



Infrastructure, buildings, environment, communications

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Subject:

Alternative Proposal for Site Remediation Services, N. Getz Property, 6854 West Beloit Road, West Allis, Wisconsin

Dear Mr. Gallo:

ARCADIS is pleased to present you with this alternate proposal for remediation services for the subject property. ARCADIS previously submitted a proposal for remediation services at the property, dated December 10, 2002. The previous proposal provided a scope of work and cost estimate for the use of chemical oxidation. Based on your November 22, 2002 request for proposal, it is understood that chemical oxidation has been approved by the Wisconsin Department of Natural Resources (WDNR) as the remedy for the property.

Chemical oxidation may be difficult to implement at this property, due to the high organic carbon content of the soil. Chemical oxidation removes carbon and changes the groundwater geochemical conditions, and could interfere with other remedies such as natural attenuation. Because natural attenuation would likely be used to address impacts beyond the chemical oxidation treatment zone, interference with attenuation mechanisms may be detrimental to project closure. Due to these limitations, ARCADIS has developed an alternate approach using enhanced biodegradation. It is noted that limited concentrations of biodegradation products were detected in the groundwater during the site investigation. Consequently, a field-scale pilot test is being recommended to evaluate the feasibility of enhanced biodegradation.

The scope of work was developed based on the history of dry cleaning activities at the site, previous investigations, and our knowledge of dry cleaning operations. This proposal presents a brief summary of the project background and a discussion of the proposed remediation activities. This proposal has been prepared in accordance with the requirements of the Drycleaner Environmental Response Program (DERP) established in Chapter NR 169, Wis. Admin. Code. Information required by Chapter NR 169 is also included. The proposed scope of work and cost estimate has been prepared in conformance with Chapter NR 169. It is noted that investigation activities may have identified impacts from a former fuel oil tank. Costs for remediation of petroleum fuels are not eligible for reimbursement under DERP. To

Part of a bigger picture

Getz

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ENVIRONMENT

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19 December 2002

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maintain DERP eligibility, this proposal does not address the identified petroleum constituents. It is recommended that a separate work plan be developed for the management of the petroleum constituents.

Project Background

The subject property is located at 6854 West Beloit Road in the city of West Allis, Wisconsin. The property is approximately 1/3-acre in size and is developed with a 7,200-square foot commercial building. The property is bounded on three sides by the following roads: Lincoln Avenue to the north, 69th Street to the west, and Beloit Road to the South. The building is located in the northern portion of the property, nearest the intersection of Lincoln Avenue and 69th Street. An asphalt parking lot is located to the south of the building, and an asphalt driveway extends from the lot north to Lincoln Avenue, along the east side of the building. A former Citgo gasoline service station is located on the east adjacent property. A restaurant is located to the west (across 69th Street) and a bookstore is located to the north (across Lincoln Avenue).

It is understood that the property is currently occupied by an active dry cleaners. Tetrachloroethene (PCE) is apparently used as the cleaning agent. In 2001, a Phase I Environmental Site Assessment was completed at the property. Identified recognized environmental conditions included a 1,000-gallon fuel oil underground storage tank (UST) and the dry cleaning operations.

Investigation History

Summary of Investigation Activities

The fuel oil tank was removed from the property on April 4, 2001. ARCADIS has not been provided with reports associated with the fuel oil tank removal or subsequent investigations. However, it appears that Sigma Environmental Services, Inc. advanced four Geoprobe borings (GP-1 through GP-4) and one monitoring well (MW-5) in the vicinity of the former tank location. Soil samples from GP-1 and MW-5 contained diesel range organics (DRO) at concentrations ranging from 18 to 2,180 milligrams per kilogram (mg/kg). The detected DRO concentrations are greater than the NR 720 generic Residual Contaminant Level (RCL) of 100 mg/kg. It is noted that the former fuel oil tank location is near the east property boundary. A former gasoline service station is located to the east.

Sigma conducted a Phase II ESA in May 2001 to evaluate soil conditions beneath the building for impacts from the dry cleaning operations. Four hand augers (HA-1 through HA-4) were advanced through the floor of the building. Six soil samples

were collected from the borings and analyzed for volatile organic compounds (VOCs). Each sample contained concentrations of PCE, ranging from 149 to 41,600 micrograms per kilogram ($\mu\text{g}/\text{kg}$). Because evidence of a chlorinated hydrocarbon release was identified, additional investigation activities were completed. Two additional hand auger borings were completed inside the building (HA-5 and HA-6). Ten monitoring wells (MW-1 through MW-10) and one piezometer (PZ-1) have also been installed.

Soils at the property consist of heterogeneous layers of silts, sands and clays to a depth of at least 16 feet. Groundwater is located at a depth of approximately 4 to 8 feet. The direction of groundwater flow is to the northwest.

Soils containing PCE were identified beneath the building and to the north and west of the building, extending beneath Lincoln Avenue and 69th Street. Detected PCE concentrations ranged up to 348,000 $\mu\text{g}/\text{kg}$. Sixteen of the 29 samples collected during the investigation contained PCE at concentrations greater than 500 $\mu\text{g}/\text{kg}$.

Groundwater samples were collected from the monitoring well network during three sampling events: November 2001, February 2002, and July 2002. Three of the ten monitoring wells (MW-2, MW-3, and MW-10) contained PCE at a concentration above the NR 140 Enforcement Standard (ES). A fourth well (MW-4) contained PCE at a concentration above the NR 140 Preventive Action Limit (PAL). In July 2002, detected PCE concentrations ranged from 4.34 to 14,300 micrograms per liter ($\mu\text{g}/\text{L}$). The primary area of impacted groundwater is located in the vicinity of Monitoring Wells MW-2, MW-3, and MW-10, located on the north and west sides of the building. Monitoring wells located to the west of 69th Street (MW-7 and MW-8) and to the north (downgradient) of Lincoln Avenue (MW-9) did not contain detectable concentrations of VOCs. In addition, monitoring wells located to the east (MW-5 and MW-6) and south (MW-1) did not contain chlorinated hydrocarbons.

The July 2002 groundwater sample from the piezometer (PZ-1) contained PCE at a concentration above the PAL. The piezometer is screened from 30 to 35 feet below land surface (ft bls).

The groundwater samples contained relatively low concentrations of VOCs that are typically associated with the biodegradation of PCE. Low concentrations of trichloroethene, 1,2-dichloroethene, and vinyl chloride were detected. Monitoring Well MW-5, located between the former fuel oil tank and the east property boundary, contained benzene at a concentration above the ES. Because benzene is not typically associated with fuel oil releases, the detected concentration may be associated with the adjacent service station property.

Overview of Investigation Results

The investigation results indicate that the lateral and vertical extent of impacted soil and groundwater has generally been defined. Soil and groundwater samples collected from locations across 69th Street and Lincoln Avenue were necessary to define the extent of impacts to the north and west.

The lateral extent of impacted soil is approximately 11,000 square feet. Assuming a groundwater depth of 6 feet, the volume of impacted soil is approximately 2,500 cubic yards. Approximately 45 percent of the impacted soil is located beneath the building. The highest PCE concentrations were detected in the northwest corner of the property.

Impacted groundwater extends from the water table to a depth of at least 35 feet. Although a PAL exceedance was detected in the piezometer, the vertical extent of impacts appears to have been defined. The lateral extent of impacted groundwater is relatively small, given the elevated concentrations of PCE detected in the soil. The lateral extent of impacted groundwater covers an area of approximately 100 feet by 180 feet. The concentration of PCE at MW-3 suggests the presence of separate-phase product. The limited extent of impacted groundwater may be due to the fine grained nature of the soil at the property. It is noted that limited concentrations of biodegradation products have been detected in the groundwater. The age of the release was not reported in the documents provided to ARCADIS.

Proposed Remedy

Sigma completed a brief review of the following remedial action options as part of its investigation:

- Excavation/off-site treatment
- Soil vapor extraction
- In situ nutrient addition
- In situ bioaugmentation
- In situ chemical oxidation
- Natural attenuation

Chemical oxidation, using potassium permanganate, was recommended as the remedial alternative. The investigation report did not provide specific information on implementation of the remedy, such as the area to be targeted, reagent volumes, injection well spacing or monitoring activities. Bench-scale or pilot testing activities have not been completed. It is understood that the WDNR has approved chemical oxidation as the remedial action option for the property.

The December 10, 2002 ARCADIS proposal presented a scope of work and cost estimate for the pilot testing and implementation of chemical oxidation. A pilot test was recommended, because the feasibility of chemical oxidation is strongly influenced by the presence of organic carbon and the ability of the chlorinated hydrocarbons to enter the dissolved phase. Use of chemical oxidation may also limit the effectiveness of other remedies, were the oxidation approach fail in a full-scale application. Chemical oxidation decreases the concentration of naturally occurring carbon, which decreases the soil's ability to sorb contaminants. Chemical oxidation also decreases the population of indigenous microorganisms and alters geochemical conditions. These effects would limit the use of natural attenuation or enhanced biodegradation.

Scope of Work

Because of the potential negative affects of chemical oxidation and the lack of site-specific pilot test or design data, ARCADIS has developed an alternate remedy for the property. ARCADIS recommends the use of enhanced biodegradation, which has been successfully employed on several chlorinated hydrocarbon projects in Wisconsin. As noted by the investigation report, limited concentrations of biodegradation products were detected during the investigation. The absence of biodegradation products may be related to the concentrations of parent products, a shortage of nutrients, or the age of the release. Consequently, ARCADIS recommends the use of a field-scale pilot test to evaluate the feasibility of enhanced biodegradation. The pilot test would also provide design parameters for full-scale implementation. The scope of work for the design and implementation of the alternate remedy will consist of the following tasks:

- Notification to the WDNR of the alternate remedy and consultant selection for implementation of the remedy.
- Preparation and submittal of a field-scale pilot test work plan to the WDNR.
- Solicitation of competitive bids for subcontractor services.
- Preparation of a site-specific Health and Safety Plan (HASP) to safely accomplish planned on-site activities.
- Obtain a Wisconsin Pollutant Discharge Elimination System (WPDES) permit for the enhanced biodegradation process.
- Completion of a field-scale pilot test.

