State of Rhode Island
Department of Administration
Division of Purchases
One Capitol Hill
Providence, RI 02908

REQUEST FOR PROPOSAL (RFP) – BID# 7585538

INTERLINK SITE REMEDIATION
WARWICK, RI

SUBMISSION DEADLINE: Thursday, February 22, 2018 at 11:30 AM (ET)

PRE-BID CONFERENCE: ☐ **NO**
☒ **YES** **Thursday February 08, 2018 at 10:00 AM**

Mandatory: ☒ **NO**
☐ **YES:** Any vendor who intends to submit a bid proposal in response to this solicitation must have its designated representative attend the mandatory pre-bid conference. The representative must register at the pre-bid conference and disclose the identity of the vendor whom he/she represents. Because attendance at the pre-bid conference is mandatory, a vendor's failure to attend and register at the pre-bid conference shall result in disqualification of the vendor's bid proposal as non-responsive to the solicitation.

Location: **RI DEPARTMENT OF TRANSPORTATION**

RIDOT Transportation Management Center Conference Room , Two Capitol Hill,

PROVIDENCE, RI

Buyer Name: Kathy Missell
Title: **CHIEF BUYER**

QUESTIONS Prospective bidders are hereby notified that all questions pertaining to this contract must be submitted to the Department of Transportation in writing through its website at http://www.dot.ri.gov/contracting/bids by accessing the questions & answers menu located within the 'contracting', then 'bidding opportunities' link. Response to the submitted questions will also be posted under this link as an addendum as appropriate. Phone calls will not be accepted.

SURETY REQUIRED: **YES**

BOND REQUIRED: **YES**

DISK BASED BID: ☒ **NO**
☐ **YES:** See attached Disk Based Bidding Information

NOTE TO VENDORS:
Vendors must register on-line at the Rhode Island Division of Purchases website at www.purchasing.ri.gov. Offers received without the completed three-page Rhode Island Vendor Information Program (RIVIP) Generated Bidder Certification Cover Form attached may result in disqualification.

THIS IS NOT A BIDDER CERTIFICATION FORM

REQUEST FOR PROPOSALS
Rhode Island Department of Transportation
Office of Transit

RFP 7585538
INTERLINK SITE REMEDIATION
WARWICK, RI

DBE GOAL: 10%

A. *INTRODUCTION:*

The Rhode Island Department of Transportation (RIDOT) is moving forward with completing remediation work at the former T.H. Baylis property (BAYLIS), a former chemical distribution facility, located at 61 Glenham Avenue in Warwick, RI. The property is currently owned by RIDOT and leased to the Rhode Island Airport Corporation (RIAC) for the Airport's *Interlink* facility. RIDOT had previously completed a remedial design investigation for the site clean up the property as part of its intermodal train station project. At that time RIDOT submitted and received an approved Remedial Action Work Plan (RAWP) which proposed the excavation of contaminated soil "hot spots" and the *insitu* treatment of groundwater through a network of air sparging interceptor wells which began in 2000 but was discontinued in November 2012. In February 2015, an amendment to the RAWP was prepared for RIDOT by The Louis Berger Group, Inc. which provided the results of pilot testing to clean up the residual contaminated soil and groundwater using a remedial technology of sodium persulfate oxidation of the existing Chlorinated Volatile Organic Compound (CVOC) to fully remediate the project site to the acceptable levels performed under standard RI Department of Environmental Management (RIDEM) guidelines and practices.

Additional site investigation and final design will be necessary to develop baseline levels and determine the limits of in-situ conditions. Post remedial investigation and treatment, furnishing of chemical agents (sodium persulfate) for soil injections, and monitoring will be conducted until acceptable maximum limits of CVOCs have been achieved in accordance to the *RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases* (*SHORT TITLE: Remediation Regulations),* current edition.

Responsibilities and capabilities shall include the following:

- Provide professional hazard safety expertise at environmental contamination site;
- Provide site evaluation and subsequent consultation/decision making;
- Possess knowledge of hazardous material and remediation practices;
- Familiarity with RIDEM Remediation Regulations;
- Capability to meet soil and groundwater goals;
- Responsible for conducting health and safety audits to assure all personnel meet OSHA regulations any suitable necessary;
- Possess knowledge of all current State requirements required for project.

B. *CONTRACT TERM / CONDITIONS:*

RIDOT anticipates the award of ONE (1) contract with a three year term and an option to renew annually for an additional two years.

Respondents are instructed to submit a **TECHNICAL PROPOSAL** response along with a separate **COST PROPOSAL** both described in detail herein.

All pricing submitted will be considered to be ***firm and fixed*** unless otherwise authorized by RIDOT. It is the intention of RIDOT to award based on fees for services outlined on the required **Cost Proposal** format defined herein. RIDOT will not increase the contract or any purchase order (either dollar amount or time) for items not included in the submitted proposal documents. RIDOT reserves the right to purchase part of the proposal or the entire proposal. ***SEE COST PROPOSAL SECTION INSTRUCTION AND FORMAT.***

Proposals received shall be in accordance with guidelines as outlined in this request and the State's General Conditions of Purchase which can be accessed online through the *Rhode Island Vendor Information Program, or "RIVIP"* as it is known, @ **www.purchasing.ri.gov**

This is a Request for Proposals (RFP), not an Invitation for Bid: responses will be evaluated on the basis of the relative merits of the proposal, in addition to price. There will be no public opening and reading of responses received by the Office of Purchases pursuant to this request other than to name those Respondents who have submitted proposals.

The Technical Proposal and the Cost Proposal shall be TWO (2) separate documents submitted in separately sealed envelopes. All Respondents are advised to review all sections of this Request carefully and to follow instructions carefully as failure to make a complete submission as described elsewhere herein may result in rejection of the proposal.

C. *GENERAL INSTRUCTIONS AND NOTIFICATIONS TO RESPONDENTS*

- All Respondents **MUST** register online at the Rhode Island Vendor Information Program (RIVIP) Internet website @ ***http://www.purchasing.ri.gov***

- A fully-completed signed ***RIVIP Bidder Certification Cover Sheet*** – *All THREE pages* **MUST** accompany **EACH** response submitted. Failure to make a complete submission inclusive of this three page document may result in disqualification.

- Should there be a need for assistance in registering and/or downloading any document, call (401) 574-8100 and request the RIVIP HELP DESK technical assistance. Office Hours: 8:30 AM – 4:00 PM.

- The State does not require E-VERIFY compliance in any of its purchasing and/or hiring of services; however, Respondents are hereby advised that in line with the Federal Acquisition Regulations any federal contract based on the services requested may require that the State obtain evidence of E-VERIFY compliance from the successful Respondent.

- The Rhode Island Department of Transportation, in accordance with Title VI of the Civil Rights Act of 1964, 42 U.S.C. §§ 2000d - 2000d-4 and 49 C.F.R. Part 21, Nondiscrimination in Federally-Assisted Programs of the Department of Transportation – Effectuation of Title VI of the Civil Rights Act of

1964, issued pursuant to such Act, hereby notifies all bidders that it will affirmatively insure that in any contract entered into pursuant to this advertisement, Disadvantaged Business Enterprises will be afforded full opportunity to submit bids in response to this invitation and will not be discriminated against on the grounds of race, color, sex, national origin, age, or disability in consideration for an award.

- Services provided by the successful Respondent - and if applicable any sub-contracts generated through this Contract - shall not discriminate on the basis of race, color, national origin, or sex in the performance of this Contract. The successful Respondent shall carry out applicable requirements of 49 C.F.R., Part 26, Participation of Disadvantaged Business Enterprises in Department of Transportation Financial Assistance Programs, in the award and administration of DOT-assisted contracts. Failure by the successful Respondent to carry out these requirements is a material breach of this Contract, which may result in the termination of this Contract or such other remedy as the recipient deems appropriate.

- All costs associated with developing and submitting a proposal in response to this RFP, and to provide oral or written clarification of its content shall be borne by the CONSULTANT. The State assumes no responsibility for these costs.

- It is intended that an award pursuant to this RFP will be made to a prime CONSULTANT, who will assume responsibility for all aspects of the work. Joint venture(s) will not be considered, but sub-contract(s) are permitted provided the sub-contractor(s) proposed are clearly identified with the type of work to be performed in response to this RFP.

- All pricing submitted will be considered to be *firm* and *fixed* unless otherwise indicated herein.

- Submissions in response to this solicitation are considered to be irrevocable for a period of not less than one hundred twenty (120) days following the established due date and may not be withdrawn without the express written permission of the State Purchasing Agent.

- Responses misdirected to other State locations or which otherwise are not received by the State Division of Purchases by the established due date for any cause will be determined to be late and will not be considered. The office clock, for the purpose of registering the arrival of a document, is in the reception area of the Department of Administration (DOA), Division of Purchases, One Capitol Hill, Providence, Rhode Island.

- Respondents must possess a working familiarity with the guidelines outlined in the current ***RIDEM Remediation Regulations*** available on line @ www.dem.ri.gov, and as applicable, the ***Rhode Island Standard Specifications for Road and Bridge Construction***, *2004 Edition,* and subsequent revisions, which is currently available on-line @ www.dot.ri.gov., as well as all applicable RIDOT Department Policy Memos (DPMS) and RIDOT Memorandums to All Consultants (TACS).

- Respondents are advised that all materials submitted to the State for consideration will be considered to be public records as defined in RI Gen Laws 38-2, unless cited as confidential or proprietary in nature, and will be released for inspection immediately upon request once an award is made.

- This project is funded by the Federal Transit Administration. FTA's Master Agreement with RIDOT stipulates that applicable Federal Contract Provisions (attached) will apply to project participants to the lowest tier necessary to ensure compliance with said provisions. The Contractor is required to adhere to the FTA Federal Contract Provisions and to include applicable Federal Contract Provisions in each sub-agreement, sub-contract, third party contract or other document as necessary.

- In accordance with RI Gen. Laws 7-1.1-1401, no **foreign corporation** (a corporation established other than in Rhode Island) has the right to transact business in this State until it has procured a Certificate of Authority to do so from the Office of the Secretary of State (401) 222-2357.

- This Project has been assigned a 10% Disadvantaged Business Enterprise (DBE) Goal. In order to comply with this requirement, a detailed disclosure of RI certified DBE firm(s) and proposed task assignment(s) to be performed must be included along with a copy of current state certification letter(s). DBE certifications must be approved at the time of proposal submission to ensure DBE compliance and availability. Be advised that this requirement will apply for the lifetime of each Contract. The selected PRIME Consultant will be responsible to submit a Monthly DBE Utilization Report documenting aggregated TOTAL contract costs and TOTAL DBE participation to date. TWO (2) copies of the DBE Reporting documentation will be forwarded directly to the RIDOT/Office of Business and Community Resources as well as a copy included with pertinent monthly progress report/ invoice package.

  A list of current Rhode Island State certified DBE firms may be obtained through the State's Office of Diversity, Equity & Opportunity website @ www.odeo.ri.gov. Questions may be directed to:

RIDOT Office of Business and Community Resources
Room 110, Two Capitol Hill
Providence, RI 02903
(401) 222-3260

D. ***REQUIRED FORMS***

In addition to the *RIVIP Bidder Certification Cover* Sheet -as required at the State level and obtained through the RIVIP website, RIDOT also requires that the following **SIX (6) FORMS** be completed and included in your submission package in compliance with federal regulations and departmental policy. These FORMS will be reviewed for completeness and at the point of award will be made part of contract document. All FORMS –except for **W-9- must be completed and copies submitted along with each proposal submission. ("Original" & Copies).

To be completed by PRIME and Sub-Consultant(s):	
DEBARMENT FORM: (ATTACHED)	Must be completed and signed by an authorized agent of your Firm
LOBBYING FORM: (ATTACHED)	Enter known project information on PAGE 1 (DESCRIPTION etc.); Firm must complete FORM and submit signed by an authorized agent of your Firm.
CONFLICTS DISCLOSURE STATEMENT: (ATTACHED)	In line with directions stated, completed FORM(s) must be signed and submitted accordingly. At a minimum, FORM shall be

	completed by Board of Directors and key personnel to be assigned to Project.
To be completed by <u>PRIME only</u>:	
<u>W-9 FORM</u>: **	Must be completed and signed by authorized agent of your Firm. Form may be downloaded **@ <u>www.purchasing.ri.gov</u>.**
<u>CERTIFICATION FOR TITLE VI ASSURANCE</u>: (ATTACHED)	Shall be fully-completed and submitted accordingly
<u>DBE SPECIAL PROVISION</u> (ATTACHED)	Shall be fully-completed and submitted accordingly

***** All FORMS (except W-9) are attached to solicitation and shall be completed and copies submitted along with <u>each</u> TECHNICAL PROPOSAL submission. ("ORIGINAL" & COPIES). Please note, <u>for W-9 form only</u>, one (1) unbound "Original" copy is required at time of submission. Copies of W-9 need <u>not</u> be included in individual proposal submissions.***

E. *<u>INSTRUCTIONS FOR RFP SUBMISSION CONTENT AND FORMAT</u>*

Upon review of the Scope of Work (SOW), TECHNICAL submissions must include, at a minimum, the following information for RIDOT review and evaluation:

<u>PLEASE LIMIT THE SIZE AND VOLUME</u> ***of the TECHNICAL PROPOSAL. The evaluation will focus on the content of the 25 PAGE technical narrative so firms are encouraged to focus on this entry in preparing their submission. RIDOT requests*** *<u>SPIRAL or GBC bound Proposals.</u>*

Do not submit 3-RING binders due to the limited storage capacity both at RIDOT and RIDOA.

TECHNICAL PROPOSAL shall contain a *Table of Contents* ***that cross-references each RFP requirement with specific page cited.***

- **<u>Letter of Transmittal</u>***:* A Letter of Transmittal shall accompany each response signed by an owner, officer, or other authorized agent of the firm.

- **<u>RIVIP Bidder Certification Form</u>:** ALL THREE (3) Pages shall accompany each response submitted. Failure to make a complete submission of this document will result in disqualification. ***(SEE GENERAL NOTIFICATIONS).***

- **<u>Proposal Format</u>**: **TECHNICAL PROPOSAL (" Original" plus FIVE (5) COPIES)** and a *<u>separately sealed</u>* **COST PROPOSAL (3 HARD COPIES)** are to be submitted *<u>simultaneously</u>*. ***Technical Proposal*** shall be bound or contained in a single volume. All documentation submitted with the proposal shall be contained in that single volume. Technical Proposal shall be prepared on **8 ½" x 11"** letter sized white paper sequentially numbered and limited in length to a total of **25 PAGES** – exclusive of exhibits, which shall be tabbed and included in the bound submission. Font size shall be a minimum of **12 POINTS** for all submittals. ALL documentation in excess of 25 PAGE MAXIMUM will be removed and discarded.

