueous samples will be analyzed with a 24-hour turnaround time to determine that PCE levels are sufficiently high. If needed, a contaminant spike of PCE will also be added to the remaining microcosms to ensure that the PCE levels in the microcosms are representative of those measured in the field.

Three sets of microcosm treatments will be prepared in triplicate as follows:

Treatment 1: KILLED CONTROL: These treatments will be amended with a formaldehyde solution (final concentration in groundwater approximately 1% by volume) to inactivate microbial activity, and will be used to evaluate abiotic loss of VOCs.

Treatment 2: LIVE CONTROL: This treatment will not receive any amendments except for deionized water (to simulate addition of amendments performed for the other treatments). This treatment will serve as a control to monitor VOC loss in the absence of any amendments.

Treatment 3: BIOAUGMENTATION 1: Shaw's SDC-9 culture will be used as the bacterial inocculum. Nutrient solution and yeast extract will also be added to ensure that the bacteria are not limited in nitrogen, phosphorus, or other trace nutrients. Bottles will also be amended with lactate to serve as the electron donor. Lactate will be added such that a concentration of 1,000 milligrams (mg/L) is attained. This treatment will be used to evaluate the effects of anaerobic bioaugmentation on contaminant biodegradation.

Treatment 4: BIOAUGMENTATION 2: Shaw's SDC-9 culture will be used as the bacterial inocculum. Nutrient solution and yeast extract will also be added to ensure that the bacteria are not limited in nitrogen, phosphorus, or other trace nutrients. Bottles will also be amended with an emulsified vegetable oil (EVO) to serve as the electron donor. EVO will be added such that a concentration of 1,000 mg/L is attained. This treatment will be used to evaluate the effects of anaerobic bioaugmentation on contaminant biodegradation.

Microcosm bottles will be incubated with gentle shaking at 15°C. At each sampling event, microcosm bottles will be removed from the shaker and placed in the anaerobic chamber. Sufficient time will be allowed for the soils to settle so that the supernatant groundwater can be sampled. Samples will be collected from Treatments 1, 2, 4 and 5 will be analyzed at t= 0 week, 1 week, 2 weeks, 4 weeks, 8 weeks. At each of these sampling events, groundwater will be analyzed for VOCs and reduced gases. In addition, at least one bottle from the Live Control and Bioaugmentation treatments will be analyzed for volatile fatty acids at each sampling event (equal sample volume will be collected from the other bottles and treatments to maintain equal groundwater volumes in all the treatments). If needed, based on results of the volatile fatty acid analysis, additional lactate will be added to the Bioaugmentation treatments. Periodic lactate addition may also be employed if the lactate consumption rate is sufficiently large. A parallel set of bottles will be prepared for each treatment (4 bottles total) and sampled at each time point to measure anions, pH and ORP throughout the study.

Task 3 - Data Evaluation and Reporting

Results from bioaugmentation treatments will be compared to the control treatments to evaluate treatment of PCE, to identify formation of biodegradation daughter- and end-products, and ultimately to determine the effectiveness of the Bioaugmentation treatment approach. Upon completion of the study, Shaw will prepare a report for RIDEM that includes a description of field activities, boring log and well construction diagram, and results of the laboratory study. This report will summarize the treatability study protocol, present results in graphical and/or tabular form, and discuss results as they relate to potential field-scale implementation.

Provided the results of the treatability study are favorable, a revised Remedial Action Work Plan (RAWP) will be prepared for full-scale enhanced bioremediation implementation at the former Gorham facility and submitted to RIDEM for approval.

Schedule

The following schedule for the above scope of work is provided. We anticipate starting the soil and groundwater sampling within approximately two weeks of obtaining RIDEM approval of the treatability study. Soil boring and well installation activities are expected to require approximately 1 or 2 days. Groundwater collection will also occur during the sample time period. The laboratory Testing is anticipated to require approximately 4 to 8 weeks. Data analysis, evaluation of a full-scale enhanced bioremediation system, preparation of a status report or revised RAWP, and submittal to RIDEM approximately 4 - 8 weeks (a revised RAWP will be prepared assuming the treatability study results are favorable).

We look forward to your approval of the treatability study at your earliest convenience. If you have any questions, please contact me at (603) 870-4530.
Sincerely,

SHAW ENVIRONMENTAL, INC.

Edward P. Van Doren, PE, LSP
Project Manager

cc: Craig Roy, RIDEM OWR
Greg Simpson, Textron
David McCabe, Textron
Jamieson Schiff, Textron