- Preparation of a pilot test report and work plan for full-scale implementation.
- Installation of an infiltration/injection gallery within the targeted treatment area.
- Completion of up to twelve injection events using a carbon amendment solution.
- Collection of groundwater samples from the monitoring well network for 1 year.
- Data evaluation and preparation of a site status report.
- Characterization of investigation-derived waste (IDW) generated during site remediation activities.

ARCADIS will also prepare a reimbursement claim under the DERP. The following sections present further details of the proposed investigation activities.

WDNR Notification and Work Plan

It is understood that the WDNR has provided approval of chemical oxidation as the remedial alternative for the property. ARCADIS will notify the WDNR of the proposed change in the remedy and the selection of our firm to implement the remedy.

To verify the effectiveness of enhanced biodegradation as a remedial alternative and obtain design parameters for full-scale implementation, ARCADIS will conduct a field-scale pilot test. The notification letter will also include a work plan for the pilot test. A draft work plan will be completed and forwarded to you for review. Comments received will be incorporated into the final copy of the work plan and forwarded to the WDNR. In accordance with DERP requirements, field activities will not be initiated until the WDNR has issued written approval to proceed.

Subcontractor Procurement

All subcontractors will be selected based on a competitive (i.e., low cost) basis in accordance with NR 169. ARCADIS will solicit three proposals for each contractor service, such as drillers or laboratories.

Health and Safety Plan

A site-specific HASP will be prepared for use in conjunction with the proposed field activities at the Site. The HASP will be designed to comply with the applicable requirements of the Occupational Safety and Health Administration (OSHA) and

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other applicable regulations. The elements of the HASP will be based upon requirements described in the:

- *“Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities”* (October 1985).
- The final (March 1989) OSHA rules (29 Code of Federal Regulations [CFR] 1910).

All reasonable precautions will be taken by ARCADIS and its subcontractors to ensure the safety and health of workers and the general public.

Injection Permitting

During the pilot test, the carbon amendment solution will be pumped into the impacted aquifer via a series of injection wells. An infiltration/injection gallery would likely be used in the full-scale application. Because the process involved the injection of a reagent into groundwater, a WPDES permit is required. In addition, a variance request must be submitted and approved by the WDNR in accordance with Chapter NR 140.28(5). Under this task, a WPDES permit and variance request will be prepared and submitted to the WDNR for review.

Enhanced Biodegradation Pilot Test

To evaluate the feasibility of enhanced biodegradation, a field scale pilot test will be completed. The pilot test will consist of three elements: installation of injection wells, application of a carbon amendment solution, and concurrent groundwater monitoring. A pilot test report and remediation work plan will be prepared following the pilot test. The following sections present a summary of each element of the pilot test.

Well Installation: To conduct the pilot test, three injection wells will be installed in the vicinity of Monitoring Well MW-3. These wells will be used to introduce the carbon amendment solution to the aquifer in the area with the highest dissolved phase VOC concentrations. The wells will be installed using hollow-stem auger drilling techniques. Borings for the injection wells will be advanced to a depth of approximately 15 feet. Prior to well installation, soil samples will be collected from the borings at 2-1/2 foot vertical intervals to provide a relatively continuous profile of the subsurface materials at each boring location. Logs will be prepared for each test boring in accordance with WDNR requirements and will present both the classification and engineering properties of the materials encountered. The soil

samples will be screened with a flame ionization detector. However, soil samples will not be collected for laboratory analysis.

Each of the soil borings will be converted to an injection well. Following completion of each borehole, a well will be constructed inside of the hollow-stem augers. Once the well is constructed, the augers will be removed to complete the well. Each injection well will consist of a 2-inch diameter Schedule 40 PVC riser and a 10-foot length of 2-inch diameter Schedule 40 PVC well screen. Upon positioning the well screen and riser within the borehole, the annular space between the well screen and borehole will be filled with a silica sand filter pack and filter pack seal. The remainder of the annular space will be sealed with bentonite, and a flush-mount well vault will be installed at the ground surface. After construction, the new wells will be developed in accordance with Chapter NR 141 of the Wisconsin Administrative Code.

Injection Activities: During this phase, a carbon amendment solution will be pumped into each of the three injection wells. Approximately 20 to 50 gallons of solution will be introduced to each well. Water levels will be periodically measured at the nearby monitoring wells MW-3, MW-4, and PZ-1 during each injection to evaluate the hydraulic zone of influence (if any) created by the injections.

Approximately four injection events will be completed during the pilot test. The injections will be conducted on a monthly basis. Additional injection events may be necessary to maintain a sufficient level of dissolved organic carbon, based on the concentrations of hydrocarbons present at MW-3. Adjustment to the injection schedule will be made based on the results of groundwater monitoring (discussed below).

Groundwater Monitoring: Five rounds of groundwater samples will be collected from MW-3, MW-7, and MW-9 during the pilot test. Prior to the start of injections, a baseline round of groundwater samples will be collected. A second round of samples will be collected 2 weeks after the first injection event. The third and fourth sampling events will be completed at one month intervals. The fifth and final event will be completed 1 month after the last injection. This program will provide data of baseline conditions and subsequent changes following introduction of the carbon amendment.

Groundwater samples will be collected using low-flow sampling techniques and analyzed for VOCs, total organic carbon (TOC), and organic gases (ethene, ethane, and methane). The results will be used to evaluate the residence time of the carbon solution in the test area, changes in geochemical parameters, and changes in VOC concentrations.

Reporting: The results of the pilot test will be compiled in a summary report. The report will provide recommendations for full-scale implementation, and will include a work plan for the implementation phase.

The subsequent sections of this proposal present a description of the tasks to be completed during implementation of the remedy. The scope may be adjusted based on the results of the pilot test.

Infiltration/Injection Gallery Installation

It is understood that the building on the property may be unoccupied. To create an adequate treatment zone, an infiltration/injection gallery will be installed within the building. A series of 11 injection wells will first be installed within the building using a low-clearance drilling rig. The wells will be installed on 20-foot centers along the west and north interior walls of the building. The well depths will be based on the capacity of the drilling unit and the clearance within the building, but will likely be 8 to 15 feet deep. These wells will be used to create a treatment zone in the groundwater, near the downgradient edge of the plume.

A small excavator will then be used to install a subsurface conveyance system to allow the introduction of a carbon amendment solution to the wells from a central location. The conveyance system will consist of 1-inch diameter high-density polyethylene. A shallow infiltration gallery, consisting of a network of 2-inch diameter PVC well screen, will also be installed with the conveyance system. The vertical injection wells and horizontal infiltration gallery will have separate conveyance piping. This combination of applications will allow treatment of the shallow soil and impacted groundwater.

The conveyance piping will be routed to a central location within the building. Two riser pipes (one for the injection wells and one for the infiltration gallery) will be installed in a flush-mount well vault. Rather than installing aboveground tanks or equipment, ARCADIS will use a mobile pumping system to conduct the applications of the carbon amendment.

The actual injection locations and well construction details will be determined during the design phase.

Injection Activities

Up to twelve injection events will be completed at the property under this scope of work. During each event, a mobile pumping unit will be used to inject a carbon amendment solution into the subsurface. The dosage will be determined by the pilot

test. During the first two injection events, only the injection wells will be used. These applications will create a reactive zone in the aquifer to treat constituents that may partition from the soil to the groundwater during later use of the infiltration gallery. Subsequent injections will be completed using both the injection wells and infiltration gallery. The injections will be conducted on a monthly basis.

Groundwater Monitoring Program

Concurrent with the injection activities, a groundwater monitoring program will be implemented. Water levels will be measured using a decontaminated electronic water level probe prior to each sampling event to evaluate groundwater flow. Groundwater samples will then be collected from each of the wells. Conventional bailer sampling methods can alter sensitive biological parameters such as dissolved oxygen. To obtain more representative groundwater samples, low-flow sampling techniques will be utilized. A downhole probe will be lowered down each well to measure aquifer parameters such as temperature, pH, dissolved oxygen, specific conductance and oxidation-reduction potential (ORP). Water will be pumped from the aquifer at a low flow rate (less than 150 milliliters per minute [ml/min]) until the probe readings stabilize. Samples will then be collected in clean, laboratory-supplied sample containers, and placed in a cooler filled with ice.

Groundwater samples will be collected from Monitoring Wells MW-2, MW-3, MW-7, MW-9, and MW-10 on a monthly basis during the first 3 months of remediation. These samples will be analyzed for VOCs, dissolved gases, and total organic carbon. All of the site monitoring wells will be sampled on a quarterly basis thereafter. Samples from five wells (MW-2, MW-3, MW-7, MW-9, and MW-10) will be analyzed for VOCs, organic gases, and TOC. The remaining six wells (MW-1, MW-4, MW-5, MW-6, MW-8, and PZ-1) will be analyzed for VOCs.

The samples will be collected using low-flow sampling techniques. The groundwater samples will be submitted to a WDNR-certified laboratory for analysis using appropriate chain-of-custody procedures.

Site Status Report

Upon completion of the injection activities and groundwater monitoring, ARCADIS will prepare a remediation status report. The report will present the results of the injection well installation, injection events, and groundwater monitoring. The results will be used to evaluate the effectiveness of the remedy and develop options for pursuing site closure.

In addition to the status report, ARCADIS will periodically schedule project meetings with you. The purpose of the meetings will be to discuss the progress of remediation and determine if any modifications are necessary.

Disposal of Investigative-Derived Waste

Soil cuttings will be generated during injection well installation activities and trenching for the conveyance piping. These soils will be placed into 55-gallon drums and/or roll-off boxes and stored on site. ARCADIS will coordinate the sampling, profiling, transportation, and disposal of IDW from the investigation. Three contractor bids will be obtained for this service in accordance with NR 169. Costs for disposal of IDW are included with this proposal, and are based on the assumption that the material can be disposed as a special waste.

Reimbursement Claim

As indicated earlier, costs associated with the remediation may be eligible for reimbursement through the DERP. ARCADIS will prepare a reimbursement claim of eligible project costs for submittal to the WDNR. Currently, up to two claims per year can be submitted during the remediation phase.

Project Schedule

ARCADIS will begin work immediately following receipt of authorization to proceed. The DERP work plan and notification will be submitted to you for review within two weeks of authorization. The bench scale pilot test will commence within two weeks after approval from the WDNR.

Estimated Costs

ARCADIS will conduct the scope of work for implementing the enhanced biodegradation remedy as described above for an estimated cost of \$133,072. These costs could vary depending upon the results of the pilot test, conditions encountered in the field, or access inside the building. Table 1 includes a breakdown of the project costs. These costs include all labor and subcontractor services. The proposed scope of work will be invoiced on a time and materials basis in accordance with the Fee Schedule presented in Appendix A.