RIDOT requires that the **TECHNICAL PROPOSAL** submission be submitted not only in hard copy form but also on CD in pdf format. Attached a clearly labeled CD to the inside cover of each TECHNICAL Proposal.

- **RIDOT Scope of Work and Addenda**: Respondents shall include as part of Technical Proposal submission a copy of RIDOT'S original Scope of Work and any supplemental Addenda, as applicable**.**

The technical narrative should be submitted in the exact order in which the following RFP requirements are presented and limited to 25 PAGES in length. This information is specific to the technical selection criteria to be evaluated and scored. The TECHNICAL PROPOSAL submission shall NOT contain any references to PROJECT COST. Inclusion of cost information within the Technical Proposal submission may result in disqualification.

BACKGROUND AND PREVIOUS EXPERIENCE:

- ***Point of Contact*****:** Respondents must provide the NAME, TITLE, OFFICE LOCATION and CONTACT INFORMATION (E-Mail and Phone Number) of the primary Point of Contact to whom clarification questions can be forwarded.

- ***Company Introduction:*** Respondents are to include a complete description of their organizational structure and other relevant information documenting the firm's professional practice and areas of specialization.

- Firms must demonstrate a minimum of **FIVE (5) YEARS** related environmental context-specific experience and a working knowledge of all State transportation and environmental laws as well as RIDOT'S design and construction policies, procedures and standard specifications.

- ***Similar Project Experience:*** Respondents are to include a comprehensive listing of similar projects and/or clients served similar in concept to the project being proposed.

- ***Client References***: Names, addresses, and telephone numbers of at least **THREE (3)** previous clients who are familiar with the services provided by your firm shall be included. By so listing, specific permission is granted to RIDOT to contact said individuals to verify the satisfactory performances of the services provided Respondent acknowledges that RIDOT is granted specific permission to discuss past performance of Respondent and any of its proposed team members on any projects.

ORGANIZATION AND STAFFING:

- ***Staff Qualifications*****:** Respondents are to include an overview of experienced KEY PERSONNEL including resumes; staff assignments and concentration of effort for each staff member identified are to be addressed. Respondents must demonstrate adequately trained staff necessary to complete each of the specified project tasks in a timely manner.

- The selected FIRM must have a Hygienist on staff with a Safety and Operations Certification. The Safety and Operations certification in the State of Rhode Island shall be maintained for the defined contract term. This requirement shall apply to both Prime and applicable Sub-consultant(s) providing professional services under this contract.
- Project Management for these services will be managed by RIDOT'S Office of Transit. The PM will be responsible for approval of all staff assigned to the project. RIDOT must be informed of any changes

in personnel at any time during the contract term. RIDOT reserves the right to reject personnel and/or if in the event key personnel are no longer available, RIDOT reserves the right to terminate the contract.

- ***Sub-Respondent(s)*****:** As applicable, disclosure of sub-respondent firm(s) as well as the type of work they will perform **must** be documented in response to this Request. Full disclosure of the proposed team to be assigned this project is required in the **Technical Proposal**. If applicable, please include Cover Letter from SUB to PRIME prefacing each sub-consultant proposal provided.

- ***Organizational Chart*** of the proposed project team must be included. The Respondent shall describe how the proposed organizational structure addresses the full scope of this project. Project Management and assigned services shall be documented on chart provided. Additionally, please include name of Project Manager assigned each organization, if applicable, cited on chart.

PROJECT WORK PLAN/ SCHEDULE:

- ***Project Approach:*** Respondents shall provide a detailed technical synopsis of their proposed services based on the SOW requested including any technical issues that will or may be confronted at each stage of the project. Proposed approach will be assessed for its feasibility, responsiveness to the SOW, effectiveness and thoroughness.

- ***Work Plan:*** Proposal must describe in detail the methodology proposed to accomplish the required work. This should include: task identification, activity milestones, and description of delivered work products.

- ***QA/QC Procedures***: Respondents must provide documentation of Quality Assurance & Quality Control (QA/QC) procedures defined as a company policy or excerpt from a company's standard operations manual and all pertinent products which requires that a QA/QC program is in place.

- ***Project Schedule:*** Respondent shall provide a project schedule for delivery of anticipated tasks and proposed deliverables.

- ***Supplemental Information*****:** Respondents are encouraged to submit any other information deemed useful to provide RIDOT with sufficient relevant information to evaluate the firm’s qualifications and technical approach to the project.

COST PROPOSAL: (THREE (3) “HARD” COPIES ONLY)

- Respondent is to submit, separate from Technical Proposal, **THREE (3) COPIES** of a completed *signed and sealed* **COST PROPOSAL** using the required format attached.

- **COST PROPOSAL** shall reflect a lump sum fixed fee price and shall be inclusive of all services/deliverables as defined in the project SCOPE OF WORK. Pricing for subconsultant services and reimbursable expenses shall also be defined along with supporting documentation for said services and fees proposed.

- **COST PROPOSAL** prices submitted will be considered ***firm and fixed***. RIDOT will not increase the contract or any purchase order (either dollar amount or time) for items not included in the submitted proposal documents. The RIDOT reserves the right to purchase part of the proposal or the entire proposal.

- **COST PROPOSAL** shall include a **payment schedule** applicable to the Respondent's offer.

- Describe, in detailed narrative, all aspects of your pricing policy.

Failure to fully disclose formatted total contract cost and pricing policy as cited may result in disqualification.

F. *PRE-PROPOSAL MEETING*:

Interested parties are encouraged to attend a Pre-Proposal Meeting to be held on February 8, 2018 @ 10:00 A.M. at the RIDOT Transportation Management Center Conference Room , Two Capitol Hill, Providence, RI 02903.

Any questions relative to the SOW as well as any questions regarding RIDOT procedures and proposal format will be addressed at the Pre-Proposal Meeting.

A summary of the Pre-Proposal Meeting will be posted at the State of Rhode Island Department of Administration-Division of Purchases website as an addendum to this solicitation. It is the responsibility of all interested parties to download addenda and include it in the proposal.

Persons requesting the services of an interpreter for the hearing impaired may obtain those services by calling (401) 222-4971 forty-eight (48) hours in advance of the scheduled Meeting.

G. *PROPOSAL QUESTIONS AND SUBMISSION REQUIREMENTS*

Questions regarding this solicitation may be posted at RIDOT'S *"Bidding Opportunities"* web page accessible at: **www.dot.ri.gov.** Follow the link to "Doing Business with Us" and 'View All New Projects Available for Bid." Select the question mark "?" next to the applicable project to submit questions. Responses to questions will also be posted at this site. The Q & A Forum will disable 7 FULL CALENDAR DAYS prior to the due date for this project. Therefore, questions will not be accepted **after NOON on February 14, 2018.** Upon the close of questions, all questions received and responses posted by RIDOT will be subsequently posted as a formal ADDENDUM on the RIVIP Website and therefore incorporated as part of this RFP.

An **"Original" and five (5) Copies** of the Proposal submissions should be sent to the Division of Purchases by the specified deadline to the address listed below. RIDOT requires that the Proposal submission also be submitted not only in hard copy form but also on CD in pdf format. Clearly labeled CD ROM should be attached to the inside cover of each Proposal submission.

Proposals may be mailed, delivered by courier delivery service, or hand delivered in a sealed envelope marked: *"RFP 7585538 INTERLINK SITE REMEDIATION"* on ***February 22, 2018*** **by** **11:30 a.m.** to:

BY COURIER OR MAIL:
RI Department of Administration
Division of Purchases (2nd fl)
One Capitol Hill
Providence, RI 02908-5855

NOTE: ***Proposals received after the above referenced due date and time will not be considered. (SEE GENERAL NOTIFICATIONS)***

H. *EVALUATION AND SELECTION*

A Technical Evaluation Committee (TEC) comprised of RIDOT technical personnel responsible for the project under consideration will evaluate the Proposals. While cost is one basic determinant for award, it is neither the sole consideration nor necessarily the principle consideration. Technical criteria will also be considered specific to the CONSULTANT'S understanding of the RIDOT requirements as specified in this RFP as well as the qualifications, experience, and organization of the firm and its personnel. The TEC'S composite scores for all steps of the evaluation process will comprise the official record for the proposal evaluation process. Individual evaluation records will not be available for public inspection at any point during or after the evaluation process.

SELECTION CRITERIA:

1.	**FIRM'S CAPABILITY, CAPACITY, AND STAFF QUALIFICATIONS**	**0-30 POINTS**	**Technical Criteria**
2.	**QUALITY OF THE PROJECT APPROACH / *Inclusive of Proposed Deliverables and Activity Milestones***	**0-30 POINTS**	
3.	**PROJECT SCHEDULE**	**0-10 POINTS**	
4.	**COST PROPOSAL (Evaluated separately)**	**0-30 POINTS**	
	MAXIMUM SCORE	**100 POINTS**	

Technical and **Cost Proposals** will be evaluated separately. **COST Proposals** will remain sealed at RIDOA-Division of Purchases until such time as technical scoring has been completed.

Technical Proposals receiving scores of less than 50 POINTS out of the 70 eligible POINTS will NOT be scored for cost and will be disqualified.

The Technical Evaluation Committee will then evaluate the qualifying **Cost Proposals** and the results will be integrated with the Technical review. This will result in a final ranking and Final Selection Recommendation.

Notwithstanding the above, the State reserves the right to accept or reject any or all options, bids, proposals, to award on the basis of cost alone, and to act in its best interest.

At any point during the review process, any proposal found to be substantially non-responsive will be dropped from further consideration.

Evaluation will also consider commitment to Affirmative Action and DBE Participation. The State may, at its sole option, elect to require presentation(s) by Respondents clearly in consideration for award. Other submissions, certifications, or affirmations may be required, as appropriate.

The State reserves the right to solicit separately for selected initiatives within this Scope of Work.

The State reserves the right to make an award or multiple awards or to reject any or all proposals based on what it considers to be in its best interest.

SCOPE OF WORK
FOR
INTERLINK SITE REMEDIATION

1.0 INTRODUCTION

The Rhode Island Department of Transportation (RIDOT) is moving forward with completing remediation work for a site located in Warwick, Rhode Island. The former T.H. Baylis property, a former chemical distribution facility that is currently owned by RIDOT and leased to the Rhode Island Airport Corporation (RIAC) for the *Interlink* facility, requires additional work to complete full remediation of remaining contaminants within the soil and groundwater. The property site, which is located to the east of the Amtrak mainline along Jefferson Boulevard, west of Glenham Avenue, and north of land owned by D'Ambra Construction, has an existing soil Remedial Work Action Plan (RAWP) amendment to clean up the soil and groundwater with RIDEM-approved chemical solution. The original RAWP had proposed an inter-well and soil ventilation system to treat the contaminated soil and groundwater. However, this system was discontinued in November 2012.

The scope of work involves implementing the remedies listed in the RAWP, which is further described under the results of a Pilot Test that was conducted on February of 2015. The intent of this project is to fully remediate contaminated groundwater and soil (CVOC) to the acceptable levels, performed under standard RIDEM guidelines and practices. Additional site investigation and final design will be necessary to develop a baseline level and determine the limits of in-situ conditions. Afterwards, furnishing of chemical agents (sodium persulfate) for soil injections, and monitoring will be conducted until acceptable maximum limits of CVOCs has been achieved in accordance to the RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Remediation Regulations), current edition.

2.0 OBJECTIVE

RIDOT is seeking to acquire a qualified consultant firm (Consultant) to provide professional services for the site remediation of contaminated soil and groundwater. The firm shall be able to: A) provide professional hazard safety expertise in environmental contamination site; B) provide site evaluation and subsequent consultation/decision making; C) have knowledge of hazardous material and remediation practices; D) have knowledge of Rhode Island Department of Environmental Management (RIDEM) Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases procurement practices; E) Be able to meet soil and groundwater goals; F) be responsible for conducting health and safety audits to assure all personnel meet OSHA regulations any suitable necessary; G) provide knowledge of all current State requirements involved for the project.

3.0 DESCRIPTION OF WORK

The work under this RIDOT project is regulated under Environmental Protection Agency (EPA) and the RIDEM. RIDOT is tasked with developing a Remedial Action Work Plan and managing the operations to achieve compliance with such work plan. RIDOT will require the selected CONSULTANT to provide support in the categories of project management, coordination, developing and implementing a work schedule, reporting. The selected Consultant will be required to perform the following work:

- ***Remedial Action Work Plan (RAWP)*** –
    - Provide groundwater remedy methodologies to comply with RAWP Amendment and complete the list of items listed on this plan (RAWP Amendment is provided as an exhibit);
    - Verify the adequacy of the February 2015 Pilot Test and establish in-situ baseline levels;
    - Have the ability to continue implementation of previously approved method;
- ***Field Investigation*** –
    - Verification of in-situ soil and groundwater conditions;
    - Investigation of conditions of wells installed in field;
    - Review the limits of contaminated groundwater plumes to determine if access is obstructed;
    - Determine the soil condition for comparison to the Remediation Regulations Method 1 Soil Leachability Goal (Referenced in Section 4.0 below)
- ***Field Work/Processes*** –
    - Have the ability and expertise to perform chemical solution injection;
    - Report the conditions of the site area for remediation;
    - Data collection;
    - Mapping of field work and limits of in-situ remediation;
    - Perform groundwater and soil sampling;
    - Inspection and Monitoring;
- ***Project Coordination*** –
    - Project coordination with RIDOT and consultant;
    - Monthly progress reports;
- ***Others*** –
    - Provide additional work related to original intent of project;
    - Waste Management: Some soil cutting and drilling fluids may be necessary to install additional monitoring wells.

- Clean up work area, where necessary, to perform above described work.

4.0 GROUNDWATER AND SOIL GOALS

A. GROUNDWATER GOALS: The goal of the remedies described in the RAWP Amendment is to reduce the concentrations of all Chlorinated Volatile Organic Compounds (CVOC) dissolved in groundwater to meet RIDEM's objective for Class GB soil. There is limited access to the locations of the two (2) plumes of groundwater contamination (as shown in RAWP Amendment drawings).

B. SOIL GOALS: It is expected that the concentrations of CVOCs in soil either already meet or will meet the Method 1 Direct Exposure Criteria (RIDEM Remediation Regulations) after in-situ oxidation. Determine if Method 1 Leachability Criteria is met. If not, perform Method 2 Soil Objectives (Rule 8.02(c)) (as referenced in RAWP Amendment).