It is noted that ARCADIS' December 10, 2002 proposal for chemical oxidation included a cost estimate of \$127,721. Given the absence of pilot test data for either option, the costs for the two options are roughly equivalent for the same approximate scope (one year of injections with one year of concurrent groundwater monitoring).

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The enhanced biodegradation technique offers several advantages. If additional injection events are needed, the cost per event for injection utilizing the carbon amendment is less than the cost for applying potassium permanganate. In addition, enhanced biodegradation will not adversely influence other attenuation parameters such as adsorption.

Project Team

The project team members assigned to implement the outlined scope of work were selected because of their experience in the following areas:

- Demonstrated successful experience in projects reimbursed by various funding programs in Wisconsin.
- Knowledge of the DERP and the evolving administrative rules.
- Experience in conducting site remediation activities at existing and former dry cleaning facilities.
- Technical expertise and experience with chlorinated hydrocarbons in soil and groundwater.
- Experience with in-situ remediation and ex-situ remediation of chlorinated solvents.

The project team was selected to satisfy the requirements of s. NR 169.21(2)(c). The project team members will work under the direction of Mr. James Drought, PH, project advisor, and Mr. James Bannantine, PG, hydrogeologist, both of whom are thoroughly familiar with technical and administrative issues associated with investigation and remediation aspects of dry cleaning projects, as well as the DERP. Supporting Mr. Drought and Mr. Bannantine in the coordination and implementation of design and field activities will be Mr. Wes May, staff engineer. Resumes for all key personnel involved in the project are presented in Appendix B.

Certification

This proposal has been prepared in accordance with the requirements of s. NR 169.21. In accordance with s. NR 169.21(6), ARCADIS certifies the following:

- If selected to complete the scope of work described herein, ARCADIS will comply with the applicable requirements of Chapters NR 169 and NR 700 through NR 728.

- ARCADIS will make available to the WDNR upon request, for inspection and copying, all of the documents and records related to the contract services.

Also in accordance with s. NR 169.21(6), ARCADIS' Certificate of Insurance is presented in Appendix C.

Qualifications

ARCADIS is a full-service environmental consulting company with over 40 years of experience in assessing soil and groundwater quality and developing remedial solutions. An intraoffice electronic mail system provides ready access to corporate resources and technical experts in ARCADIS offices worldwide. A company-wide project management system has been implemented to provide project managers and team members with tools to manage client communications, track budgets and select personnel for executing project work. The Milwaukee office employs a staff of over 35 geologists, engineers and scientists. We are thoroughly experienced in assessing and remediating chlorinated compounds and implementing cost effective remedial solutions, including natural attenuation.

Case study information for investigation and remediation activities on dry cleaning projects completed or currently in-progress by ARCADIS is included in Appendix D. A case study for chemical oxidation pilot testing is also included in Appendix D. Among the remedial techniques utilized by ARCADIS to address dry cleaner releases is a patented process that enhances the biological degradation of chlorinated hydrocarbons. ARCADIS has also employed natural attenuation as a remedy for chlorinated hydrocarbons. The dissolved gases concentrations and other groundwater quality data collected during the investigation can be used to assess whether natural attenuation or enhanced biodegradation are feasible remedial methods.

The experience and administrative systems described above will enable the ARCADIS project team to meet and exceed the following criteria established in s. NR 169.21(2)(c)1-4, Wis. Admin. Code:

- Be fully informed about this project's scope and services, and have the experience and ability to analyze alternatives and design the most suitable response action consistent with technical and economic feasibility, environmental statutes and rules, restoration timeframes, and the latest technical advances.
- Provide necessary staff and facilities for all phases of planning, investigation, design, construction and operation.
- Retain and confer with specialists on unusual matters; provide qualified technical reviewers, who will keep the owners advised on technical and regulatory matters and work toward planned remediation goals.
- Perform all services in an ethical, professional and timely manner.

References

A list of client references is included in Appendix E.

Closing

ARCADIS appreciates the opportunity to submit this proposal to you and looks forward to working with you on this project. Should you have any questions relating to the information presented herein, please feel free to call us at your convenience.

Sincerely,
ARCADIS G&M, Inc.



Edmund A. Buc, PE
Senior Engineer



James F. Drought, PH
Principal Hydrogeologist

Attachments

This proposal and its contents shall not be duplicated, used, or disclosed—in whole or in part—for any purpose other than to evaluate the proposal. This proposal is not intended to be binding or form the terms of a contract. The scope and price of this proposal will be superseded by the contract. If this proposal is accepted and a contract is awarded to ARCADIS as a result of—or in connection with—the submission of this proposal, ARCADIS and/or the client shall have the right to make appropriate revisions of its terms, including scope and price, for purposes of the contract. Further, client shall have the right to duplicate, use, or disclose the data contained in this proposal only to the extent provided in the resulting contract.

Table 1. Cost Estimate for Implementation of Enhanced Biodegradation Remediation, N. Getz Property, 6854 West Beloit Road, West Allis, Wisconsin.

ARCADIS Services			
<u>WDNR Notification</u>			
Senior Engineer	2 hours @ \$125/hr		\$250
Engineer II	6 hours @ \$78/hr		\$468
Administrative Support	1 hours @ \$62/hr		\$62
		Subtotal	\$780
<u>Pilot Test Work Plan</u>			
Senior Engineer	2 hours @ \$125/hr		\$250
Staff Engineer I	16 hours @ \$92/hr		\$1,472
Drafting	1 hour @ \$78/hr		\$78
Administrative Support	2 hours @ \$62/hr		\$124
		Subtotal	\$1,924
<u>Subcontractor Procurement</u>			
Engineer II	3 hours @ \$78/hr		\$234
Administrative Support	1 hours @ \$62/hr		\$62
		Subtotal	\$296
<u>Health and Safety Plan</u>			
Staff Engineer I	1 hour @ \$78/hr		\$78
Administrative Support	1 hour @ \$62/hr		\$62
		Subtotal	\$140
<u>Injection Permitting</u>			
Senior Engineer	1 hour @ \$125/hr		\$125
Staff Engineer I	15 hours @ \$92/hr		\$1,380
Drafting	1 hour @ \$78/hr		\$78
Administrative Support	2 hours @ \$62/hr		\$124
		Subtotal	\$1,707
<u>Pilot Test Well Installation Oversight</u>			
Staff Engineer I	4 hours @ \$92/hr		\$368
Scientist II	12 hours @ \$78/hr		\$936
Equipment and Expenses			\$500
		Subtotal	\$1,804
<u>Pilot Test Injections (Four Events)</u>			
Senior Engineer	2 hours @ \$125/hr		\$250
Project Engineer	8 hours @ \$110/hr		\$880
Engineer I	24 hours @ \$78/hr		\$1,872
Equipment and Expenses			\$1,200
		Subtotal	\$4,202
<u>Pilot Test Groundwater Monitoring (Five Events, Three Wells per Event)</u>			
Project Engineer	8 hours @ \$110/hr		\$880
Scientist I	40 hours @ \$78/hr		\$3,120
Equipment and Expenses			\$1,500
		Subtotal	\$5,500
<u>Pilot Test Report/Remediation Work Plan</u>			
Senior Engineer	4 hours @ \$125/hr		\$500
Project Engineer	10 hours @ \$110/hr		\$1,100
Staff Engineer I	35 hours @ \$78/hr		\$2,730
Administrative Support	6 hours @ \$62/hr		\$372
Drafting	8 hours @ \$78/hr		\$624
Expenses			\$200
		Subtotal	\$5,526

Table 1. Cost Estimate for Implementation of Enhanced Biodegradation Remediation, N. Getz Property, 6854 West Beloit Road, West Allis, Wisconsin.

<u>Bid Documents and Subcontractor Selection</u>		
Project Engineer	2 hours @ \$110/hr	\$220
Staff Engineer I	6 hours @ \$78/hr	\$468
	Subtotal	\$688
<u>Oversight of Infiltration/Injection Gallery Installation</u>		
Senior Engineer	8 hours @ \$125/hr	\$1,000
Project Engineer	25 hours @ \$110/hr	\$2,750
Engineer II	80 hours @ \$78/hr	\$6,240
Equipment and Expenses		\$4,000
	Subtotal	\$13,990
<u>Injection Event (One Event)</u>		
Senior Engineer	1 hours @ \$125/hr	\$125
Project Engineer	2 hours @ \$110/hr	\$220
Scientist II	12 hours @ \$78/hr	\$936
Equipment and Expenses		\$1,000
	Subtotal	\$2,281
<u>Remediation Groundwater Sampling (One Event, Five Wells per Event)</u>		
Project Engineer	2 hours @ \$110/hr	\$220
Scientist II	16 hours @ \$78/hr	\$1,248
Equipment and Expenses		\$700
	Subtotal	\$2,168
<u>Sitewide Groundwater Sampling (One Quarter, Ten Well per Quarter)</u>		
Project Engineer	2 hours @ \$110/hr	\$220
Scientist II	35 hours @ \$78/hr	\$2,730
Equipment and Expenses		\$1,500
	Subtotal	\$4,450
<u>Remediation Status Report</u>		
Senior Engineer	4 hours @ \$125/hr	\$500
Project Engineer	15 hours @ \$110/hr	\$1,650
Staff Engineer I	35 hours @ \$78/hr	\$2,730
Administrative Support	6 hours @ \$62/hr	\$372
Drafting	8 hours @ \$78/hr	\$624
Expenses		\$200
	Subtotal	\$6,076
<u>Characterization of Investigative Derived Waste</u>		
Project Engineer	6 hours @ \$110/hr	\$660
Scientist II	8 hours @ \$78/hr	\$624
Administrative Support	2 hours @ \$62/hr	\$124
	Subtotal	\$1,408
	<i>Subtotal, ARCADIS Services</i>	<u>\$91,267</u>
	<i>Including Twelve Injection Events, Three Sampling Events of Five Wells, and Three Quarters of Sitewide Groundwater Sampling</i>	

Table 1. Cost Estimate for Implementation of Enhanced Biodegradation Remediation, N. Getz Property, 6854 West Beloit Road, West Allis, Wisconsin.

Subcontractor Services		
<u>Subcontracted Drilling Services - Pilot Test Well Installation (Three Wells)</u>		
Mobilization	Lump Sum	\$250
Drilling	45 LF @ \$20/LF	\$900
Well Installation	45 LF @ \$3.50/LF	\$158
Flush-Mount Cover	3 units @ \$70/ea	\$210
Decontamination	Lump Sum	\$750
	Subtotal	\$2,268
<u>Subcontracted Drilling Services - Remediation Injection Well Installation (11 Wells)</u>		
Mobilization	Lump Sum	\$250
Drilling	165 LF @ \$20/LF	\$3,300
Well Installation	165 LF @ \$3.50/LF	\$578
Decontamination	Lump Sum	\$750
	Subtotal	\$4,878
<u>Subcontracted Conveyance System Installation</u>		
Mobilization	Lump Sum	\$1,000
Saw Cutting Trenches	1200 LF @ \$2/LF	\$2,400
Trench Excavation	600 LF @ \$10/LF	\$6,000
Conveyance Piping	800 LF @ \$3.50/LF	\$2,800
Infiltration Gallery	450 LF @ \$4/LF	\$1,800
Backfill Material	50 CY @ \$2/CY	\$100
Placement and Compaction	50 CY @ \$4/ea	\$200
Concrete Replacement	1200 SF @ \$5/SF	\$6,000
Site Restoration	Lump Sum	\$2,000
Loading of Soil	50 CY @ \$4/CY	\$200
	Subtotal	\$22,500
<u>Subcontracted Analytical Testing Services</u>		
Pilot Test Groundwater Samples (Five Rounds from Three Wells)		
VOCs	15 samples @ \$70/each	\$1,050
Total Organic Carbon	15 samples @ \$30/each	\$450
Ethene, Ethane, Methane	15 samples @ \$80/each	\$1,200
Startup Remediation Sampling (Three Rounds from Five Wells)		
VOCs	15 samples @ \$70/each	\$1,050
Total Organic Carbon	15 samples @ \$30/each	\$450
Ethene, Ethane, Methane	15 samples @ \$80/each	\$1,200
Sitewide Groundwater Sampling - (Three Quarters of 11 Wells)		
VOCs	33 samples @ \$70/each	\$2,310
Total Organic Carbon	15 samples @ \$30/each	\$450
Ethene, Ethane, Methane	15 samples @ \$80/each	\$1,200
	Subtotal	\$9,360
<u>Subcontracted Disposal of Investigative-Derived Waste</u>		
Soil Cuttings	50 CY @ \$50/CY	\$2,500
Purge Water	3 drums @ \$100/ea	\$300
	Subtotal	\$2,800
<i>Subtotal, Subcontractor Services</i>		\$41,805

Total Cost for	\$133,072
Implementation of Remedy	

ARCADIS
FEE SCHEDULE FOR PROFESSIONAL SERVICES

Invoices for services provided by ARCADIS consist of: (1) hourly rate professional services fees; (2) material and equipment expenditures and usage; (3) subcontractor costs; (4) travel, shipping, and communications charges; and (5) sales or gross receipt taxes, as applicable.

Subject to periodic revisions, hourly rate fees for ARCADIS professional services are indicated below:

<u>STAFF CATEGORIES</u>	<u>HOURLY RATES</u>
<u>ENGINEERS & SCIENTISTS</u>	
Scientist II	\$78
Staff Scientist I	\$85
Senior Engineer	\$125
<u>OFFICE SUPPORT STAFF</u>	
Administrative Support	\$62
Draftsperson	\$78

INVOICING & PAYMENT: Progress invoices will be issued monthly and payment is due within thirty (30) days of invoice date. Invoices for subcontractor charges are payable upon presentation. Non-standard, client-requested invoice formats and supporting documentation will be invoiced at \$49.00 per hour plus expenses. A finance charge of 1.5% per month will be payable on past-due account balances.

ARCADIS

FEE SCHEDULE FOR PROFESSIONAL SERVICES

ADDITIONAL TERMS

PROJECT MATERIALS AND EQUIPMENT: All project-related expenses, materials, field supplies, equipment charges; premiums for insurance, bonds, and letters of credit required by the client in addition to normal coverage; project-required permits and licenses; et. will be invoiced at cost plus 15%.

PROJECT COMMUNICATION AND SHIPPING EXPENSES: Charges for long-distance telephone, photocopying, blueprints, express and regular shipping, and postage will be invoiced at cost plus 15%.

TRAVEL AND RELATED EXPENSES: Charges for rental vehicles, meals, travel, and lodging will be invoiced at actual cost plus 15%. Personal vehicles will be charged at \$0.40/mile.

SUBCONTRACTS: Subcontractor (drillers, analytical laboratories, etc.) charges will be invoiced at cost plus 15%.

LEGAL PROCEEDINGS: A surcharge of 50% will be added to the professional services rates for actual sequestered preparation time and for actual time spent in depositions, public testimony, court, and/or hearings.

PROJECT ADVISORS AND SENIOR EXPERTS: Rates for Project Advisors are \$230/hour. Rates for Senior Experts are a function of the individual and are quoted upon request.

ARCADIS EQUIPMENT AND MATERIALS: ARCADIS-owned equipment, vehicles, and materials will be invoiced at fixed unit rates. A summary of these rates will be provided upon request.

ARCADIS TREATABILITY LAB ANALYSES: Routine Treatability Laboratory analyses will be invoiced at a fixed price per test. Rates will be available upon request.

Mr. Drought has been employed with ARCADIS since 1995. As Vice President and Principal Hydrogeologist, Mr. Drought is responsible for the development, management and completion of brownfield remediation and redevelopment, real property due diligence, Guaranteed Property Remediation™, peer review, and litigation support services. Mr. Drought and his staff provide these services to clients throughout the United States and the world. Mr. Drought's Project Director responsibilities include staff development and monitoring, client and regulatory agency coordination, project scope and budget development and control, development and execution of investigation and remediation work plans, analytical and feasibility data review, and report technical review.

As coordinator of the business development activities within the Great Lakes Region of ARCADIS, Mr. Drought is responsible for organizing an annual business development retreat and the development of sales plans for each of the eight regional offices. In addition, Mr. Drought's responsibilities include professional seminar presentations to attorneys, financial institutions, realtors, and contractors, and proposal preparation and execution. Mr. Drought serves as a regulatory compliance specialist by tracking and commenting on proposed regulations at the state and federal level. Mr. Drought also serves as the account manager for several national and regional clients.

Prior to joining ARCADIS, Mr. Drought was the Assistant Environmental Manager at a national environmental and geotechnical consulting firm from 1989 through 1994 and was responsible for the development, management and completion of soil and groundwater remedial investigations, feasibility studies and remedial design. Mr. Drought was also responsible for the supervision of professional and technical staff and the coordination of an analytical laboratory certified under Chapter NR 149 of the Wisconsin Administrative Code.

Mr. Drought also served as an Assistant Environmental Planner at the Bay-Lake Regional Planning Commission (BLRPC) and the Southeastern Wisconsin Regional Planning Commission (SEWRPC) from 1985 through 1988. Mr. Drought's responsibilities included the preparation of resource management and environmental planning reports, and serving as a regulatory agency liaison between USEPA, WDNR, WDOA, and local and county units and agencies of government.

Education

MS, Contaminant Hydrogeology and Geosciences, University of Wisconsin-Milwaukee, June 1999

Graduate Coursework in Biological and Chemical Sciences, University of Wisconsin-Milwaukee, 1983-1985

BS, Physical Geography and Biology, Carroll College, May 1982

Professional Registrations

Wisconsin Professional Hydrogeologist (No. 45-111)

NR 712 Hydrogeologist

WDHFS Asbestos Inspector (Certification No. AII-4259)

COMM UST Site Assessor

COMM PECFA Consultant

Professional Associations

National Ground Water Association

Wisconsin Fabricare Institute

Wisconsin Ground Water Association

Professional Training

- ARCADIS Advanced Management Programme Training, October 2000 (The Netherlands); January 2001 (Los Angeles, CA); April 2001 (The Netherlands)
- Wisconsin Department of Commerce Brownfield Seminar, 2000
- 8-Hour Health and Safety Refresher Training Completed in 1991-2001
- In-Situ and On-Site Bioremediation: The Fifth International Symposium, Sponsored by Batelle, San Diego, California, 1999
- Wisconsin Ground Water Association Fall Conference, 1998 and 1999
- National Ground Water Association Soil and Groundwater Modeling for Soil Clean-up Level Evaluation and Risk Assessment Seminar, 1996
- Symposium of Natural Attenuation of Chlorinated Organics in Groundwater, Sponsored by USEPA, Dallas, Texas, 1996
- UWEX and WDNR Environmental Clean-Ups Under NR 700 Seminar, 1994
- Nuclear Density Gauge Operation and Radiation Safety Training, 1993
- UWEX and WDNR Remediation Technologies for Environmental Contamination Clean-Ups Seminar, 1993
- 40-Hour Health and Safety Training for CERCLA and RCRA Remediation, 1990
- USEPA AHERA Asbestos Building Inspection Course, 1989. AHERA update courses completed in 1990-2000
- Microscopic Identification of Asbestos, McCrone Research Institute, 1989
- Federation of Environmental Technologist (FET) Programs:
 - FET Annual Conference and Exhibition, 1990-2002
 - RCRA Update, 2000
 - Environmental Update, 1998
 - Solid and Hazardous Waste Committee, 1996-Present
 - Legal Committee, 1995-Present
 - NR 700 Update Seminar, 1994
 - Soil Remediation Issues in Wisconsin, 1992
 - Current and Future Wastewater Concerns, 1992
 - Criminal Enforcement of Environmental Law, 1992

Fields of Specialization

- Brownfield remediation, redevelopment, and financing
- Real property due diligence and Guaranteed Property Remediation™ services
- Petroleum and chlorinated hydrocarbon (NR 700), hazardous waste (NR 600), and PCB remedial investigations, feasibility studies, and remedial design
- Underground storage tank (UST) closure assessments, and leaking underground storage tank (LUST) remedial investigations
- Commingled petroleum aromatic and chlorinated aliphatic hydrocarbon remedial investigations and remedial design
- Ex-situ remedial design and monitoring utilizing thermal desorption, passive aeration, and bioremediation technologies
- Petroleum Environmental Clean-up Fund Act (PECFA) reimbursement guidance
- Dry cleaning solvent (PCE and stoddard solvent) investigation, remedial design, and remediation cost recovery under the Drycleaner Environmental Response Program (DERP)

- Computer fate and transport modeling utilizing the USEPA SESOIL model
- Abiotic and biotic degradation of chlorinated and petroleum hydrocarbons
- Subsurface explorations utilizing Geoprobe, truck and track-mounted, portable and low clearance, and all-terrain drilling equipment
- Feasibility evaluations including vapor extraction and air sparging, aquifer studies, and in-situ hydraulic conductivity determinations
- State and Federal regulatory compliance

Committee Representation

- WDNR NR 169 Committee (DERP)
- WDNR Consultant Focus Group
- WDNR Brownfields Committee
- COMM 47 Advisory Committee
- River Revitalization Committee (Board Member)

Key Projects

- Project advisor for the investigation, remediation, and redevelopment of the former Pabst Brewery Complex in Milwaukee, Wisconsin. The 150-year-old, 1,400,000 square foot Pabst Brewer Complex had been vacant

since 1997 and was selected for commercial and residential redevelopment in 2002. ARCADIS was selected to assess and inventory the environmental impairment, developed restoration plans and cost projections, and coordinated the restoration with the redevelopment activities.