5.0 GENERAL REQUIREMENTS

- The selected CONSULTANT shall be aware that the property is owned by the RIDOT, however, this property is leased by the Rhode Island Airport Corporation (RIAC) and is actively used as property for the use of the T.F. Green Airport Train Station and operations relating to T.F. Green Airport. The Selected CONSULTANT shall be required to coordinate their field work in accordance to all RIAC policies governing this establishment, rules and regulations, schedules and processes and abide with existing facility operations and conditions.
- Coordination with RIAC is required for all work the subject property. Registration and all request for information shall be provided to RIAC. The RIAC shall have exclusive legal authority of all work to be performed in and immediately adjacent to the subject property.
- The selected CONSULTANT shall become aware of the existing monitoring wells and establish the necessary project limits for this particular site, and can make recommendations for either extending a section of the project limits or relocating some existing facilities.
- The selected CONSULTANT shall acknowledge all area that have been marked or signed as prohibited areas. If any of the Selected CONSULTANT's work or operation requires access to these prohibited area, a request shall be made with the RIDOT and RIAC in advance to such work to request access to such an area.

6.0 CONSULTANT RESPONSIBILITIES

The selected CONSULTANT shall act responsibly and perform their duties as follows:

- The selected CONSULTANT shall permit RIDOT to review, at any time, all work performed under the terms of this Contract at any stage of the work, and to conform to all instructions and directives that may be issued by RIDOT and included in the RAWP.
- The selected CONSULTANT shall be responsible for the proper performance of the functions, duties, and services under this Contract, to furnish in such numbers at such time, and in such manner as RIDOT shall require, the services of personnel experienced in the pertinent technical fields described in the Scope together with administrative and clerical personnel. Any person who, in RIDOT's opinion, is considered to be inexperienced, uncooperative, or whose services

are not needed, or whose separation from the work would be in RIDOT's best interest, shall be removed from the project payroll immediately upon RIDOT request.

- The selected CONSULTANT, upon request by RIDOT, shall furnish statements as to the experience record of any person employed under this Contract and the anticipated or actual duties to be performed by that person.
- All field notes, records, computations, work sheets, drawings, correspondence, and all other property resulting from the selected CONSULTANT's services under this Contract will be the permanent property of RIDOT. RIDOT reserves the right to withhold the final payment to the Selected CONSULTANT until all property is transferred to RIDOT.
- The selected CONSULTANT and their Sub-Consultant(s), if applicable, shall maintain the required safety certification in the State of Rhode Island for the lifetime of the Contract.
- When an individual project is removed from the work under this Contract, the Selected CONSULTANT shall turn over to RIDOT all materials and records incidental thereto and will receive no further compensation for that project.
- Monthly progress reports must accompany monthly invoicing in accordance with RIDOT Policy. Progress reports must briefly outline work accomplished; hours and costs expended; and outstanding issues which require resolution. Requisitions will be processed only if the required progress reports are current.

7.0 POINT OF CONTACT AND REPORTING DELIVERABLES

The designated point of contact (POC) for the project will be the assigned Office of Transit Project Manager. All deliverables shall be submitted to his/her attention by the scheduled due dates. The CONSULTANT should not consider this a staff resource. It is the CONSULTANT'S responsibility to obtain all necessary information, to complete all tasks and prepare and submit the required deliverables to the POC. Reports will be disseminated by the POC for formal review and acceptance by RIDOT. Any comments will be forwarded in writing to the CONSULTANT for further revision until formally accepted. All reporting shall be submitted to the POC in both electronic and hard copy for review and comment.

-END -

RFP #7585538 / INTERLINK SITE REMEDIATION
COST PROPOSAL (ITEMIZE PER TASK)

Respondents must indicate in the space provided their firm fixed price for each of the services and deliverables proposed below. These services and deliverables are the only charges that will be eligible to be paid to the CONSULTANT and shall include all associated costs of delivering services covered by this Request

Firm Name				
Address				
City/State/Zip				
Phone				
e-mail				
TASK CATEGORY	**TASK**	**DELIVERABLE**	**DUE DATE**	**COST per TASK**
TASK 1 PREPARATION	1.1 Mobilization			$
	1.2 Field Investigation for Existing Conditions	Report - Existing Conditions	Start no later than 4/30/18	$
	1.3 Sampling (Baseline Determinations)	Report		$
	1.4 Miscellaneous Work (Clearing of debris, installation of additional injection wells)			$
	1.5 Develop Health and Safety Plan	Submit Plan		$
	1.6 Develop Traffic and Pedestrian Controls	Submit Plan		$
TASK 2 INJECTIONS	2.1 Injection Events (per RAWP Amendment)		Start no later than 4/30/18	$
	2.2 Develop Injection Report		Within 30 days of Task 2.1	$
TASK 3 MONITORING	3.1 Monitoring	On-going	One month after injection event for 3 months	$
	3.2 Monthly Monitoring Reports	Report	Monthly	$
TASK 4 CLOSE-OUT	4.1 Removal of Injection Wells (as directed by RIDOT)			$
	4.2 Final Close-out Report			$

FEDERAL CONTRACT PROVISIONS

FTA's Master Agreement contains a current, but not all-inclusive, description of statutory and regulatory requirements that may affect procurement. The Master Agreement states that applicable Federal requirements will apply to project participants to the lowest tier necessary to ensure compliance with those requirements. The recipient will need to include applicable Federal requirements in each sub-agreement, lease, third party contract, or other document as necessary. For specific guidance on cross-cutting requirements administered by other Federal agencies, FTA recommends that the recipient contact those agencies.

The requirements listed herein must be adhered to by any firms selected to perform work required under these agreements.

1. AUDIT AND INSPECTION OF RECORDS

The Contractor agrees to provide the Rhode Island Department of Transportation (Department), the FTA Administrator, the Comptroller General of the United States or any of their authorized representatives' access to any books, documents, papers and records of the Contractor which are directly pertinent to this contract for the purposes of making audits, examinations, excerpts and transcriptions. Contractor also agrees, pursuant to 49 C. F. R. 633.17 to provide the FTA Administrator or his authorized representatives including any PMO Contractor access to Contractor's records and construction sites pertaining to a major capital project, defined at 49 U.S.C. 5302(a)1, which is receiving federal financial assistance through the programs described at 49 U.S.C. 5307, 5309 or 5311. By definition, a major capital project excludes contracts of less than the simplified acquisition threshold.

The Contractor agrees to permit any of the foregoing parties to reproduce by any means whatsoever or to copy excerpts and transcriptions as reasonably needed.

2. ACCESS REQUIREMENTS FOR INDIVIDUALS WITH DISABILITIES

The Contractor agrees to comply with all applicable requirements of the Americans with Disabilities Act of 1990 (ADA), 42 U.S.C. Section 12101 et seq. And 49 U.S.C. Section 322; Section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. Section 794; Section 16 of the Federal Transit Act, as amended, 49 U.S.C. App. Section 1612; and implementing regulations, as may be amended

3. CERTIFICATION REGARDING DEBARMENT, SUSPENSION, AND OTHER RESPONSIBILITY MATTERS – Lower Tier Covered Transactions (Third Party Contracts over $100,000)

a) By signing and submitting this bid or proposal, the prospective lower tier participant is providing the signed certification set out below.

b) The certification in this clause is a material representation of fact upon which reliance was placed when this transaction was entered into.

c) If it is later determined that the prospective lower tier participant knowingly rendered an erroneous certification, in addition to other remedies available to the Federal Government, the Department may pursue available remedies, including suspension and/or debarment.

d) The prospective lower tier participant shall provide immediate written notice to the Department if at any time the prospective lower tier participant learns that its certification was erroneous when submitted or has become erroneous by reason of changed circumstances.

e) The terms “covered transaction,” “debarred,” “suspended,” “ineligible,” “lower tier covered transaction,” “participant,” “persons,” “principal,” “proposal,” and “voluntarily excluded,” as used in this clause, have the meanings set out in the Definitions and Coverage sections of rules implementing Executive Order 12549 [49 CFR Part 29]. You may contact the Department for assistance in obtaining a copy of those regulations.

f) The prospective lower tier participant agrees by submitting this proposal that, should the proposed covered transaction be entered into, it shall not knowingly enter into any lower tier covered transaction with a person who is debarred, suspended, declared ineligible, or voluntarily excluded from participation in this covered transaction, unless authorized in writing by the Department.

g) The prospective lower tier participant further agrees by submitting this proposal that it will include the clause “Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transaction”, without modification, in all lower tier covered transactions.

h) A participant in a covered transaction may rely upon a certification of a prospective participant in a lower tier covered transaction that it is not debarred, suspended, ineligible, or voluntarily excluded from the covered transaction, unless it knows that the certification is erroneous. A participant may decide the method and frequency by which it determines the eligibility of its principals. Each participant may, but is not required to, check the No Procurement List issued by the U. S. General Service Administration.

i) Nothing contained in the foregoing shall be construed to require establishment of system of records in order to render in good faith the certification required by this clause. The knowledge and information of a participant is not required to exceed that which is normally possessed by a prudent person in the ordinary course of business dealings.

j) Except for transactions authorized under Paragraph E of these instructions, if a participant in a covered transaction knowingly enters into a lower tier covered transaction with a person who is suspended, debarred, ineligible or voluntarily excluded from participation in this transaction, in addition to all remedies available to the Federal Government, the Department may pursue available remedies including suspension and/or debarment.

k) The prospective lower tier participant certifies, by submission of this bid or proposal, that neither it nor its “principals” [as defined at 49 CFR §29.105(p)] is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.

l) When the prospective lower tier participant is unable to certify to the statements in this certification, such prospective participant shall attach an explanation to this proposal.

4. CLEAN WATER REQUIREMENTS

The Contractor agrees to comply with all applicable standards, orders or regulations issued pursuant to the Federal Water Pollution Control Act, as amended, 33 U.S.C. 1251 et seq. The Contractor agrees to report each violation to the Department and understands and agrees that the Department will, in turn, report each violation as required to assure notification to FTA and the appropriate EPA Regional Office. (2) The Contractor also agrees to include these requirements in each subcontract exceeding $100,000 financed in whole or in part with Federal assistance provided by FTA.

5. FEDERAL CHANGES

Contractor shall at all times comply with all applicable FTA regulations, policies, procedures and directives, including without limitation those listed directly or by reference in the Master Agreement between the Department and FTA, as they may be amended or promulgated from time to time during the term of this contract. Contractor's failure to so comply shall constitute a material breach of this contract.

6. CLEAN AIR

(1) The Contractor agrees to comply with all applicable standards, orders or regulations issued pursuant to the Clean Air Act, as amended, 42 U.S.C. §§ 7401 et seq . The Contractor agrees to report each violation to the Department and understands and agrees that the Department will, in turn, report each violation as required to assure notification to FTA and the appropriate EPA Regional Office. (2) The Contractor also agrees to include these requirements in each subcontract exceeding $100,000 financed in whole or in part with Federal assistance provided by FTA.

7. ENERGY CONSERVATION

The Contractor shall recognize mandatory standards and policies relating to energy efficiency which are contained in the State Energy Conservation Plan issued in compliance with the Energy Policy and Conservation Act (42 US Section 321 et seq.).

8. CONTRACT TERMINATION

a) Termination for Convenience

The Department may terminate this contract, in whole or in part, at any time by written notice to the Contractor. The Contractor shall be paid its costs, including contract close-out costs, and profit on product delivered up to the time of termination. The Contractor shall promptly submit its termination claim for payment. If the Contractor has any property in its possession belonging to the Department, the Contractor will account for the same and dispose of it in the manner the Department directs.

b) Termination for Default

If the Contractor does not deliver supplies in accordance with the contract delivery schedule, or, if the contract is for services, the Contractor fails to perform in the manner called for in the contract, or if the Contractor fails to comply with any other provisions of the contract, the Department may terminate this contract for default. Termination shall be affected by serving a notice of termination on the Contractor setting forth the manner in which the Contractor is in default. The Contractor will only be paid the contract price for supplies delivered and accepted, or services performed in accordance with the manner of performance set forth in the contract.

If it is later determined that the Contractor had an excusable reason for not performing, such as a strike, flood, events which are not the fault of or are beyond the control of the Contractor, the Department, after setting up a new delivery or performance schedule, may allow the Contractor to continue work, or treat the termination as a termination of convenience.

In the event the Department exercises its right of termination for default, and if an amount for liquidated damages is set forth, the Contractor shall be liable to the Department for excess costs and, in addition, for liquidated damages in the amount set forth, as fixed, agreed, and liquidated damages for each calendar day of delay, until such time as the Department may reasonably obtain delivery or performance of similar supplies or services.

If the contract is so terminated, the Contractor shall continue performance and be liable to the Department for such liquidated damages for each calendar day of delay until the supplies are delivered or services performed.

The Contractor shall not be liable for liquidated damages resulting from delays such as acts of God, strikes, fire or flood, and events which are not the fault of, or are beyond the control of the Contractor.

9. CIVIL RIGHTS

(1) Non-discrimination - In accordance with Title VI of the Civil Rights Act, as amended, 42 U.S.C. § 2000d, section 303 of the Age Discrimination Act of 1975, as amended, 42

U.S.C. § 6102, section 202 of the Americans with Disabilities Act of 1990, 42 U.S.C. § 12132, and Federal transit law at 49 U.S.C. § 5332, the Contractor agrees that it will not discriminate against any employee or applicant for employment because of race, color, creed, national origin, sex, age, or disability. In addition, the Contractor agrees to comply with applicable Federal implementing regulations and other implementing requirements FTA may issue.

(2) Equal Employment Opportunity - The following equal employment opportunity requirements apply to the underlying contract:

(a) Race, Color, Creed, National Origin, Sex - In accordance with Title VII of the Civil Rights Act, as amended, 42 U.S.C. § 2000e, and Federal transit laws at 49 U.S.C. § 5332, the Contractor agrees to comply with all applicable equal employment opportunity requirements of U.S. Department of Labor (U.S. DOL) regulations, "Office of Federal Contract Compliance Programs, Equal Employment Opportunity, Department of Labor," 41 C.F.R. Parts 60 et seq ., (which implement Executive Order No. 11246, "Equal Employment Opportunity," as amended by Executive Order No. 11375, "Amending Executive Order 11246 Relating to Equal Employment Opportunity," 42 U.S.C. § 2000e note), and with any applicable Federal statutes, executive orders, regulations, and Federal policies that may in the future affect construction activities undertaken in the course of the Project. The Contractor agrees to take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, creed, national origin, sex, or age. Such action shall include, but not be limited to, the following: employment, upgrading, demotion or transfer, recruitment or recruitment advertising, layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

(b) Age - In accordance with section 4 of the Age Discrimination in Employment Act of 1967, as amended, 29 U.S.C. § 623 and Federal transit law at 49 U.S.C. § 5332, the Contractor agrees to refrain from discrimination against present and prospective employees for reason of age. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

(c) Disabilities - In accordance with section 102 of the Americans with Disabilities Act, as amended, 42 U.S.C. § 12112, the Contractor agrees that it will comply with the requirements of U.S. Equal Employment Opportunity Commission, "Regulations to Implement the Equal Employment Provisions of the Americans with Disabilities Act," 29 C.F.R. Part 1630, pertaining to employment of persons with disabilities. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

(1) The contractor agrees to comply with all applicable requirements of the Americans with Disabilities Act of 1990 (ADA), 42 U.S.C. Section 12101 et seq. And 49 U.S.C. Section 322; Section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C.

Section 794; Section 16 of the Federal Transit Act, as amended, 49 U.S.C. App. Section 1612; and implementing regulations, as may be amended.

(4) The Contractor also agrees to include these requirements in each subcontract financed in whole or in part with Federal assistance provided by FTA, modified only if necessary to identify the affected parties.

10. DISADVANTAGED BUSINESS ENTERPRISES

It is the policy of the Department of Transportation that Disadvantaged Business Enterprises as defined in 49 CFR Part 26 shall have the opportunity to participate in the performance of contracts financed in whole or part with Federal funds under this contract. Consequently, the DBE Requirements of 49 CFR Part 26 apply to this contract. The recipient or its contractor agrees to ensure that Disadvantaged Business Enterprises as defined in 49 CFR Part 26 have the opportunity to participate in the performance of contracts and subcontracts financed in whole or in part with Federal funds provided under this contract. In this regard all recipients or contractors shall take all necessary and reasonable steps in accordance with 49 CFR Part 26 to ensure that Disadvantaged Business Enterprises have the opportunity to compete for and perform contracts. The contractor or subcontractor shall not discriminate on the basis of race, color, national origin, or sex in the performance of this contract. The contractor shall carry out applicable requirements of 49 CFR part 26 in the award and administration of FTA assisted subcontracts. Failure by the contractor to carry out these requirements is a material breach of this contract, which may result in the termination of this contract or such other remedy, as the Department deems appropriate.

The successful bidder agrees to comply with the following clauses:

Prompt Payment: The prime contractor agrees to pay each subcontractor under this prime contract for satisfactory performance of its contract no later than 30 days from the receipt of each payment the prime contractor receives from the Department. This clause applies to both DBE and Non- DBE subcontractors.

Retainage: The prime contractor agrees to return retainage payments to each subcontractor within 30 days after the subcontractor's work is satisfactorily completed. Any delay or postponement of payment from the above referenced time frame may occur only for good cause following written approval of the Department. This clause applies to both DBE and non-DBE subcontractors.

The specific goal for this contract is shown above under Disadvantaged Business Enterprise.

11. ENVIRONMENTAL VIOLATIONS

The Contractor agrees to comply with all applicable standards, orders, or requirements issued under Section 306 of the Clean Air Act (42 USC 1857 (h)), Section 508 of the Clean Water Act (33 USC 1368), Executive Order 11378, and Environmental Protection

Agency regulations: (40 CFR, Part 15) which prohibit the use under nonexempt Federal contracts, grants or loans, of facilities included on the EPA List for Violating Facilities. The Contractor shall report violations to the FTA.

12. EQUAL EMPLOYMENT OPPORTUNITY

In connection with the execution of this contract, the Contractor shall not discriminate against any employee or applicant for employment because of race, creed, religion, color, national origin, age, sex or disability. The Contractor shall take affirmative action to insure that applicants are employed, and that employees are tested during their employment without regard to their race, creed, religion, color, national origin, age, sex or disability. Such actions shall include, but not be limited to the following; employment, upgrading, demotion, or transfer, recruitment or recruitment advertising, layoff or termination; rates of pay, or other forms of compensation. The Contractor further agrees to insert a similar provision in all subcontracts, except subcontracts for standard commercial supplies or raw materials.

13. FTA FUNDING REQUIREMENTS

This project may be financed in part by funds from the Federal Transit Administration. Contractor shall at all times comply with all applicable FTA regulations, policies, procedures and directives, including without limitation those listed directly or by reference in the Master Agreement between the Department and FTA, as they may be amended or promulgated from time to time during the term of this contract. Contractor's failure to so comply shall constitute a material breach of this contract.

14. INCORPORATION OF FEDERAL TRANSIT ADMINISTRATION (FTA) TERMS

The preceding provisions include, in part, certain Standard Terms and Conditions required by DOT, whether or not expressly set forth in the preceding contract provisions. All contractual provisions required by FTA, as set forth in FTA Circular 4220.1F are hereby incorporated by reference. Anything to the contrary herein notwithstanding, all FTA mandated terms shall be deemed to control in the event of a conflict with other provisions contained in this Agreement. The Contractor shall not perform any act, fail to perform any act, or refuse to comply with any Department requests which would cause the Department to be in violation of the FTA terms and conditions.

15. LOBBYING:

The Contractor is required to certify using the Certification of Restrictions on Lobbying Form included that, to the best of his or her knowledge and belief:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation,

renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for making lobbying contacts to an officer or employee of any agency, a

Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form--LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions [as amended by "Government wide Guidance for New Restrictions on Lobbying," 61 Fed. Reg. 1413 (1/19/96). Note: Language in paragraph (2) herein has been modified in accordance with Section 10 of the Lobbying Disclosure Act of 1995 (P.L. 104-65, to be codified at 2 U.S.C. 1601, *et seq* .)]

(3) The undersigned shall require that the language of this certification be included in the award documents for all sub-awards at all tiers (including subcontracts, sub-grants, and contracts under grants, loans, and cooperative agreements) and that all sub-recipients shall certify and disclose accordingly.

The certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of the certification is a prerequisite for making or entering into this transaction imposed by 31, U.S.C. § 1352 (as amended by the Lobbying Disclosure Act of 1995). Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Pursuant to 31 U.S.C. § 1352(c)(1)-(2)(A), any person who makes a prohibited expenditure or fails to file or amend a required certification or disclosure form shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such expenditure or failure.

16. NO GOVERNMENT OBLIGATION TO THIRD PARTIES

(1) The Department and Contractor acknowledge and agree that, notwithstanding any concurrence by the Federal Government in or approval of the solicitation or award of the underlying contract, absent the express written consent by the Federal Government, the Federal Government is not a party to this contract and shall not be subject to any obligations or liabilities to the Department, Contractor, or any other party (whether or not a party to that contract) pertaining to any matter resulting from the underlying contract.

(2) The Contractor agrees to include the above clause in each subcontract financed in whole or in part with Federal assistance provided by FTA. It is further agreed that the clause shall not be modified, except to identify the subcontractor who will be subject to its provisions.

17. PROGRAM FRAUD AND FALSE OR FRAUDULENT STATEMENTS AND RELATED ACTS

(1) The Contractor acknowledges that the provisions of the Program Fraud Civil Remedies Act of 1986, as amended, 31 U.S.C. § 3801 et seq . and U.S. DOT regulations, "Program Fraud Civil Remedies," 49 C.F.R. Part 31, apply to its actions pertaining to this Project. Upon execution of the underlying contract, the Contractor certifies or affirms the truthfulness and accuracy of any statement it has made, it makes, it may make, or causes to be made, pertaining to the underlying contract or the FTA assisted project for which this contract work is being performed. In addition to other penalties that may be applicable, the Contractor further acknowledges that if it makes, or causes to be made, a false, fictitious, or fraudulent claim, statement, submission, or certification, the Federal Government reserves the right to impose the penalties of the Program Fraud Civil Remedies Act of 1986 on the Contractor to the extent the Federal Government deems appropriate.

(2) The Contractor also acknowledges that if it makes, or causes to be made, a false, fictitious, or fraudulent claim, statement, submission, or certification to the Federal Government under a contract connected with a project that is financed in whole or in part with Federal assistance originally awarded by FTA under the authority of 49 U.S.C. § 5307, the Government reserves the right to impose the penalties of 18 U.S.C. § 1001 and 49 U.S.C. § 5307(n)(1) on the Contractor, to the extent the Federal Government deems appropriate.

(3) The Contractor agrees to include the above two clauses in each subcontract financed in whole or in part with Federal assistance provided by FTA. It is further agreed that the clauses shall not be modified, except to identify the subcontractor who will be subject to the provisions.

18. PROTEST PROCEDURES

Protests based upon the award of the contract shall be made according to the State of Rhode Island Procurement Regulations – Section 1.6 Resolution of Protests. Notice of Bid Protest pursuant to RIGL §37.2.52. must be filed with the Chief Purchasing Officer c/o Office of the Director-Dept of Administration, One Capitol Hill Providence, RI 02908 Contract Services Administrator not later than fourteen (14) calendar days before the date set in the solicitation for receipt of bids.

19. RECORD RETENTION

The Contractor agrees to maintain all books, records, accounts and reports required under this contract for a period of not less than three years after the date of termination or expiration of this contract, except in the event of litigation or settlement of claims arising from the performance of this contract, in which case Contractor agrees to maintain same until the Department, the FTA Administrator, the Comptroller General, or any of their duly authorized representatives, have disposed of all such litigation, appeals, claims or exceptions related thereto. Reference 49 CFR 18.39(i)(11).

20. SEISMIC SAFETY

The contractor agrees that any new building or addition to an existing building will be designed and constructed in accordance with the standards for Seismic Safety required in Department of Transportation Seismic Safety Regulations 49 CFR Part 41 and will certify to compliance to the extent required by the regulation. The contractor also agrees to ensure that all work performed under this contract including work performed by a subcontractor is in compliance with the standards required by the Seismic Safety Regulations and the certification of compliance issued on the project.

21. TITLE VI COMPLIANCE

During the performance of any Contract entered into pursuant to these specifications, the Contractor, for itself, its assignees and successor in interest, agrees that it shall comply with Title VI of the Civil Rights Act of 1964 (42 U.S.C. section 2000d) and the Regulations relative to nondiscrimination in federally assisted programs of the Department of Transportation, Title 49, Code of Federal Regulations Part 21, as they may be amended from time to time which are incorporated by reference and made a part of this contract.

22. LABOR

The Contractor agrees to comply with and assures compliance with applicable employee protection requirements for non-construction employees of section 102 of the Contract Work Hours and Safety Standards Act, as amended, 40 U.S.C. §§ 3701 et seq; and implementing USDOL regulations, Labor Standards Provisions Applicable to Contracts Governing Federally Financed and Assisted Construction (also Labor Standards Provisions Applicable to Non-construction Contracts Subject to the Contract Work Hours and Safety Standards Act), 29 C.F.R. Part 5.

23. DAVIS-BACON ACT

During the performance of all construction contracts in excess of $2,000, the Contractor agrees to comply with all applicable provisions of the Davis-Bacon Act (29 C.F.R. Part 5)

CONSULTANTS

CERTIFICATION REGARDING DEBARMENT, SUSPENSION AND OTHER RESPONSIBILITY MATTERS PRIMARY COVERED TRANSACTIONS FOR PRIME CONSULTANTS AND LOWER TIER PARTICIPANTS (SUBCONSULTANTS ETC.)

Appendix B - - certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion – Lower Tier Covered Transactions

INSTRUCTIONS FOR CERTIFICATION:

1. By signing and submitting this proposal, the prospective lower tier participant is providing the certification set out below.

2. The certification in this clause is a material representation of fact upon which reliance was placed when this transaction was entered into. If it is later determined that the prospective lower tier participant knowingly rendered an erroneous certification, in addition to other remedies available to the Federal Government, the department or agency with which this transaction originated may pursue available remedies, including suspension and/or debarment.

3. The prospective lower tier participant shall provide immediate written notice to the person to which this proposal is submitted if at any time the prospective lower tier participant learns that its certification was erroneous when submitted or has become erroneous by reason of changed circumstances.

4. The terms "covered transaction," "debarred," "suspended," "ineligible," "lower tier covered transaction," "participant," "person," "primary covered transaction," "principal," "proposal," and "voluntarily excluded," as used in this clause, have the meanings set out in the Definitions and Coverage sections of rules implementing Executive Order 12549. You may contact the person to which this proposal is submitted for assistance in obtaining a copy of those regulations.

5. The prospective lower tier participant agrees by submitting this proposal that, should the proposed covered transaction be entered into, it shall not knowingly enter into any lower tier covered transaction with a person who is debarred, suspended, declared ineligible, or voluntarily excluded from participation in this covered transaction, unless authorized by the department or agency with which this transaction originated.

6. The prospective lower tier participant further agrees by submitting this proposal that it will include this clause titled "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion--Lower Tier Covered Transaction," without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions.

7. A participant in a covered transaction may rely upon a certification of a prospective participant in a lower tier covered transaction that it is not debarred, suspended, ineligible, or voluntarily excluded from the covered transaction, unless it knows that the certification is erroneous. A participant may decide the method and frequency by which it determines the eligibility of its principals. Each participant may, but is not required to, check the Nonprocurement List.

8. Nothing contained in the foregoing shall be construed to require establishment of a system of records in order to render in good faith the certification required by this clause. The knowledge and information of a participant is not required to exceed that which is normally possessed by a prudent person in the ordinary course of business dealings.

9. Except for transactions authorized under paragraph 5 of these instructions, if a participant in a covered transaction knowingly enters into a lower tier covered transaction with a person who is suspended, debarred, ineligible, or voluntarily excluded from participation in this transaction, in addition to other remedies available to the Federal Government, the department or agency with which this transaction originated may pursue available remedies, including suspension and/or debarment.

Certification Regarding Debarment, Suspension, ineligibility And Voluntary Exclusion - - Lower Tier Covered Participants

1. The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.

2. Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

CERTIFICATION REGARDING DEBARMENT, SUSPENSION AND OTHER RESPONSIBILITY MATTERS
PRIMARY COVERED TRANSACTIONS

In accordance with the code of Federal Regulations, Part 49 CFR Section 29.510, the prospective primary participant ________________________ (name of Authorized Agent), ___________________________ (Title), being duly sworn (or under penalty of perjury under the laws of the United States), certifies to the best of his/her knowledge and belief, that its principals:

a. Are not presently debarred, suspended, proposed for debarment, declared ineligible or voluntarily excluded from covered transactions by any Federal department or agency;

b. Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a pubic (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statues or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

c. Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification;

d. Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.

Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall list exceptions below.

Exceptions will not necessarily result in denial of award, but, will be considered in determining contractor responsibility. For any exception noted, indicate below to whom it applies, the initiating agency, and the dates of the action. Providing false information may result in criminal prosecution or administrative sanctions. If an exception is noted the contractor must contact the Department to discuss the exception prior to award of the contract.