- Project advisor for PCE-impacted soil and groundwater investigation and remediation activities at the former Crestwood Shopping Center brownfield site located in Glendale, Wisconsin. A dry cleaning facility had operated within the mall, two different locations, from the early 1960s to 2000. A plume of PCE-impacted soils and groundwater existed on and off the seven-acre shopping center.
 - A combination of aggressive in-situ soil and groundwater treatment and institutional controls were selected, approved by the Wisconsin Department of Natural Resources (WDNR), and completed within six months of contract execution. Demolition of the existing mall and construction of new retail and commercial buildings were completed concurrently with treatment activities. Investigation and remediation activities were completed under a guaranteed maximum price contract.
 - Project advisor for the completion of a remedial investigation and an in-situ remedial pilot test at a existing
- industrial facility located in Oconomowoc, Wisconsin. A spill of TCE occurred at this site in 1994 within a former vapor degreasing system. The spill resulted in the release of TCE to soils and groundwater. The TCE migrated in saturated coarse alluvial deposits in a long and narrow groundwater plume (“core”) off-site in the direction of the Oconomowoc River.
 - The remedial investigation consisted of the advancement and sampling of 52 Geoprobe borings, eight groundwater monitoring wells, and four piezometers on and off the property. In addition, five seepage meters were installed in the Oconomowoc River to determine rates of contaminant and water fluxes. The in-situ pilot test included injection and recirculation of a natural carbon supplement to enhance anaerobic conditions and promote reductive dechlorination of TCE as an electron donor. The in-situ pilot test was completed over the course of six months and demonstrated to the WDNR that the injection of natural carbon represented a feasible and cost effective remedial alternative.
 - A risk assessment was also completed as part of the pilot test activities to determine “threshold” levels for the chlorinated hydrocarbons venting to the Oconomowoc River. The “threshold” levels determined by the risk assessment demonstrated that active remediation was not warranted

adjacent to the Oconomowoc River. The project was managed under Chapter NR 700 of the Wisconsin Administrative Code.

- Project advisor for a PCE impacted soil and groundwater investigation and remediation project at the Washington Square Mall brownfield site located in Germantown, Wisconsin. A dry cleaning facility operated within the retail mall over the period from 1980 to 1997. The remedial investigation consisted of the advancement and sampling of Geoprobe borings, monitoring wells, and piezometers within and adjacent to the retail mall. Soil remediation consisted of the excavation and off-site disposal (at a RCRA subtitle C landfill in Michigan) of approximately 3,500 tons of PCE impacted soils. Groundwater remediation consisted of the extraction and treatment of approximately 80,000 gallons of PCE-impacted groundwater from the resulting excavation, and the injection of a natural carbon solution as an electron donor to promote the reductive dechlorination of PCE.
- This project was completed under the Wisconsin Brownfields Program (Wisconsin Act 453) and Chapters NR 700 and 600 of the Wisconsin Administrative Code. In addition, all investigation and remediation activities were completed under a guaranteed maximum price contract. The Washington Square Mall project was closed by the WDNR in January 2001, approximately 2-1/2 years after the initiation of remediation activities.
- Project advisor for a commingled polychlorinated biphenyl (PCB) and tetrachloroethylene (PCE) impacted soil and groundwater project at an existing die casting facility located in Milwaukee, Wisconsin. Prior to 1981, some of the die casting machines within the facility used phosphate ester oil (PEO) hydraulic oils that contained PCBs. PCE was utilized during the die casting process as a vapor degreaser.
- Investigation activities included an evaluation of the extent of PCB and PCE impacted soils and groundwater by advancing and sampling Geoprobe borings and monitoring wells. Groundwater samples were collected using low-flow sampling methods. Soil and groundwater remedial alternatives were evaluated in accordance with Chapter NR722 of the Wisconsin Administrative Code. A performance standard consisting of an engineered cap and long-term monitoring was selected as the final remedial alternative.
- Project manager for the assessment and remedial design of commingled petroleum aromatic and chlorinated aliphatic hydrocarbon impacted soil and groundwater at two existing dry cleaning/former gasoline service station facilities located in Milwaukee, Wisconsin. Projects were initiated by completing closure assessments on the

former USTs that remained from the former gasoline service station operations. Investigation activities identified the presence of petroleum (BTEX) and chlorinated (PCE, TCE) hydrocarbons within the groundwater in exceedance of Chapter NR 140 regulatory levels. The assessment and remedial design activities were completed in accordance with Chapters NR 600 and 700 of the Wisconsin Administrative Code. Feasibility studies completed at these sites included soil vapor extraction, air sparging and aquifer testing. A dual phase vapor and groundwater extraction system was designed and installed for treatment of the commingled plumes at one site; a program to monitor the degradation of PCE was approved by the WDNR for the other site. The cost for the assessment and remediation of the petroleum and chlorinated hydrocarbons were eligible for reimbursement under the PECFA and DERF programs, respectively.

- Project manager for site investigation, remediation, and risk assessment activities completed at a former retail gasoline service station located in northern Illinois. The site operated as a retail gasoline service station over the period from about 1935 to 1985. ARCADIS was retained in March 1996 to review ten years of groundwater gauging, analytical testing, and remedial system performance data, and to implement a strategy for site closure. A risk assessment was completed in accordance with the Illinois Environmental Protection Agency (IEPA) Tiered Approach for Clean-up Objectives (TACO) for the dissolved phase hydrocarbons. An evaluation of the historical groundwater gauging data indicated that the mass of the separate phase product, both on and off the site, had been reduced by approximately ninety percent from the mass that was present in the mid-1980s.
- ARCADIS met with representatives from the IEPA in Springfield, Illinois in June 1996. The meeting was held to discuss the site investigation and remediation activities that were previously completed on the site, the TACO risk assessment, and a request for no further action. The representatives from the IEPA indicated at the meeting that the groundwater SSLs developed for the risk assessment were generated correctly and, since the maximum analyte levels were below the site-specific levels, further remediation of dissolved phase hydrocarbons was not necessary. The risk assessment developed for this project was the first TACO Tier III risk assessment approved by the IEPA.
- Project manager for a reactive cyanide impacted soil (F listed hazardous waste) assessment and remediation project at a construction project adjacent to the Fox River in Waukesha, Wisconsin. Project was

completed in accordance with Chapter NR 600 of the Wisconsin Administrative Code. As the Project Manager, Mr. Drought designed and supervised the installation of a containment system to protect worker and public welfare during construction activities, and to prevent the migration of exposed cyanide wastes from entering the Fox River. Following completion of the investigation activities, remedial alternatives were evaluated including excavation and off-site stabilization and treatment, which was implemented and completed at the CWM facility in Lake Charles, Louisiana.

- Project manager for the investigation and remediation of petroleum and chlorinated hydrocarbon-impacted soil and groundwater on active and former gasoline service stations, dry cleaning facilities, and commercial and industrial sites. Most projects were completed under the PECFA or DERP reimbursement programs to maximize claimant eligibility for recovery of eligible costs. Soil remediation technologies included development of direct contact and groundwater pathway residual contaminant levels (RCLs), and performance standards, low temperature thermal desorption, passive aeration, landfill disposal, and vapor extraction. Groundwater remediation technologies included natural attenuation, air sparging, and groundwater extraction and treatment.

- Project manager for Phase I and Phase II Environmental Site Assessments completed in South America, Western Europe, and The United Kingdom. All Phase I environmental site assessments were completed in accordance with ASTM 1527. All Phase II environmental site assessments were completed in accordance with national or international regulatory guidelines.

Selected Presentations

Regulatory Update: Principles and Applications, Milwaukee Bar Association, July 24, 2002.

Crestwood Shopping Center Brownfield Case Study, Wisconsin Department of Natural Resources, Bureau for Remediation and Redevelopment In-House Conference, Wisconsin Dells, Wisconsin, November 9, 2000.

Natural Attenuation of a Mixed Hydrocarbon Plume, Summer Intern Program, University of Wisconsin-Milwaukee Great Lakes Water Institute, July 19, 1999.

Development and Implementation of a Better Mouse Trap! Technical Update - Trends and Developments in Site Investigation, Remediation, and Institutional Controls, 1999 Environmental Law Update,

Sheraton Hotel, Brookfield,
Wisconsin; May 4, 1999.

Environmental Manager Training,
University of Wisconsin -
Extension, Madison, Wisconsin;
April 22, 1996.

Fate of Tetrachloroethene and Benzene at
a Dry Cleaning Facility, In-Situ
and On-Site Bioremediation - The
Fifth International Symposium,
Sheraton San Diego Hotel and
Marina, San Diego, California;
April 22, 1999.

Public Comments, Proposed Wisconsin
Department of Natural Resources
Groundwater Reform Policy,
Havenswood State Forest
Auditorium, Milwaukee,
Wisconsin, March 21, 1996.

A Case Study of Natural Attenuation at a
Dry Cleaning Facility, American
Water Resources Association
Annual Meeting, Radisson Hotel,
La Crosse, Wisconsin; March 25,
1999.

The Petroleum Environmental Clean-up
Fund Act: Proposed Changes and
a Consultants Perspective on the
Future of the Program, The
Milwaukee Bar Association,
Milwaukee, Wisconsin; December
14, 1995.