____

____

____

______________________________ ______________________

Signature of Authorized Agent Date

Certification for Federal-Aid Construction/Consultant Contracts

IN ACCORDANCE WITH PUBLIC LAW 101-1210 SECTION 319 (DEPARTMENT OF THE INTERIOR AND RELATED AGENCIES) THE PROSPECTIVE PARTICIPANT CERTIFIES, BY SIGNING AND SUBMITTING THIS BID OR PROPOSAL, TO THE BEST OF HIS/HER KNOWLEDGE AND BELIEF, THAT:

1. No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any Federal agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

2. If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any Federal agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

The prospective participant also agrees by submitting his or her bid or proposal that he or she shall require that the language of this certification be included in all lower tier subcontracts, which exceed $100,000 and that all such subrecipients shall certify and disclose accordingly.

(R.I.D.O.T. APPENDIX C)

INSTRUCTIONS FOR COMPLETION OF SF-LLL, DISCLOSURE OF LOBBYING ACTIVITIES

This disclosure form shall be completed by the reporting entity, whether subawardee or prime Federal recipient, at the initiation or receipt of a covered Federal action, or a material change to a previous filing, pursuant to Title 31, U.S.C. Section 1352. The filing of a form is required for each payment or agreement to make payment to any lobbying entity for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with a covered Federal action. Use the SF-LLL-A Continuation Sheet for additional information if the space on the form is inadequate. Complete all items that apply for both the initial filing and material change report. Refer to the implementing guidance published by the Office of Management and Budget for additional information.

1. Identify the type of covered Federal action for which lobbying activity is and/or has been secured to influence the outcome of a covered Federal action.

2. Identify the status of the covered Federal action.

3. Identify the appropriate classification of this report. If this is a followup report caused by a material change to the information previously reported, enter the year and quarter in which the change occurred. Enter the date of the last previously submitted report by this reporting entity for this covered Federal action.

4. Enter the full name, address, city, state and zip code of the reporting entity. Include Congressional District, if known. Check the appropriate classification of the reporting entity that designates if it is, or expects to be, a prime or subaward recipient. Identify the tier of the subawardee, e.g., the first subawardee of the prime is the 1st tier. Subawards include but are not limited to subcontracts, subgrants and contract awards under grants.

5. If the organization filing the report in item 4 checks "Subawardee," then enter the full name, address, city, state and zip code of the prime Federal recipient. Include Congressional District, if known.

6. Enter the name of the Federal agency making the award or loan commitment. Include at least one organizational level below agency name, if known. For example, Department of Transportation, United States Coast Guard.

7. Enter the Federal program name or description for the covered Federal action (item 1). If known, enter the full Catalog of Federal Domestic Assistance (CFDA) number for grants, cooperative agreements, loans, and loan commitments.

8. Enter the most appropriate Federal identifying number available for the Federal action identified in item 1 (e.g., Request for Proposal (RFP) number, Invitation for Bid (IFB) number, grant announcement number, the contract, grant, or loan award number, the application/proposal control number assigned by the Federal agency). Include prefixes, e.g., "RFP-DE-90-001."

9. For a covered Federal action where there has been an award or loan commitment by the Federal agency, enter the Federal amount of the award/loan commitment for the prime entity identified in item 4 or 5.

10. (a) Enter the full name, address, city, state and zip code of the lobbying entity engaged by the reporting entity identified in item 4 to influence the covered Federal action.
    (b) Enter the full names of the individual(s) performing services, and include full address if different from 10(a). Enter Last Name, First Name, and Middle Initial (MI).

11. Enter the amount of compensation paid or reasonably expected to be paid by the reporting entity (item 4) to the lobbying entity (item 10). Indicate whether the payment has been made (actual) or will be made (planned). Check all boxes that apply. If this is a material change report, enter the cumulative amount of payment made or planned to be made.

12. Check the appropriate box(es). Check all boxes that apply. If payment is made through an in-kind contribution, specify the nature and value of the in-kind payment.

13. Check the appropriate box(es). Check all boxes that apply. If other, specify nature.

14. Provide a specific and detailed description of the services that the lobbyist has performed, or will be expected to perform, and the date(s) of any services rendered. Include all preparatory and related activity,not just time spent in actual contact with Federal officials. Identify the Federal official(s) or employee(s) contacted or the officer(s), employee(s), or Member(s) of Congress that were contacted.

15. Check whether or not a SF-LLL-A Continuation Sheet(s) is attached.

16. The certifying official shall sign and date the form, print his/her name, title, and telephone number.

Public reporting burden for this collection of information is estimated to average 30 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any o her aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (03-48-00-46), Washington, D.C. 20503.

Approved by
03-48-0046

DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C. 1352 - 0348-0046
(see reverse for public burden disclosure)

1. Type of Federal Action:
☐
a. contract
b. grant
c. cooperative agreement
d. loan
e. loan guarantee
f. loan insurance

2. Status of Federal Action:
☐
a. bid/offer/application
b. initial award
c. post-award

3. Report Type:
☐
a. initial filing
b. material change

For Material Change Only:
year ________ quarter ______________
date of last report ________________

4. Name and Address of Report Entity:
☑ Prime ☐ Subawardee
Tier ___, if known:

Congressional District, if known:

5. If Reporting Entity in No. 4 is Subawardee, Enter Name and Address of Prime:

Congressional District, if known:

6. Federal Department Agency:

7. Federal Program Name/Description:

CFDA Number, if applicable: ____________________________

8. Federal Action Number, if known:

9. Award Amount, if known:

$

10. a. Name and Address of Lobbying Entity:

(if individual, last name, first name, mi):

10. b. Individuals Performing Services (including address if different from No. 10a)

(last name, first name, mi):

11. Amount of Payment (check all that apply)

$________________ ☐ actual ☐ planned

13. Type of Payment (check all that apply):
☐ a. retainer
☐ b. one-time fee
☐ c. commission
☐ d. contingent fee
☐ e. deferred
☐ f. other; specify: ____

12. Form of Payment (check all that apply):
☐ a. cash
☐ b. in-kind; specify: nature ____________________
value ____________________

14. Brief Description of Services Performed or to be Performed and Date(s) of Service, including officer(s), employee(s), or Member(s) contracted, for Payment indicated in Item 11 (Attach Continuation Sheet(s) SF-LLL-A, if necessary):

15. Continuation Sheet(s) SF-LLL-A attached: ☐ yes ☑ no

16. Information requested through this form is authorized by title 31 U.S.C. section 1352. this disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when this transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Signature: ______________________________
Print Name: ______________________________
Title: ______________________________
Telephone No: ____________________ Date: ________________

For Federal use Only:

Authorized for Local Reproduction
Standard Form – LLL-A

Approved by
03-48-0046

DISCLOSURE OF LOBBYING ACTIVITIES

CONTINUATION SHEET

Reporting Entity: ______________________ Page ______ of ______

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Standard Form - LLL-A

RIDOT 12/27/07

CONFLICTS DISCLOSURE POLICY

To ensure that the Rhode Island Department of Transportation (RIDOT) maintains the continued confidence and trust of the people of Rhode Island in carrying out its mission, prospective vendors must disclose any family (or other personal) relationships, associations or connections that the vendor, its affiliates, or employees, may currently have with any RIDOT employee. A Conflicts Disclosure Statement shall be submitted to RIDOT from the following:

- Owners;
- Directors;
- Principals;
- Officers, board members, or individuals with corporate authority;
- If the vendor is a partnership, the applicant's partners;
- If the vendor is a limited liability company, its members and managers;
- Employees with decision-making authority, including executive directors, managers or individuals in a similar position with corporate authority; and
- Shareholders with a controlling interest.

RIDOT 12/27/07

CONFLICTS DISCLOSURE STATEMENT

RE: ____
____

I, ____hereby certify as follows:

I am employed as a ____________________ of ______________________________
[TITLE] [COMPANY]
and to the best of my knowledge:

PLEASE CHECK THE APPROPRIATE BOX:

☐ **I have no family or personal relations currently employed either on a full-time or part-time basis at the Rhode Island Department of Transportation.**

☐ **I do have family or personal relations currently employed at the Rhode Island Department of Transportation. Please list their name(s), title(s), and RIDOT Division(s) (if known):**

NAME	TITLE	RIDOT DIVISION

If necessary, please add any additional names as attachments hereto.

FOR ILLUSTRATIVE PURPOSES, FAMILY RELATIONS SHALL INCLUDE, WHETHER BY BLOOD, ADOPTION OR MARRIAGE, ANY OF THE FOLLOWING RELATIONSHIPS:

Father, Mother, Son, Daughter, Brother, Sister, Grandfather, Grandmother, Grandson, Granddaughter, Father-In-Law, Mother-In-Law, Brother-In-Law, Sister-In-Law, Son-In-Law, Daughter-In-Law, Stepfather, Stepmother, Stepson, Stepdaughter, Stepbrother, Stepsister, Half-Brother Or Half-Sister, Niece, Nephew, And Cousin

- *If you are unsure whether a relationship, association, or connection you have may need to be disclosed, please consult with RIDOT's Legal Office at (401) 222-6510.*

____
SIGNATURE DATE

By signing this form you: (1) certify that the information contained in this form is complete and accurate to the best of your knowledge; and (2) acknowledge your continuing obligation to complete and submit a new Disclosure form when there is any change in your family or personal relations during the course of this Contract.

This document is used for internal RIDOT purposes only in order to address and avoid any potential conflicts at the inception of the contract process and to avoid any impropriety or the appearance of impropriety during the contract process. Any disclosures made hereto will not prejudice prospective vendors from selection.

USDOT Standard Title VI/Nondiscrimination Assurances for Contractors
DOT Order 1050.2A

I, _________ ______________________, ___________________________, a duly
authorized representative of ____
do hereby certify that the organization affirmatively agrees to the provisions set forth by *U.S. DOT Order 1050.2A, DOT Standard Title VI Assurances and Non-Discrimination Provisions (April 11, 2013)*

____
Signature

____
Date

APPENDIX A

During the performance of this contract, the contractor, for itself, its assignees, and successors in interest (hereinafter referred to as the "contractor") agrees as follows:

1. **Compliance with Regulations:** The contractor (hereinafter includes consultants) will comply with the Acts and the Regulations relative to Non-discrimination in Federally-assisted programs of the U.S. Department of Transportation, Federal Highway Administration, as they may be amended from time to time, which are herein incorporated by reference and made a part of this contract.

2. **Non-discrimination:** The contractor, with regard to the work performed by it during the contract, will not discriminate on the grounds of race, color, or national origin in the selection and retention of subcontractors, including procurements of materials and leases of equipment. The contractor will not participate directly or indirectly in the discrimination prohibited by the Acts and the Regulations, including employment practices when the contract covers any activity, project, or program set forth in Appendix B of 49 CFR Part 21.

3. **Solicitations for Subcontracts, Including Procurements of Materials and Equipment:** In all solicitations, either by competitive bidding, or negotiation made by the contractor for work to be performed under a subcontract, including procurements of materials, or leases of equipment, each potential subcontractor or supplier will be notified by the contractor of the contractor's obligations under this contract and the Acts and the Regulations relative to Non-discrimination on the grounds of race, color, or national origin.

4. **Information and Reports:** The contractor will provide all information and reports required by the Acts, the Regulations, and directives issued pursuant thereto and will permit access to its books, records, accounts, other sources of information, and its facilities as may be determined by the Recipient or the Federal Highway Administration to be pertinent to ascertain compliance with such Acts, Regulations, and instructions. Where any information required of a contractor is in the exclusive possession of another who fails or refuses to furnish the information, the contractor will so certify to the Recipient or the Federal Highway Administration, as appropriate, and will set forth what efforts it has made to obtain the information.

5. **Sanctions for Noncompliance:** In the event of a contractor's noncompliance with the Non-discrimination provisions of this contract, the Recipient will impose such contract sanctions as it or the Federal Highway Administration may determine to be appropriate, including, but not limited to:

   a. withholding payments to the contractor under the contract until the contractor complies; and/or
   b. cancelling, terminating, or suspending a contract, in whole or in part.

6. **Incorporation of Provisions**: The contractor will include the provisions of paragraphs one through six in every subcontract, including procurements of materials and leases of equipment, unless exempt by the Acts, the Regulations and directives issued pursuant thereto. The contractor will take action with respect to any subcontract or procurement as the Recipient or the Federal Highway Administration may direct as a means of enforcing such provisions including sanctions for noncompliance. Provided, that if the contractor becomes involved in, or is threatened with litigation by a subcontractor, or supplier because of such direction, the contractor may request the Recipient to enter into any litigation to protect the interests of the Recipient. In addition, the contractor may request the United States to enter into the litigation to protect the interests of the United States.

APPENDIX E

During the performance of this contract, the contractor, for itself, its assignees, and successors in interest (hereinafter referred to as the "contractor") agrees to comply with the following non-discrimination statutes and authorities; including but not limited to:

Pertinent Non-Discrimination Authorities:

- Title VI of the Civil Rights Act of 1964 (42 U.S.C. § 2000d *et seq*., 78 stat. 252), (prohibits discrimination on the basis of race, color, national origin); and 49 CFR Part 21;
- The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, (42 U.S.C. § 4601), (prohibits unfair treatment of persons displaced or whose property has been acquired because of Federal or Federal-aid programs and projects);
- Federal-Aid Highway Act of 1973, (23 U.S.C. § 324 *et seq*.), (prohibits discrimination on

the basis of sex);

- Section 504 of the Rehabilitation Act of 1973, (29 U.S.C. § 794 *et seq*.), as amended, (prohibits discrimination on the basis of disability); and 49 CFR Part 27;
- The Age Discrimination Act of 1975, as amended, (42 U.S.C. § 6101 *et seq*.), (prohibits discrimination on the basis of age);
- Airport and Airway Improvement Act of 1982, (49 USC § 471, Section 47123), as amended, (prohibits discrimination based on race, creed, color, national origin, or sex);
- The Civil Rights Restoration Act of 1987, (PL 100-209), (Broadened the scope, coverage and applicability of Title VI of the Civil Rights Act of 1964, The Age Discrimination Act of 1975 and Section 504 of the Rehabilitation Act of 1973, by expanding the definition of the terms “programs or activities” to include all of the programs or activities of the Federal-aid recipients, sub-recipients and contractors, whether such programs or activities are Federally funded or not);
- Titles II and III of the Americans with Disabilities Act, which prohibit discrimination on the basis of disability in the operation of public entities, public and private transportation systems, places of public accommodation, and certain testing entities (42 U.S.C. §§ 12131 -- 12189) as implemented by Department of Transportation regulations at 49 C.F.R. parts 37 and 38;
- The Federal Aviation Administration’s Non-discrimination statute (49 U.S.C. § 47123) (prohibits discrimination on the basis of race, color, national origin, and sex);
- Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, which ensures non-discrimination against minority populations by discouraging programs, policies, and activities with disproportionately high and adverse human health or environmental effects on minority and low-income populations;
- Executive Order 13166, Improving Access to Services for Persons with Limited English Proficiency, and resulting agency guidance, national origin discrimination includes discrimination because of limited English proficiency (LEP). To ensure compliance with Title VI, you must take reasonable steps to ensure that LEP persons have meaningful access to your programs (70 Fed. Reg. at 74087 to 74100);
- Title IX of the Education Amendments of 1972, as amended, which prohibits you from discriminating because of sex in education programs or activities (20 U.S.C. 1681 *et seq*).

Last Update: November 2017

DBE SPECIAL PROVISION

DISADVANTAGED BUSINESS ENTERPRISE AFFIRMATIVE ACTION CERTIFICATION FOR CONTRACTORS AND CONSULTANTS

With respect to the above numbered project, I hereby certify that I am the ______________________
and duly authorized representative of __________________ whose address is ___________________
____.

I do hereby certify that it is the intention of the above organization to affirmatively seek out and consider Disadvantaged Business Enterprises to participate in this contract as contractors, subcontractors and/or suppliers of materials and services. I agree to comply with the requirements of the U.S. Department of Transportation's regulations 49 CFR Part 26.

I understand and agree that any and all contracting in connection with this contract, whether undertaken prior to or subsequently to award of contract, will be in accordance with this provision. I also understand and agree that no contracting will be approved until the State Department of Transportation has reviewed and approved the affirmative actions taken by the above organization.

DEFINITIONS:

A "Broker," for purposes of this provision, is a DBE that has entered into a legally binding relationship to provide goods or services delivered or performed by a third party.

A "DBE Contractor" or "DBE Subcontractor," for purposes of this provision, is a DBE that has entered into a legally binding relationship with an obligation to furnish services, including the materials necessary to complete such services.

"Disadvantaged Business Enterprise" or "DBE," for purposes of this provision, means a for-profit small business concern certified by the Rhode Island Department of Administration, under U.S. Department of Transportation certification guidelines (a) that is at least 51 percent owned by one or more socially and economically disadvantaged individuals or, in the case of any corporation, in which 51 percent of the stock is owned by one or more such individuals; and (b) whose management and daily business operations are controlled by one or more of the socially and economically disadvantaged individuals who own it.

A "Joint Venture," for purposes of this provision, is an association of a DBE firm and one or more other firms to carry out a single, for-profit business enterprise, for which the parties combine their property, capital, efforts, skills and knowledge, and in which the DBE is responsible for a distinct, clearly defined portion of the work of the contract and whose share in the capital contribution, control, management, risks, and profits of the joint venture are commensurate with its ownership interest.

A "Manufacturer," for purposes of this provision, is a DBE that operates or maintains a factory or establishment that produces, on the premises, the materials, supplies, articles or equipment required under the contract and of the general character described by the specifications.

A "Regular Dealer" is a DBE that owns, operates, or maintains a store, warehouse, or other establishment in which the materials, supplies, articles or equipment of the general character described by the specifications and required under the contract are bought, kept in stock, and regularly sold or leased to the public in the usual course of business. In the sale of bulk items, such as cement, asphalt, steel and stone, a DBE firm may be considered a "regular dealer" if it owns and operates the distribution equipment used to deliver its products. Any additional equipment used by a regular dealer shall be through long-term lease agreements rather than on an ad hoc or contract-by-contract basis.

"Race conscious" measures (goals) or programs are those that are focused specifically on assisting DBEs.

"Race neutral" measures (goals) or programs are those that are, or can be, used to assist all small businesses, including DBEs.

"Small Business Concern" means, with respect to firms seeking to participate as DBEs in DOT-assisted contracts, a small business concern as defined pursuant to Section 3 of the Small Business Act and Small Business Administration regulations implementing it (13 CFR part 121), and that does not also exceed the cap on average annual gross receipts specified in 49 CFR 26.65(b).

"Socially and economically disadvantaged individual" means any individual who is a citizen (or lawfully admitted permanent resident) of the United States and who has been subjected to racial or ethnic prejudice or cultural bias within American society because of his or her identity as a member of a group and without regard to his or her individual qualities. The social disadvantage must stem from circumstances beyond the individual's control.

1. Any individual who a recipient finds to be a socially and economically disadvantaged individual on a case-by-case basis.
2. Any individual in the following groups, members of which are rebuttably presumed to be socially and economically disadvantaged:
    a. "Black Americans," which includes persons having origins in any of the Black racial groups of Africa;
    b. "Hispanic Americans," which includes persons of Mexican, Puerto Rican, Cuban, Dominican, Central or South America, or other Spanish or Portuguese culture or origin, regardless of race;
    c. "Native Americans," which includes persons who are enrolled members of a federally or State recognized Indian Tribe[1], Alaska Natives, or Native Hawaiians;
    d. "Asian-Pacific Americans," which includes persons whose origins are from Japan, China, Taiwan, Korea, Burma (Myanmar), Vietnam, Laos, Cambodia (Kampuchea), Thailand, Malaysia, Indonesia, the Philippines, Brunei, Samoa, Guam, the U.S. Trust Territories of the Pacific Islands (Republic of Palau), Republic of Northern Marianas Islands, Macao, Fiji, Tonga, Kirbati, Tuvalu, Nauru, Federated States of Micronesia, or Hong Kong;
    e. "Subcontinent Asian Americans," this includes persons whose origins are from India, Pakistan, Bangladesh, Bhutan, the Maldives Islands, Nepal, or Sri Lanka;
    f. Women; and
    g. Any additional groups whose members are designated as socially and economically disadvantaged by the Small Business Administration (SBA), at such as time as the SBA designation becomes effective.
3. Being born in a particular country does not, standing alone, mean that a person is necessarily a member of one of the groups listed in this definition.

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[1] A "tribally-owned concern" means any concern at least 51 percent (51%) owned by an Indian tribe as defined in 49 CFR 26.5.

I. GENERAL REQUIREMENTS AND SANCTIONS:

A. Failure by the Contractor to demonstrate every good faith effort in fulfilling its DBE commitment during the construction period will result in the reduction in contract payments by the amount determined by multiplying the awarded contract value by the established DBE percentage (listed in Section II. A. below), and subtracting the dollar value of the work actually performed by DBE contractors. This action will not preclude RIDOT from imposing sanctions or other remedies available as specified in paragraphs below.

B. Contractors and subcontractors are advised that failure to carry out the requirements of this provision shall constitute a breach of contract and, after notification by the Department, may result in termination of the agreement or contract by the Department, or such remedy as the Department deems appropriate. Greater detail of the rules and regulations regarding DBE utilization can be found in the Rules and Regulations for RIDOT DBE Program.

C. Brokering of work by DBEs is not allowed and is a contract violation unless DBE is a certified DBE broker. A DBE firm involved in brokering of work may have their certification removed or suspended and shall be subject to the sanctions stated herein. Any firm that engages in willful falsification, distortion or misrepresentation with respect to any facts related to the project shall be subject to sanctions described in paragraph (B) above and referred to the U.S. Department of Transportation's Office of the Inspector General for prosecution under Title 18, USC Section 1001.

D. The Disadvantaged Business Enterprises Directory or other available resources may be obtained at the Rhode Island Department of Transportation Office of Civil Rights (OCR), 2 Capitol Hill, Providence, RI 02903, or at http://odeo.ri.gov/.

E. The utilization of Disadvantaged Business Enterprises is in addition to all other equal opportunity requirements of this contract. The Contractor shall keep such records as are necessary to determine compliance with its Disadvantaged Business Enterprises Utilization obligations. The records kept by the Contractor shall include:

  1. The number of DBE contractors, subcontractors and suppliers; and the type of work, materials or services being performed on or incorporated in this project.
  2. The progress and efforts being made in seeking out DBE contractor organizations and individual DBE contractors for work on this project.
  3. Documentation of all correspondence, contacts, telephone calls, etc. necessary to obtain the services of DBEs on this project.
  4. Copies of canceled checks or other documentation that substantiates payments to DBE firms.
  5. All such records must be maintained for a period of three (3) years following acceptance of final payment and will be available for inspection by RIDOT and the Federal Highway Administration.

F. A contractor for a construction contract will not be eligible for award of contract under this invitation for bids unless such contractor has submitted, at the time of the Bid Opening, this Certification. A Consultant will be required to sign this Certification at the time of the contract execution or the award of contract will be nullified.

II. PRE-AWARD REQUIREMENTS:

A. Prior to contract award and within five (5) days from the opening of bids, the contractor/consultant shall, at a minimum, take the following actions to meet the race-conscious goal established by OCR, hereinafter referred to as the 'contract goal,':

  1. Appoint an EEO Officer to administer the Contractor's DBE obligations.
  2. Submit to the RIDOT Construction Section for approval any subcontractor and/or supplier, and submit executed subcontract agreement(s)/purchase orders, including a detailed description of the

work and price, between the contractor and the qualified DBE to be utilized during the performance of work. In the case of consultant contracts, the consultant shall submit the above DBE obligation as stated in the Scope of Work. This DBE obligation shall be included in the proposal submission to the Design Section, and include the name of the DBE, scope of work, and the actual dollar value.

3. Each construction subcontract submitted shall be accompanied by a completed "DBE Utilization Plan" that specifies the items of work to be performed and the contractor's commitment to complete each subcontract entered into with a DBE pursuant to meeting the contract goal stated herein.
4. Any subcontract for materials or supplies provided by a DBE broker, or for other services not provided directly by a DBE firm, shall be accompanied by the RIDOT Broker Affidavit form.

B. In the event that the cumulative percentages submitted do not equal or exceed the contract goal, RIDOT will conduct a good faith effort (GFE) review to determine the extent of the prime contractor's efforts to seek out DBEs and afford adequate subcontracting opportunities to meet the contract goal. Evidence in support of the prime's actions must be submitted using RIDOT's Good Faith Effort Form (GFEF). This form contains examples of the types of evidence set forth in 49 CFR Part 26, Appendix A. RIDOT will consider this and other relevant evidence in making its GFE determination.

1. Where RIDOT has determined that the prime contractor made every good faith effort to meet the contract goal, the contract shall be awarded.
2. Where RIDOT has determined that the prime contractor failed to make every good faith effort in meeting the contract goal, the contract shall not be awarded, and an opportunity for administrative reconsideration shall be provided.

III. CONSTRUCTION PERIOD REQUIREMENTS:

A. Counting of Participation and Commercially Useful Function (CUF)

The total dollar value of a prime contract awarded to a DBE will be counted toward the DBE requirement. Likewise, all subcontract work performed by a DBE will count toward the DBE requirement.

The allowable value of a subcontract with DBE participation will be treated as the commitment of the prime contractor toward meeting the contract goal. The specific rules for crediting DBE participation toward contract goals are as follows:

1. When a DBE participates in a contract, RIDOT will consider only the value of the work actually performed by the DBE toward DBE goals. RIDOT includes the entire amount of that portion of a construction contract (or other contract not covered by paragraph (3) of this section) that is performed by the DBE's own forces. RIDOT credits the cost of supplies and materials purchased or leased by the DBE subcontractor for the work of the contract. However, supplies and equipment the DBE subcontractor purchases or leases from the prime contractor or its affiliate are not counted toward participation.
2. RIDOT credits the entire amount of fees or commissions charged by a DBE firm for providing a bona fide service, such as professional, technical, consultant, or managerial services, or for providing bonds or insurance specifically required for the performance of a USDOT-assisted contract, toward DBE goals, provided the fee is determined to be reasonable and not excessive as compared with fees customarily allowed for similar services.
3. When a DBE subcontracts part of the work of its contract to another firm, the value of the subcontracted work may be counted toward DBE goals only if the DBE's subcontractor is itself a DBE. Work that a DBE subcontracts to a non-DBE firm does not count toward DBE goals.
4. When a DBE performs as a participant in a *joint venture*, RIDOT will count a portion of the total dollar value of the contract equal to the distinct, clearly defined portion of the work of the contract that the DBE performs with its own forces toward DBE goals.

RIDOT will count expenditures to a DBE contractor toward DBE goals only if the DBE is performing a commercially useful function (CUF) on that contract.

1. A DBE performs a CUF when it is responsible for execution of the work of the contract, and is carrying out its responsibilities by actually performing, managing, and supervising the work involved. To perform a commercially useful function, the DBE must also be responsible, with respect to materials and supplies used on the contract, for negotiating price, determining quality and quantity, ordering the material, and installing (where applicable) and paying for the material itself. To determine whether a DBE is performing a commercially useful function, RIDOT evaluates the amount of work subcontracted, industry practices, whether the amount the firm is to be paid under the contract is commensurate with the work it is actually performing and the DBE credit claimed for its performance of the work, and other relevant factors. Even if a DBE is performing pursuant to normal industry practices, if those practices, in fact, erode the ability of the DBE to control its work and remain independent, the practice may affect how much can be credited toward the DBE goal and may raise questions about the DBE eligibility.
2. Suppliers: A supplier is considered to perform a CUF when it packages, i.e. takes quotes from several manufacturers, and/or sells from its own inventory in order to provide one or more items to a contractor. A supplier may own a franchise and/or may be a factory representative to one or more manufacturers. Consistent with a contractor's probable needs, a supplier, not a contractor, may place orders for production with manufacturers.
3. "Pass through" supply operations occur when the contractor decides what items shall be bought from what sources and/or agrees directly with the manufacturer, or other non-DBE party, to schedule delivery and/or directs adjustments and/or routes payments and purchase orders through the DBE. Pass through operations are not commercially useful functions and will not be counted toward contract goals.
4. Management: The DBE must manage the work that has been contracted to its firm. The DBE owner must supervise daily operations, either personally, or with a full-time, skilled and knowledgeable superintendent employed by and paid wages by the DBE. The superintendent must be present on the job site and under the DBE owner's direct supervision. The DBE owner must make all operational and managerial decisions for the firm. Mere performance of administrative duties is not considered supervision of daily operations.
5. Workforce: In order to be considered an independent business, a DBE must keep a regular workforce. DBEs cannot "share" employees with non-DBE contractors, particularly the prime contractor. The DBE shall perform its work with employees normally employed by and under the DBE's control, see paragraph 9 of this section. The DBE must be responsible for payroll and labor compliance requirements for all employees performing on the contract and is expected to prepare and finance the payrolls. Direct or indirect payments by any other contractor are not allowed.
6. Trucking: RIDOT will consider the following factors in determining whether a DBE trucking company is performing a CUF. The DBE must manage and supervise the entire trucking operation for which it is responsible on a particular contract, and there cannot be a contrived arrangement for the purpose of meeting DBE goals.
    a. The DBE itself must own and operate at least one fully licensed, insured, and operational vehicle being used on the contract.
    b. The DBE must receive compensation for the total value of the services it provides on the contract using vehicles it owns, insures, and which are operated by drivers it employs.
    c. The DBE may lease vehicles from another DBE firm, including an owner-operator who is certified as a DBE. The DBE which leases vehicles from another DBE shall receive credit for the total value of the services the lessee DBE provides on the contract.
    d. The DBE may also lease vehicles from a non-DBE firm, including from an owner-operator. The DBE which leases vehicles from a non-DBE is entitled to credit for the total value of

services provided by non-DBE lessees not to exceed the value of services provided by DBE-owned vehicles on the contract. Additional participation by non-DBE lessees receives credit only for the fee or commission it receives as a result of the lease arrangement.