Controlling and Managing Investigation
and Remediation Activities and
Costs, Wisconsin Fabricare
Institute Fall Convention, Devil's
Head Resort, Merrimac,
Wisconsin; September 20, 1998.

Fate and Transport of Tetrachloroethylene,
Wisconsin Fabricare Institute Fall
Convention, Pioneer Inn,
Oshkosh, Wisconsin; September
17, 1995.

Natural Attenuation of Petroleum and
Chlorinated Hydrocarbons,
Graduate Student Groundwater
Seminar, University of Wisconsin-
Milwaukee, Milwaukee,
Wisconsin; March 31, 1997.

Overview: Environmental Site
Assessments, Registered
Environmental Manager Training
Seminar, University of Wisconsin
- Extension, Madison, Wisconsin;
August 28, 1995.

Natural Attenuation and the Wisconsin
Groundwater Reform Policy,
Wisconsin Fabricare Institute
Winter Convention, Radisson
Hotel, Green Bay, Wisconsin;
February 8, 1997.

The Petroleum Environmental Clean-Up
Fund Act (PECFA) and Recent
Updates, Milwaukee Bar
Association, Milwaukee, WI;
October 24, 1994.

Fate, Transport, and In-Situ Remediation
of Hazardous Wastes, Registered

Environmental Consultant's Perspective -
Practice Under the New NR 700

Rule Series, State Bar of Wisconsin 1994 Annual Convention, Milwaukee, WI; June 23, 1994.

Mayfair, Wauwatosa, WI; March 13, 1990.

Featured on PBS "Outdoor Wisconsin" (1987, 1989, & 1990).

Wetlands: Features, Functions, and Regulations, Commercial Real Estate Issues Seminar sponsored by Hiller and Frank S.C., Marriott Hotel, Brookfield, WI; March 17, 1994.

Organizer of ARCADIS In-House Training Seminars

Dry Cleaning Initiatives Training Seminar for the Great Lakes Region, April 17-18, 1998.

USTs and Petroleum-Impacted Soil: Concerns and Solutions, Wisconsin Mortgage Banker's Association meeting, Midway Hotel, Brookfield, WI; January 18, 1994.

Great Lakes Region Real Estate Training Seminar, July 14-15, 2000.

Business Development Retreats for the Great Lakes Region, 1997-2002.

Environmental Assessments and Remediation Alternatives, Upper Midwest Fabricare Exposition sponsored by the Wisconsin Fabricare Institute, Waukesha Exposition Center, Waukesha, WI; October 17, 1992.

Multi-Phased Approach to Environmental Assessments, Hazardous Contamination and Environmental Protection Seminar sponsored by the Metropolitan Builders Association of Greater Milwaukee, Milwaukee Athletic Club, Milwaukee, WI; November 13, 1990.

Environmental Liabilities in Real Property Transactions, CECO Exchange Club meeting, Sheraton Inn-

**Peer Review and Litigation Support
Services**

Cook & Franke – Milwaukee, WI

Davis & Kuelthau – Milwaukee,
WI

Foley & Lardner – Milwaukee,
WI

Fox, O'Neill & Shannon –
Milwaukee, WI

Leonard, Street & Deinard –
Minneapolis, MN

McCarter & English – Newark, NJ

Michael Best & Friedrich –
Milwaukee, WI

Reinhart Boerner & Van Deuren –
Milwaukee, WI

Whyte Hirschboeck Dudek –
Milwaukee, WI

Mr. Bannantine is a Senior Hydrogeologist in the Milwaukee office of ARCADIS, with 12 years of experience managing construction projects, site investigations and environmental audits, feasibility studies, and site remediation design on numerous commercial, industrial, and residential projects. Mr. Bannantine is familiar with obtaining and recovering costs for environmental projects from multiple funding sources. His experience includes the project management, field supervision, and analysis for projects relating to environmental and engineering problems with up to \$5 million budgets. He provides internal consultation to company personnel regarding project funding and budgets, hydrogeologic and geologic evaluations, and assists in performing groundwater and soil treatment feasibility studies and design of treatment systems. Mr. Bannantine has given seminars and presentations to groups of professionals inside and outside of the technical arena, regarding site characterization and feasibility study techniques and has performed soil and groundwater computer modeling to assist with remediation cost reduction.

Education

M.S., Geology, Northern Illinois University, 1990

B.S., Geology, University of Wisconsin-Oshkosh, 1987

Professional Registrations

Wisconsin Registered Professional Geologist

Wisconsin DILHR-Certified for UST Closure Assessments

American Institute of Professional Geologists, Certified Professional Geologist

OSHA 40-Hour Hazardous Waste Operations Certificate

Professional Associations

American Institute of Professional Geologists

Wisconsin Ground Water Association

Environmental Assessments/Audits

Conducted over 50 Phase I and Phase II Environmental Site Assessments (ESA) on properties throughout the United States for refinancing and property transfers.

Reviewed over 100 Phase I and Phase II ESAs for property transfers and refinancing throughout the United States.

Site Investigation and Remediation

Project Manager for over 300 site investigations characterizing the magnitude and extent of environmental problems.

Project involvement in over 200 petroleum release investigations including monitoring well design, installation and development; soil,

groundwater and air sampling; mapping; permitting; and report preparation.

Project Manager for site characterization and remediation of perchloroethane (PCE) releases at several dry cleaning facilities. Remediation systems utilized included air stripping and on-site groundwater treatment facilities.

Project Manager for site characterization and remediation of an acetone solvent spill at a printing facility using ex-situ thermal desorption.

Project Manager for site characterization and remediation of a multiple solvent UST release at a manufacturing facility.

Project Manager for site characterization of a 17-acre solid waste landfill. Contaminants at issue included methane, benzene and heavy metals.

Underground Storage Tank Management, Tank Removal and Site Remediation/ Corrective Action

Project Manager, including on-site supervision, subsurface investigation of soil and groundwater and oversight management for the removal of petroleum underground storage tanks (USTs) and the subsequent remediation of petroleum impacted soils and groundwater, using a variety of strategies.

Assisted clients with the completion of cost recovery applications from a variety of agencies, resulting in the maximization of reimbursement.

Project Management

Project Manager for investigation and remediation of a 60-acre railroad yard facility in north-central Wisconsin and 52-acre railroad yard in northwest Minnesota. Contaminants include gasoline, diesel, hydraulic oil, heavy metals, Stoddard solvents, TCE and vinyl chloride.

Lead Project Manager for negotiations with regulatory agency regarding solid waste landfill closure. Successfully negotiated to reduce cap and operation and maintenance requirements, resulting in project savings of \$1 to \$3 million.

Project Manager for numerous remediation feasibility studies including bail down tests, aquifer pump tests, vapor extraction and air sparging pilot studies,

initial bioremediation and bioventing assessments, and enhanced bioremediation studies.

Project Manager for groundwater remediation projects using water/LNAPL separation techniques, oxygen injection, air stripping, activated carbon absorption, in-situ air sparging, and several “pump and treat” methodologies, natural attenuation and bioremediation.

Lead Project Manager for Phase I ESA, Phase II ESA, and site remediation for an industrial property that a lending institution foreclosed on.

Project Manager for several soil remediation projects. Techniques included on-site bioremediation, excavation and landfilling, asphalt incorporation, on-site thermal desorption, thinspreading, soil vapor extraction and biopiles.

Responsible for budget control and state reimbursement applications for several projects up to \$5 million in cost.

Experience working with several state reimbursement programs for USTs, including Wisconsin, Illinois, Indiana, Michigan, Tennessee, Florida, and Missouri.

Site Closure

Obtained regulatory closure for approximately 100 residential, commercial and industrial facilities.

Project Manager for closure activities including well abandonment, treatment system dismantlement and site restoration.

Provided expert witness testimony for a village in southeastern Wisconsin. The village was attempting to gain access to a property to conduct an environmental investigation prior to acquiring the property through condemnation proceedings.

Construction Oversight

Oversaw construction of a 32-foot diameter interceptor tunnel for the Milwaukee Metropolitan Sewerage District Deep Tunnel Project. The project covered over four miles and included blasting, drilling and various activities to provide structural support for the tunnel.

Legal/Litigation Support

Provided assistance to attorney working for the owner of a landfill in southeastern Wisconsin. The Wisconsin Department of Natural Resources attempted to place this landfill into the Superfund program. Working with the client's attorney, we successfully prevented this site from being entered into the Superfund program, thereby protecting our client's assets.

Mr. Buser is a Hydrogeologist in the Milwaukee office of ARCADIS. His experience covers a wide range of environmental applications, including coordination of field activities and implementation of complex investigation and remediation projects. Mr. Buser’s primary responsibilities include the oversight of drilling operations, collection of soil and groundwater samples, subcontractor coordination, data analysis and interpretation, task management and report preparation. His experience also includes computer-aided drafting, remedial system maintenance and contributions to system design.

Education

Bachelor of Geology, University of Wisconsin-Madison, 1997

Professional Training

OSHA 1910.120 Certification, 40-Hour Health and Safety Training

Site Assessor Certification

First Aid Certification

CPR Certification

Fields of Specialization

Task management

Coordination of field activities at numerous sites within the Great Lakes region

Implementation of field investigations and remedial technologies

Innovative drilling and soil sampling technologies

Conventional and low-flow groundwater sampling

Soil vapor monitoring

Geological mapping and stratigraphic interpretation, with an emphasis on glacial stratigraphy

Drafting using AutoCAD

hydrocarbons in groundwater. Responsibilities included collection and analysis of investigative data, report preparation, coordination of various subcontractors, communications with state environmental regulators and budget management. Site activities included installation of off-site groundwater monitoring wells in addition to well and system abandonment. Accomplished successful case closure when chlorinated hydrocarbons were found to be emanating from an off-site source.

Served as field geologist for investigation of metals-impacted soil and groundwater on a large Superfund site in Michigan. Responsibilities included collection and analysis of investigative data, report preparation and coordination of various subcontractors. Site activities were completed in accordance with EPA and state environmental regulators.

Key Projects

Investigation

Served as task manager and field team leader for investigation of site in Wisconsin with low levels of chlorinated

Served as field team leader for investigation of a dry cleaner site in Wisconsin with chlorinated hydrocarbons in groundwater. Responsibilities included collection and analysis of investigative data, coordination of various subcontractors

and interactive communication with merchants occupying the site.

Served as field geologist for investigation of groundwater contamination and elevated methane levels in subsurface at a large site in Michigan. Responsibilities included collection and analysis of investigative data, and communications with various subcontractors. Investigation involved the installations of monitoring wells to depths exceeding 300 feet using Rotosonic drilling techniques.

Participated in a door-to-door public safety program in which methane detectors were tested and installed. Site activities included cooperating with city officials and working closely with state environmental regulators.

Remediation

Served as field team leader for in-situ remediation and disposal of metals-impacted soil at a brownfield site in Wisconsin. Responsibilities included implementation of cost-effective remedial technologies, soil sampling and coordination of various subcontractors.

Served as field geologist on a federally funded remedial alternatives study at a confined disposal facility in Wisconsin. Dredged sediment within the facility contained soils impacted with polyaromatic hydrocarbons (PAHs) and metals, including polychlorinated biphenols (PCBs). Responsibilities included soil sampling and surveying with the use of global positioning

satellite (GPS) system. Site activities were completed under the direction of EPA and U.S. Army Corp of Engineers.

Served as field team leader for remediation at an abandoned rail yard in Wisconsin with lead, PAHs, and both petroleum and chlorinated hydrocarbons in soil. Responsibilities included soil sampling, oversight of soil excavation, coordination of various subcontractors and report preparation.

MARSH USA INC.

CERTIFICATE OF INSURANCE

CERTIFICATE NUMBER
SEA-000470032-00

PRODUCER
MARSH USA INC
1225 17TH STREET STE 2100
DENVER, CO 80202-5534

33320 -12345-5/5-00-01

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER OTHER THAN THOSE PROVIDED IN THE POLICY. THIS CERTIFICATE DOES NOT AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES DESCRIBED HEREIN.

COMPANIES AFFORDING COVERAGE

- COMPANY
A GREENWICH INSURANCE COMPANY
- COMPANY
B INDIAN HARBOR INSURANCE COMPANY
- COMPANY
C
- COMPANY
D

INSURED
ARCADIS G & M, INC.
ATTN: CHANDRA DOWNEY
630 PLAZA DRIVE SUITE 200
HIGHLANDS RANCH, CO 80129-2377

COVERAGES This certificate supersedes and replaces any previously issued certificate for the policy period noted below.

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

CO LTR	TYPE OF INSURANCE	POLICY NUMBER	POLICY EFFECTIVE DATE (MM/DD/YY)	POLICY EXPIRATION DATE (MM/DD/YY)	LIMITS
A	GENERAL LIABILITY <input checked="" type="checkbox"/> COMMERCIAL GENERAL LIABILITY <input type="checkbox"/> CLAIMS MADE <input checked="" type="checkbox"/> OCCUR <input type="checkbox"/> OWNER'S & CONTRACTOR'S PROT	GEC0010761	01/01/02	01/01/03	GENERAL AGGREGATE \$ 2,000,000
					PRODUCTS - COMP/OP AGG \$ 2,000,000
					PERSONAL & ADV INJURY \$ 1,000,000
					EACH OCCURRENCE \$ 1,000,000
					FIRE DAMAGE (Any one fire) \$ 1,000,000
					MED EXP (Any one person) \$ 10,000
A	AUTOMOBILE LIABILITY <input checked="" type="checkbox"/> ANY AUTO <input type="checkbox"/> ALL OWNED AUTOS <input type="checkbox"/> SCHEDULED AUTOS <input checked="" type="checkbox"/> HIRED AUTOS <input checked="" type="checkbox"/> NON-OWNED AUTOS	AEC0010758	01/01/02	01/01/03	COMBINED SINGLE LIMIT \$ 1,000,000
					BODILY INJURY (Per person) \$
					BODILY INJURY (Per accident) \$
					PROPERTY DAMAGE \$
	GARAGE LIABILITY <input type="checkbox"/> ANY AUTO				AUTO ONLY - EA ACCIDENT \$
					OTHER THAN AUTO ONLY: \$
					EACH ACCIDENT \$
					AGGREGATE \$
A	EXCESS LIABILITY <input checked="" type="checkbox"/> UMBRELLA FORM <input type="checkbox"/> OTHER THAN UMBRELLA FORM	UEC0010759	01/01/02	01/01/03	EACH OCCURRENCE \$ 5,000,000
					AGGREGATE \$
A	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY THE PROPRIETOR/ PARTNERS/EXECUTIVE OFFICERS ARE: <input checked="" type="checkbox"/> INCL <input type="checkbox"/> EXCL	WEC0010760	01/01/02	01/01/03	<input checked="" type="checkbox"/> WC STATU-TORY LIMITS <input type="checkbox"/> OTH-ER \$ 1,000,000
					EL EACH ACCIDENT \$ 1,000,000
					EL DISEASE-POLICY LIMIT \$ 1,000,000
					EL DISEASE-EACH EMPLOYEE \$ 1,000,000
B	OTHER CLAIMS-MADE PROFESSIONAL LIABILITY AND CONTRACTORS POLLUTION LIABILITY	PEC0008763-01	03/16/02	03/16/03	10,000,000

DESCRIPTION OF OPERATIONS/LOCATIONS/VEHICLES/SPECIAL ITEMS (LIMITS MAY BE SUBJECT TO DEDUCTIBLES OR RETENTIONS)
 EVIDENCE OF INSURANCE
 FOR PROFESSIONAL LIABILITY COVERAGE, THE AGGREGATE LIMIT IS THE TOTAL INSURANCE AVAILABLE FOR CLAIMS PRESENTED WITHIN THE POLICY PERIOD FOR ALL OPERATIONS OF THE INSURED. THE LIMIT WILL BE REDUCED BY PAYMENTS OF INDEMNITY AND EXPENSE.

CERTIFICATE HOLDER **CANCELLATION**

SPECIMEN

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

MARSH USA INC.
 by: Dorothy A. Stevens *Dorothy A. Stevens*



Client
Financial Institution

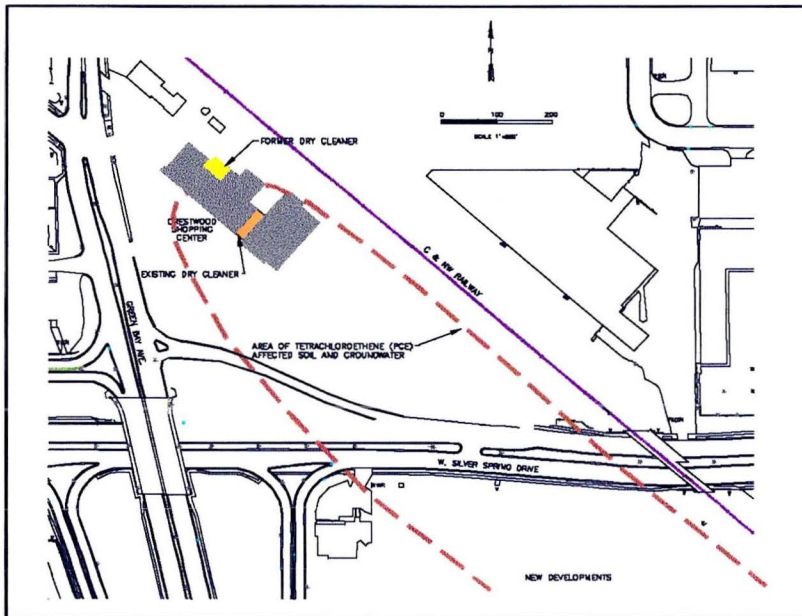
Scope of Services
Soil Remediation Using
Enhanced Soil Vapor
Extraction
Groundwater Remediation
Using Carbon-Enhanced
Reductive Dechlorination
Natural Attenuation
Risk Assessment Monitoring
Guaranteed Remediation
Program™

Background

Prior to 2000, the Crestwood Shopping Center was an underused and dilapidated 27,000 square foot strip mall. Chlorinated hydrocarbons, including tetrachloroethene (PCE), trichloroethene (TCE), dichloroethene (DCE) and vinyl chloride (VC) were present in soils and groundwater on and off the seven acre Crestwood site. A groundwater plume of dissolved chlorinated solvents had migrated off-site approximately 5,000 feet in the direction of a residential subdivision and the Milwaukee River. The chlorinated hydrocarbons were released during dry cleaning operations, which had been ongoing at the shopping center at one of two locations since the early 1960s. Initial redevelopment efforts for the site were unsuccessful due to regulatory and financial uncertainties associated with the contamination at, and emanating from, the site.

Guaranteed Remediation Program™ (GRiP™)

To address these uncertainties, ARCADIS was able to work with the land owners, local municipality, Wisconsin Department of Natural Resources (WDNR), and the site developer to formulate a guaranteed, fixed-price remediation agreement. Under this agreement, ARCADIS is responsible for all remediation work necessary to obtain regulatory closure and for coordinating remediation work with site redevelopment activities. The ARCADIS guaranteed, fixed-price remediation agreement was instrumental in getting all parties to agree to the terms for this successful property redevelopment project. To minimize the liability of the various parties involved with this redevelopment project, remediation stop-loss and pollution legal liability insurance policies were obtained



in conjunction with the ARCADIS guaranteed, fixed-price remediation agreement.

Remedial Program

The remedial program developed by ARCADIS consists of comprehensive in-situ treatment of impacted soil and groundwater to reduce contaminant mass within the source areas. Enhanced soil vapor extraction (SVE) using an injection and extraction system with horizontal and vertical wells is being used to treat the soils. The SVE system installation began in December 2000 and the system startup began in August 2001. The groundwater remediation program, which was initiated in June 2000, involves the periodic injection of an organic carbon

solution to promote the biological degradation of the groundwater contaminants (i.e., an in-situ bioremediation process).

Once the source area treatment has been accomplished, groundwater monitoring will be completed to confirm that natural attenuation will reduce contaminant mass over time within the downgradient plume.

Engineered barriers will be used to prevent infiltration into the vadose zone and prevent exposure to any residual soil contamination remaining across the site. A risk assessment has also been conducted to assess whether current and future constituent concentrations, on-site and downgradient of the site, pose any unacceptable risks to human health or

the environment. Supplemental remedial actions may be necessary if constituent concentrations are found to exceed the threshold levels established in the risk assessment.