Example to this subsection (6) (d): DBE firm X uses two of its own trucks on a contract. It leases two trucks from DBE firm Y and six trucks from non-DBE firm Z. DBE credit would be awarded for the total value of transportation services provided by firm X and firm Y, and may also be awarded for the total value of transportation services provided by four of the six trucks provided by firm Z. In all, full credit would be allowed for the participation of eight trucks. With respect to the other two trucks provided by firm Z, DBE credit could be awarded only for the fees or commission pertaining to those trucks firm X receives as a result of the lease with firm Z.

   e. For purposes of this subsection, a lease must indicate that the DBE has exclusive use of and control over vehicles used on the project. This does not preclude vehicles from working for others during the term of the lease with the consent of the DBE, so long as the lease gives the DBE absolute priority for the use of the leased vehicle. Leased vehicles must display the name and identification number of the DBE.

7. All expenditures with manufacturers and suppliers must be properly documented in writing in order to count toward a DBE obligation. RIDOT will count expenditures with DBEs for materials or supplies toward DBE goals as follows:
   a. For a DBE contractor (furnish and install) to receive credit for supplying materials, the DBE must perform the following four functions: (1) negotiate price; (2) determine quality and quantity; (3) order the materials; and (4) pay for the material itself. If the DBE does not perform all of these functions, it has not performed a CUF with respect to obtaining the materials, and the cost of the materials may not be counted toward the DBE goal. Invoices for the material should show the payor as the DBE.
   b. If the materials or supplies are purchased from a DBE manufacturer, RIDOT will count 100 percent of the cost of the materials or supplies.
   c. If the materials or supplies are purchased from a DBE regular dealer, RIDOT will count 60 percent of the cost of the materials or supplies toward DBE goals.
   d. With respect to flaggers, when flaggers are provided, RIDOT will count 60 percent of the labor. When traffic signs are included with flaggers, the work will be counted as 100 percent.
   e. With respect to materials or supplies purchased from a DBE which is neither a manufacturer nor a regular dealer, RIDOT will count the entire amount of fees or commissions charged for assistance in the procurement of the materials and supplies, or fees or transportation charges for the delivery of materials and supplies required on a job site, toward DBE goals, provided RIDOT determines the fees to be reasonable and not excessive as compared with fees customarily allowed for similar services. The fees will be evaluated by RIDOT after receiving the Broker's Affidavit Form from the DBE. RIDOT will not count any portion of the cost of the materials and supplies themselves toward DBE goals.
8. Subcontractor: A subcontractor arrangement exists when a person or firm has a contractual obligation to perform a defined portion of the contract work and the following conditions are present:
   a. Compensation is determined by the amount of work accomplished, rather than being paid on an hourly basis.
   b. The subcontractor exercises control over work methods (except as limited by project specifications), while furnishing and managing its own labor and equipment with only minimal, general supervision being exercised by the prime contractor.

   c. The personnel involved in the DBE subcontractor's portion of the project are both under the subcontractor's direct supervision and identified on its payroll records. When warranted by unique circumstances of a project, a DBE subcontractor may be permitted to employ on a limited basis specialty trades personnel who are not normally employed by the DBE subcontractor.
   d. Second tier DBE subcontracting will be approved only in accordance with normal industry practice and when the type of work differs from work which the DBE usually performs.
9. All factors pertaining to the unique conditions of a project shall be considered in determining whether a DBE subcontractor relationship actually exists on the project. A DBE subcontractor may need to lease/rent equipment, other than over-the-road trucks, and/or augment its workforce with additional skilled personnel in order to perform certain project-related work. The DBE subcontractor is required to arrange for the necessary equipment through rental/leasing agreements, as necessary. (Off-the-road equipment, such as "Euclids," may be rented/leased from the prime contractor even though the CUF guidelines prohibit rental/lease of over-the-road trucks from the prime contractor.) Likewise, in limited instances, the prime contractor may provide some, but not all, personnel to the DBE subcontractor when the following conditions are present:
   a. A DBE must perform or exercise responsibility for at least 30 percent of the total cost of its contract with its own work force.
   b. The DBE must not subcontract a greater portion of the work of a contract than would be expected on the basis of normal industry practice for the type of work involved.
   c. The personnel must have a specialized expertise which has not been mastered by the DBE's own skilled/supervising/managerial personnel.
   d. Such personnel must be placed on the DBE's payroll and come under the direct supervision of the DBE for the performance of the particular subcontract work.
   e. The deployment of such personnel must be accomplished within the framework of a mentor-protégé agreement; or for emergency purposes, by contract change order. All instances of combining personnel must be for developmental purposes in which teaching/demonstration/consulting to the DBE must occur.
   f. Long term, continual (e.g. from one contract to another) or chronic use by a DBE firm, of personnel normally employed by another specific firm, lacking a mentor-protégé agreement which is being carried out in good faith, is not consistent with the CUF guidelines.
   g. To place entire work crews on DBE's payrolls when such personnel are normally employed by another specific firm is not consistent with the CUF guidelines.
   h. A DBE may need to lease/rent equipment, except for over-the-road trucks, in order to be properly equipped to execute the work of a mentor-protégé agreement. In such cases where the DBE has investigated several possible sources of such equipment within a reasonable geographical area to the project, the DBE may find the best offer was made by the prime contractor or another subcontractor on the project. In such cases, the DBE may rent/lease such equipment from the prime or another subcontractor, provided that the use of such equipment is material to demonstrating/teaching objectives set forth in the mentor-protégé agreement. Thus, the DBE's regular employees, not those temporarily furnished by the prime contractor, or another subcontractor, shall operate such equipment for the majority of the time during which the equipment is used in the work of the DBE subcontractor under the mentor-protégé agreement.
   i. A DBE's use of equipment owned by a prime contractor or another subcontractor or without an appropriate mentor/protégé program is inconsistent with the CUF guidelines and will result in noncompliance.
10. If a contractor or subcontractor is not certified as a DBE by the Minority Business Enterprise Compliance Office under the specific NAICS code of line items identified in the contract, at the

time of the execution of the contract or issuance of the purchase order, RIDOT will not count that firm's participation toward any DBE goals, except as provided in 49 CFR 26.87(i).

11. RIDOT will not count toward the contract goal the dollar value of work performed by a contractor or subcontractor after it has ceased to be a certified DBE.
12. RIDOT will not count the participation of a DBE subcontractor toward a contractor's final compliance with its DBE obligations on a contract until all payments being credited have been fully paid to the DBE.

B. DBE Replacement and Termination:

The contractor shall utilize the specific DBEs listed to perform the work and supply the materials for which each is listed unless the contractor obtains RIDOT's written consent as provided in this section; and unless RIDOT's consent is provided under this paragraph, the contractor shall not be entitled to any payment for work or material unless it is performed or supplied by the listed DBE.

1. Good Cause for Replacement or Termination

The prime contractor must provide the Department's OCR with a copy of its "Intent to Substitute /Terminate" notice to the DBE setting forth the reasons for the request. This notice must advise the DBE that it has five (5) days to respond (to prime and State) with objections and why the State should not approve the prime's proposed action.

After adequate notice by the Contractor, if any DBE is unable to perform work committed toward the goal, the DBE shall provide to the OCR a signed statement stating why it is unable to complete the work. The Contractor shall document its efforts to have another DBE perform the item or to have a DBE perform other items to replace the original DBE commitment amounts. In the event the Contractor is not able to find replacement DBE work, the Contractor must provide the OCR with documentation clearly evidencing its good faith efforts. Contractors are prohibited from terminating for convenience any DBE firm used to fulfill a commitment pursuant to meeting the contract goal stated herein.

Prior to substitution or termination of a DBE subcontractor, the contractor shall demonstrate good cause and obtain written approval from the OCR.

In accordance with 49 CFR Part 26.53 good cause includes the following circumstances:

a. The listed DBE subcontractor fails or refuses to execute a written contract;
b. The listed DBE subcontractor fails or refuses to perform the work of its subcontract in a way consistent with normal industry standards. Provided, however, that good cause does not exist if the failure or refusal of the DBE subcontractor to perform its work on the subcontract results from the bad faith or discriminatory action of the prime contractor;
c. The listed DBE subcontractor fails or refuses to meet the prime contractor's reasonable, nondiscriminatory bond requirements;
d. The listed DBE subcontractor becomes bankrupt, insolvent, or exhibits credit unworthiness;
e. The listed DBE subcontractor is ineligible to work on public works projects because of suspension and debarment proceedings pursuant 2 CFR Parts 180, 215 and 1200 or applicable state law;
f. RIDOT determines that the listed DBE subcontractor is not a responsible contractor;
g. The listed DBE subcontractor voluntarily withdraws from the project and provides to RIDOT written notice of its withdrawal;
h. The listed DBE is ineligible to receive DBE credit for the type of work required;

i. A DBE owner dies or becomes disabled with the result that the listed DBE contractor is unable to complete its work on the contract;
j. Other documented good cause that RIDOT determines compels the termination of the DBE subcontractor. Provided, that good cause does not exist if the prime contractor seeks to terminate a DBE it relied upon to obtain the contract so that the prime contractor can self-perform the work for which the DBE contractor was engaged or so that the prime contractor can substitute another DBE or non-DBE contractor after contract award.

In addition to post-award terminations, the provisions of this section apply to pre-award deletions of or substitutions for DBE firms put forward by offerors in negotiated procurements.

Failure by the contractor to carry out the requirements of this part is a material breach of the contract and may result in the termination of the contract or such other remedies that RIDOT deems appropriate.

2. Good Faith Efforts to Replace

When a DBE subcontractor is terminated as provided in paragraph (1) of this section, or fails to complete its work on the contract for any reason, RIDOT requires the prime contractor to make good faith efforts to find another DBE subcontractor to substitute for the original DBE. These good faith efforts shall be directed at finding another DBE to perform at least the same amount of work under the contract as the DBE that was terminated, to the extent needed to meet the contract goal RIDOT established for the procurement. The good faith efforts shall be documented by the contractor. If RIDOT requests documentation under this provision, the contractor shall submit the documentation within 7 days, which may be extended for an additional 7 days if necessary at the request of the contractor, and RIDOT shall provide a written determination to the contractor stating whether or not good faith efforts have been demonstrated. The determination shall be made by the DBELO, under the criteria established below.

If there is a change order to a contract on which there is a DBE contract goal, then that contract goal applies to the change order as well as to the original contract. In the event of significant change orders, good faith efforts are required dependent upon the type of change order; RIDOT determines on a case-by-case basis what constitutes good faith efforts in the context of a particular change order. This could include modifying the contract goal amount applicable to the change order if circumstances warrant. When a change order decreases work, i.e. RIDOT determines specific line items are no longer necessary on a contract or there is a quantity change on an item, no good faith effort must be shown. However, when an increase of work occurs or there is a termination of a DBE, good faith efforts must be shown in accordance with the preceding requirements.

C. Monthly Payment Certifications:

All contractors on RIDOT projects are required to certify their payments to subcontractors by use of RIDOT's contractor compliance software on a minimum of a monthly basis (which, at time of publishing, is Prism). A project may not proceed to finalization without the input of this information. RIDOT's Prompt Payment Clause applies to both DBE and non-DBE subcontracts. The Contractor is responsible for the subcontractors' compliance with the submission of their payment reporting by way of this software.

D. Joint Check Procedure for DBEs:

A prime contractor must receive written approval by the Department's DBELO before using a joint check for materials/supplies called for under a subcontract with a DBE. Joint check requests shall be submitted by the prime contractor to the Department's OCR in writing along with a Joint Check Affidavit and the subcontract agreement. The following are general conditions that must be met regarding joint check use:

1. The use of the joint check shall only be allowed by exception and shall not compromise the independence of the DBE;
2. The second party (typically the prime contractor) acts solely as a guarantor;
3. The DBE must release the check to the supplier;
4. The subcontract agreement must reflect the total contract value, including the cost of materials and installation; actual payments for work performed by the DBE may reflect labor only; and
5. The DBE remains responsible for negotiation of price, determining quality and quantity, ordering materials and installing (where applicable) and paying for the material itself.

IV. FINAL SUBCONTRACTOR PAYMENTS AND RELEASE OF RETAINAGE

Prior to receiving final payment, the Contractor shall provide to the Resident Engineer certification of the dollars paid to each DBE firm using Form "DBE Request for Verification Payment." The certification shall be dated and signed by a responsible officer of the Contractor and by the DBE. Falsification of this certification will result in sanctions listed in Sections I. of this provision.

If this contract contains a DBE goal, the Contract Compliance Officer with the OCR will verify that the Contractor has attained the DBE goal specified on said project or has provided adequate documentation justifying a lesser amount. The final estimate will not be paid to the Contractor until proper certifications have been made.

When a subcontractor's work is satisfactorily complete (i.e., all the tasks called for in the subcontract have been accomplished and documented), and the Department has partially accepted the work and all payments have been certified by the Contractor and subcontractor on the "Certification of Progress Payment" form, the Prime Contractor shall release all retainage held by the Prime Contractor within thirty (30) days of satisfactory completion of the subcontractor's work. The subcontractor shall submit to the Prime Contractor the final executed form within ten (10) days of receipt of payment.

____

Signature of Contractor or Consultant

____

Date

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RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT REMEDIAL ACTION WORK PLAN AMENDMENT

T.F. Green InterLink
Baylis Site Remediation
61 Glenham Avenue
Warwick, Rhode Island
RIDEM THB-DOT SR-35-0109B

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1.0 INTRODUCTION

This revised Remedial Action Work Plan (RAWP) has been prepared to describe an in-situ oxidation and down gradient anaerobic reductive dechlorination remedy for the Former T. H. Baylis Chemical property, shown on Figure 1. In a letter dated October 10, 2012, the Rhode Island Department of Transportation (RIDOT) informed the Rhode Island Department of Environmental Management (RIDEM) that the existing inter-well air sparge and soil ventilation system had reached the end of its useful life. An alternative remedial approach, in-situ oxidation and reductive anaerobic dechlorination, was proposed. In a letter dated November 14, 2012, RIDEM acknowledged that the existing remedial system was at the end of its useful life and concurred with the proposed in-situ chemical oxidation and reductive anaerobic dechlorination remedial approach. A draft RAWP was submitted to RIDEM on April 2, 2014. The results of pilot tests have been evaluated and the RAWP has been modified based on the pilot test results.