Proposed Redevelopment

Concurrent with the installation of the soil vapor extraction system and groundwater treatment activities, the former shopping center was demolished in June/July 2000. Construction of the proposed redevelopment at the site will likely be initiated in Fall 2001. The proposed development was used to create a Tax Incremental Financing (TIF) district to finance a portion of the property redevelopment.

**Guaranteed
Remediation
Program,
Washington Square
Mall Project**

Germantown, Wisconsin



Client

General Capital

Scope of Services

Excavation/Off-Site Disposal of
RCRA F-Listed Soils
Enhanced Biodegradation of
Impacted Groundwater
Guaranteed Property
Remediation and Insurance
Program

Background

Prior to 1998, the Washington Square Mall in Germantown, Wisconsin was a dilapidated retail center that was over 80 percent vacant. Initial attempts to redevelop the property were unsuccessful due to uncertainties associated with contamination at the site. This contamination resulted from the release of tetrachloroethylene (PCE), a common dry cleaning solvent, from a dry cleaning facility that operated within the former shopping mall.

On behalf of General Capital the site developer, ARCADIS was able to formulate a cost-effective remedial strategy with a **fixed-price remediation guarantee** for site closure. In addition, ARCADIS was able to obtain several supplemental insurance policies for minimizing the developer's long-term

liability associated with this project. The **fixed-price remediation guarantee** and associated insurance policies effectively minimized the risks associated with developing the contaminated property and were instrumental in obtaining the financing necessary for this successful property redevelopment.

Remedial Program

The soil remediation program, which was conducted over the period of August through September 1998, consisted of excavation and off-site disposal of unsaturated soils (RCRA F-listed soils) that contained PCE at levels above the soil cleanup objective approved by the Wisconsin Department of Natural Resources (WDNR). The groundwater remediation program, involved the periodic injection of an organic carbon solution to promote the biological degradation of the groundwater contaminants (i.e., an in-situ bioremediation process).

Photo Above: Vacant shopping mall prior to initiating site remediation and redevelopment activities

Photo Below: Initial carbon injection within partially backfilled excavation





Financial/Liability Protection Highlights

- **Guaranteed Fixed-Price Remediation Contract** (for a guaranteed fixed-price, ARCADIS is responsible for all remediation work necessary to obtain regulatory closure)
- Tax Incremental Financing (TIF) district established to pay for remediation and site development costs
- Cleanup activities conducted under WDNR's purchaser liability exemption program
- Remediation stop-loss insurance policy
- Pollution legal liability insurance policy

Project Accomplishments

- Design and implementation of the site remedy within a 10 week time frame
- Excavation and off-site disposal of approximately 3,125 tons of contaminated soil
- Completion of an initial carbon injection event using 182 temporary injection wells
- Installation of permanent carbon injection system
- Average PCE concentration within the groundwater plume decreased from 1,600 ppb to 23 ppb within a 9 month time frame
- Site closure letter received from the WDNR in January 2001, less than 30 months following initiation of site remediation

Photos:
Completed site development

DESCRIPTION

In 2000, column testing conducted at ARCADIS G&M’s (ARCADIS) Treatability Laboratory was used to provide engineering guidance to the implementation of *In Situ* Chemical Oxidation (ISCO) at a confidential CT manufacturing site. Two phases of column testing were conducted.

In Phase I unsaturated soil samples were collected in four stainless steel sleeves from identical intervals in closely adjacent locations at the site. The cores were quickly homogenized to minimize volatilization. The homogenized soil was then repacked into glass columns with a target in place density approximating the density of the cores as received. A sample of the homogenized pretreated soil was taken for volatile organic compounds (VOC), metals and hexavalent chromium analyses. Six gallons of site city water was collected, which was used to saturate the soil in the columns while also ensuring proper column operation and was also used to make up the permanganate solution.

Tests were conducted using a 3% permanganate solution prepared from industrial grade KMnO₄ and site city water. The column length was 1 foot with a 2.17 inch O.D. and column volume of 570 mL. A peristaltic pump was used to pump influent into the column from the influent reservoir. The liquid pressure was measured through an attached pressure gauge before the influent entered the column. The effluents were collected by displacement in HPLC type bottles.

The displaced and any evolved gases were collected on one KMnO₄ treated column in an initially flat Tedlar bag.

Treatment consisted of pumping approximately seven pore volumes of permanganate solution (or site water in the case of the control) through the columns at room temperature. This was followed by one pore volume of deionized (DI) water as a flush in an attempt to quench the reaction.

After pumping a total of four pore volumes, and again after seven pore volumes, effluent samples were collected from the collection bottle for analyses of metals, VOC, hexavalent chromium, chloride and permanganate. Permanganate analyses were performed frequently throughout the study at the treatability lab using chemetrics kits.

Following a DI water purge, an influent and effluent end soil sample was collected from each column for analysis of metals, VOCs, and total organic carbon (TOC).

In Phase II another column study was conducted using the same soil homogenate and apparatus. The primary difference between the initial study and this Phase II study was the use of a recirculating permanganate feed system. In addition, the Phase II test was continued until measurable permanganate consumption ceased.

Figure 1 shows the experimental apparatus for Phase I. Figures 2 and 3 show the experimental apparatus for Phase II.

RTP, NC

Client
Confidential Industrial Client, CT

Scope of Services
Soil Treatability

Contact
Chris Lutes
919-544-4535

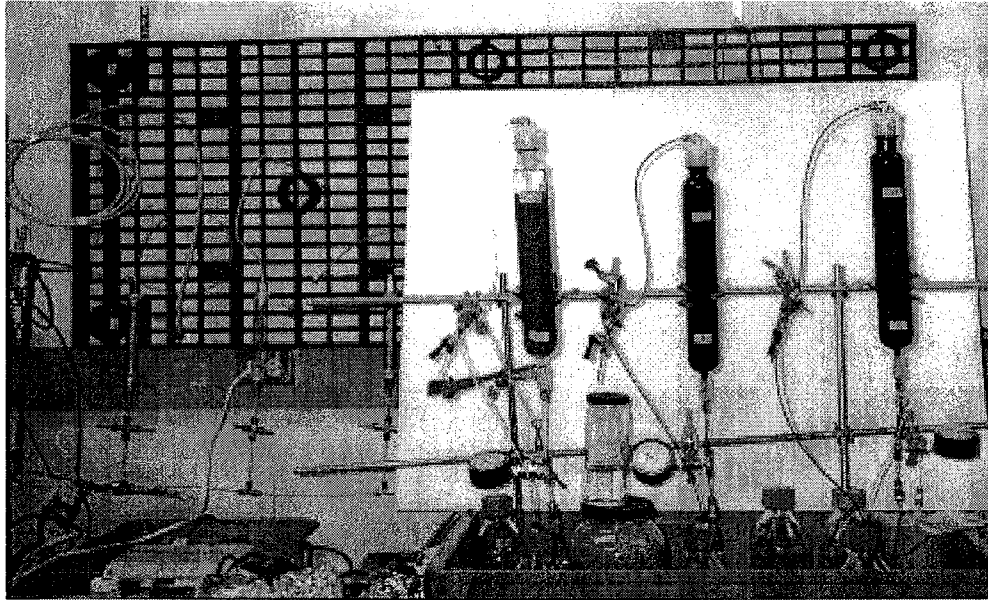


Figure 1. Wide View of Phase I Set-Up.

Bottles with red tops were effluent collection vessels. Pumps were located in the red bin to the left. The control column is on the left; treated columns are in the center and on the right.

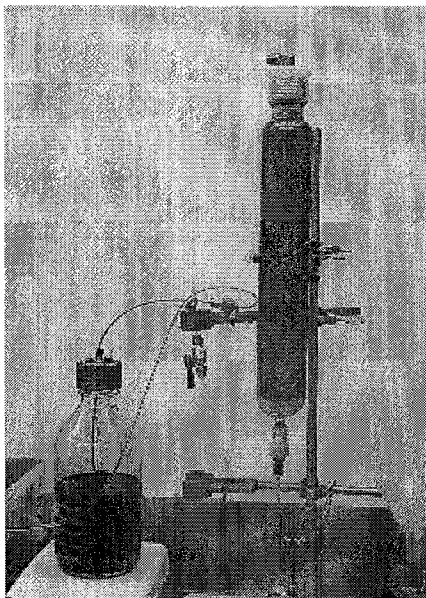


Figure 2. Phase II Test Apparatus before Permanganate Flow

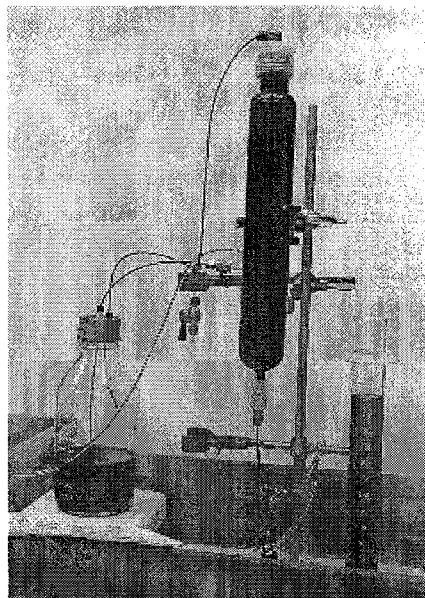


Figure 3. Phase II Test Apparatus after Permanganate Flow

This study demonstrated:

- A significant percentage of the soil PCE was not oxidized (50%) even after the study was allowed to proceed until permanganate consumption ceased and even though PCE was very effectively treated in the water phase
- A significant proportion of the soil TOC was consumed (50%)
- The decrease in aqueous phase PCE concentration even after a brief rebound period was much greater than the soil PCE concentration decrease – suggesting that the technology would be effective in treating groundwater *because it preferentially attacked the portion of the contaminant that was available to the groundwater and thus available to receptors. Stated another way even the partial treatment could meet groundwater remedial objectives in the field application. Those results combined to make it clear that soil organic matter was a significant factor in the behavior and effectiveness of in situ oxidation methods.*
- Acetone and 2-butanone were formed as oxidation byproducts
- Hexavalent chromium was released into the water phase
- Problems with heat release and gas generation that are commonly observed in chemical oxidation processes may be less significant at this site
- Oxidation efficiency at this site will be primarily limited by the thoroughness of contact between the PCE contaminated soil and permanganate that can be achieved both at a macro and micro scale.

Client References

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