The pilot test results were described in the Limited Design Investigation Report (LDI) dated February 25, 2015. To answer questions asked by RIDEM following review of the LDI and to quantify anticipated concentration changes often referred to as "rebound," additional groundwater samples were collected (on July 7, 2015) from the pilot test wells for laboratory analysis more than six months after the pilot test oxidant injections. The results are summarized in the attached response document (Appendix 1) that specifically addresses each of the 12 comments and questions posed by RIDEM. The July 7, 2015, groundwater sample results are also incorporated into Table 1 of this report and the laboratory report is included as Appendix 2.

The results of the south area pilot test using unactivated persulfate were not encouraging and do not support any additional injections of persulfate without activation. As is described in detail in the document in Appendix 1, the results of the north area pilot test which used pH-activated persulfate were more encouraging. There were however, measured increases in PCE concentrations, and to a lesser extent, TCE concentrations. It is our opinion that these concentration increases do not indicate a failure of the in-situ oxidation approach, but rather, they illustrate that there is considerable mass of PCE and TCE adsorbed to soil and trapped in soil pores in the source areas. It is our opinion that in-situ oxidation is the appropriate remedy to reduce CVOC concentrations in the source areas, but we recommend careful periodic evaluation of groundwater data to assess if progress is being made to achieve the site remediation goals and to adjust the remedy if necessary. The same is true of the reductive dechlorination portion of the remedy, whose design is not based on pilot testing. Groundwater chemistry, including changes in dissolved oxygen and changes in CVOC concentrations, should be evaluated periodically and the remedy amended or altered if the results suggest that action is needed to achieve the remediation goals.

2.0 SITE HISTORY

The former T. H. Baylis Co. property and associated down gradient properties (herein referred to as "the Site") are located between Glenham Avenue and Jefferson Boulevard in Warwick, RI (see Figure 1, Site Plan). The area in and around the Site is comprised of mixed industrial, commercial, railroad, and residential properties. Louis Berger and ES&M have not conducted independent research to the site history; we have relied on information previously reported by others.

2.1 Owner and Operations History

Prior to 1946, the former T. H. Baylis Co. property is believed to have been undeveloped. During the 1950's through the 1970's, companies dealing in pressure treated lumber and plastics reportedly occupied the property. Beginning in 1967, Thomas H. Baylis began to acquire some of the lots that comprise the Site. From 1981 to 1988, T. H. Baylis reportedly used the property for chemical distribution and hazardous waste storage. In June 1998 the T. H. Baylis Co. property was purchased by the City of Warwick. The T. F. Green InterLink intermodal facility has been constructed over most of the Site. The InterLink covers most of what will be referred to as the north plume. Most of land over the south plume has not yet been developed.

2.2 Release History

The exact details of the release of chlorinated solvents are unknown. What is known is that there are two plumes of chlorinated volatile organic compounds (CVOCs). The larger plume originates where a number of chemical storage tanks used by T. H. Baylis were once located. The second plume is located further south and originates between Fresno Road and Fullerton Road.

2.3 Oil and/or Hazardous Materials Use and Storage

During the 1980's, the T. H. Baylis Company is believed to have stored and/or handled the following chemicals: trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1,1-trichloroethane (1,1,1-TCA), acetone, methyl ethyl ketone, isopropanol, methanol, methylene chloride, mineral spirits, trichlorotrifluoroethane, toluene, and xylene.

In 1998, RIDEM conducted several site inspections and discovered thirteen above-ground storage tanks (AST's). The contents of the tanks reportedly included hydrochloric acid, acetic acid, sulfuric acid, TCE, PCE, hydrogen peroxide, and other unknown solvents. Four closed underground storage tanks (UST's) were noted in the paved parking area at the southern end of the property. The UST's formerly held diesel fuel, isopropyl alcohol, methanol, and methyl ethyl ketone. Two additional UST's, which were installed at the property on or around 1970, were reportedly closed and removed in 1986.

2.4 Waste Management History

Little is known about the waste disposal practices of T. H. Baylis Company.

2.5 Environmental Permits and Compliance

In January 1981, the T. H. Baylis Co. filed a Notification of Hazardous Waste Activity with the USEPA. During a subsequent RIDEM and USEPA RCRA inspection, violations of hazardous waste rules and regulations were reported, and a Notice of Violation and Order was issued to the company. Throughout the 1980's, additional violations pertaining to the operation of an unpermitted hazardous waste storage facility as well as deficiencies in the storage and labeling of hazardous wastes were reportedly observed.

2.6 Responsible and Potentially Responsible Parties

This work is being completed by RIDOT as Owner of the Site. The work to design and implement this Remedial Action Work Plan is performed under a Master Price Agreement (MPA) 309 contract for Environmental Technical Services provided by The Louis Berger Group, Inc. to RIDOT and includes field monitoring and reporting, as well as field oversight of the work conducted by the remediation contractor.

3.0 REMEDIAL ACTION WORK PLAN

This remedial action work plan provides a detailed description of how RIDOT plans to implement the in-situ oxidation and anaerobic reductive dechlorination remedy.

3.1 Remedial Action Work Plan Submittal and Fee

A copy of this RAWP is being submitted in both hard copy and electronic format to RIDEM for review and approval. This Remedial Action work plan has been prepared in accordance with Rule 9.00.

3.2 Remedial Objectives

After more than ten years of remediation, current conditions at the T. H. Baylis have been evaluated and remediation objectives for the proposed remedial action have been developed based on the following:

- What concentration reductions are required to be protective of human health and the environment given the current and potential future uses of the areas where the releases originated and where the groundwater plume has migrated?

- What concentration reductions are achievable given the restricted access beneath the T. F. Green InterLink which was constructed over the north CVOC source area and most of the groundwater CVOC plume?

The objectives for each media are discussed below.

3.2.1 Groundwater Objectives

A comprehensive set of groundwater samples were collected in November 2014 from 74 site-related wells deemed to be in suitable condition for sample collection. The results of the laboratory analyses were reported in the 2015 LDI and are summarized in Table 1. Figures 2, 3, 4, and 5 are maps showing the areal distribution of CVOCs, 1,1,1-TCA, TCE and PCE, respectively, in groundwater. Figures 4 and 5 include contour lines that indicate where concentrations exceed the GB groundwater objectives for the respective compounds. These figures clearly show the large area where the concentrations of these compounds in groundwater are greater than GB standards. The maps also show that most of the dissolved groundwater plume, and the north source area are located beneath the T. F. Green InterLink and active railroad tracks bi-sect the plume.

The goal of the remedies described in the RAWP is to reduce the concentrations of all CVOCs dissolved in groundwater to meet RIDEM's GB Objectives. However, Louis Berger and ES&M caution all stakeholder that because of low permeability soils and access restrictions posed by the InterLink structure, railroad tracks, and Jefferson Boulevard, it will very likely take a considerably long time to achieve this goal.

3.2.2 Surface Water and Sediment Objectives

Surface water and sediments have not been impacted by the T. H. Baylis site.

3.2.3 Soil Objectives

It is expected that the concentrations of CVOCs in soil either already meet or will meet the Method 1 Direct Exposure Criteria after in-situ oxidation. It is less likely that the Method 1 Leachability Criteria will be met. If soil analytical data indicates that these criteria are not met, Method 2 Soil Objectives will be developed consistent with the approach outlined in Rule 8.02(c).

3.2.4 Air Objectives

The CVOCs detected in soil and groundwater at the T. H. Baylis site should have no impact on ambient air and the proposed remedy will not create emission to ambient air.

3.3 Proposed Remedy

This Remedial Action Work Plan documents a change in the remedy for this site from inter-well air sparging and soil vapor extraction to in-situ chemical oxidation with down gradient anaerobic reductive dechlorination. A Limited Design Investigation (LDI) was performed and the results were used to refine the draft RAWP and to prepare this RAWP.

3.4 Engineering Design

The in-situ oxidation program described in the following subsections is designed to distribute pH activated sodium persulfate in both the north and south source areas. In addition, a plan to inject and monitor EHC, an agent selected to enhance anaerobic reductive dechlorination down gradient of the source areas, is also described.

3.4.1 Maps and Figures

Figures 6 shows the characteristics of the Site including existing and six proposed injection well locations along with anticipated radii of influence. Engineering drawings showing the typical injection well construction and piping and instrumentation and process flow diagrams are presented as Figures 7 and 8.

3.4.2 Conceptual Plan

A total of 42 E-series wells, 18 in the northern plume and 24 in the southern plume, were evaluated for potential repurposing as oxidant injection wells. As described in the LDI, a number of wells have been lost or destroyed and testing shows that some others will not accept injected fluids. However, many wells were deemed suitable for injection use. Similarly, 26 W-series wells located parallel to Jefferson Boulevard were evaluated and many were found to be suitable for injection of the reductive dechlorination agent.

PeroxyChem owns the rights to patents for application of persulfate activated by various agents and marketed under Klozur® Persulfate. Activation of persulfate by elevated pH has been selected for this site because it can be applied safely and residual sodium hydroxide will be neutralized by hydrochloric and sulfuric acid formed by the oxidation reactions. This activation method should return groundwater to normal or near normal pH.

A mobile oxidant injection unit will be brought to the Site. Aqueous oxidant solution will be prepared by dissolving solid sodium persulfate into clean water to form a 23% w/w aqueous solution. Sodium hydroxide solution (25% w/w) will periodically be added to activate the persulfate. When the prescribed amount of oxidant has been injected into the select well, the injection equipment will be rinsed and then disconnected from the well head. The apparatus will then be fitted to the next well. This process will continue until each designated well has received the desired dose of oxidant and activator.

Groundwater monitoring will be conducted after each injection to determine how quickly the oxidant reacts and where additional oxidant is needed to achieve the desired concentration reductions. It is likely that over time, monitoring will indicate that GB standards are met at some wells but not at others. If so, the injection schedule will be adjusted such that oxidant is injected only where it is needed.

EHC, also marketed by PeroxyChem, has been selected to create an environment favorable to in-situ reductive dechlorination. EHC® Liquid ISCR reagent is a concentrated, buffered, microemulsion of a controlled-release, food-grade carbon, nutrients, and iron designed for on-site dilution with cold water. It is a liquid variant of PeroxyChem's EHC® ISCR Reagent and is specially designed for injection via existing wells or hydraulic injection networks for the treatment of a wide range of groundwater contaminants. EHC Liquid is composed primarily of ELS™ Microemulsion, a controlled-release organic carbon substrate and EHC Liquid mix, an organo-ferrous compound (both food-grade). The anaerobic bioremediation processes and abiotic dechlorination reactions promoted by EHC Liquid are effective at remediating chlorinated solvents, energetics, and pesticides/herbicides.

EHC reagents will be injected into the W-series wells to maintain a zone favorable to anaerobic reductive dechlorination. Groundwater monitoring will be conducted to determine when (and if) additional agent will be added to maintain the anaerobic reductive dechlorination zone.

3.4.3 Design and Operating Parameters

ES&M has worked with PeroxyChem's technical support staff to design in-situ oxidation and reductive dechlorination programs. The combination of these technologies will aggressively attack CVOCs in the source area which should reduce the flux of CVOCs migrating south and east. The anaerobic reductive dechlorination zone will promote CVOC concentration reductions down gradient of the source area using an approach that is longer lasting and requires less frequent maintenance.

3.4.3.1 Design Criteria, Assumptions and Calculations

It is not possible to precisely predict the amount of oxidant that will be needed to achieve the remediation goals at the T. H. Baylis site. Environmental data used to support calculations of oxidant demand are highly variable by nature. For example, the residual concentration of CVOCs in soil are not well known or documented, nor is it known if there are pockets of dense non-aqueous phase liquids (DNAPL) in bedrock fractures. This in-situ chemical oxidation program will be conducted in an iterative fashion, whereby injection events are followed by monitoring to assess the performance of the remedy and to plan additional events.

Based only on groundwater concentration data, the theoretical mass of sodium persulfate needed to oxidize the CVOCs dissolved in groundwater in the target treatment area is approximately 2,000 pounds. However, oxidant will be consumed by naturally occurring compounds, and much will undoubtedly be consumed by CVOCs adsorbed to soil or perhaps even by CVOCs present as DNAPL. It is therefore expected that the actual mass of persulfate required to achieve a permanent solution will be significantly greater than 2,000 pounds.

The plan is to add 10,000 pounds of persulfate during the each injection event. Injection events, each involving addition of 10,000 pounds of persulfate, are proposed until the results indicate that the project goals have been or will be achieved. Monitoring will be conducted to track how long the persulfate persists and the changes in pH, ORP and CVOC concentrations that occur after each injection event.

The pilot test results indicated that un-reacted persulfate was present five weeks following injection but had completely reacted after six months. Based on this result, two injection events per year will be completed with the results of the groundwater monitoring program used to plan and refine each successive injection event. For example, changes in dissolved CVOC concentrations will be evaluated and the injection schedule developed to add more oxidant to wells where CVOC concentrations are highest and less where the CVOC concentrations are lower.

The design basis for the reductive dechlorination program was described in the LDI and a copy of the supporting design calculations are in Appendix 4 of this report. Injections of EHC will be less frequent, perhaps years apart.

3.4.3.2 Destruction Efficiencies and Rationale

Persulfate, with the chemical formula $S_2O_8^{-2}$, is a relatively strong oxidizer (oxidation reduction potential = 2.1V) capable of destroying a wide range of contaminants including TCE and PCE. When activated, persulfate produces sulfate radicals ($SO_4.^-$), which are even stronger oxidizers (oxidation reduction potential 2.6 V). This extremely strong oxidant can destroy a wide variety of chemical compounds including 1,1,1-TCA.

Two pilot test were conducted, test #1 involved injection of pH adjusted activated persulfate into wells E-34 and E-42, both located in the north source area. Test #2 evaluated injection of unactivated persulfate into well in the south source area. The LDI reported on preliminary test results. Additional groundwater samples were collected in July 2015, to assess potential CVOC concentration rebound after all of the persulfate had reacted.

Anaerobic reductive dechlorination is well documented in available literature. PCE, TCE and 1,1,1-TCA are readily biodegradable and the remedial agent will help to promote complete degradation to ethane or complete mineralization to carbon dioxide.

3.4.4 Design Features to Control Spills and Malfunctions

The oxidant solution will be mixed onsite in a mobile treatment system specifically designed for the application of sodium persulfate (i.e., construction materials will be compatible with persulfate). Before each injection event, the oxidant mixing/injection system will be inspected. Any suspect hose, pipe, fittings or other equipment will be repaired or replaced. To complete an injection, chemical resistant hoses will be attached to the appropriate wells. The injection will be constantly monitored for leaks or other signs of potential system problems. Operators will have the ability to immediately terminate the injection process and have been trained to respond to a release.

The anaerobic reductive dechlorination agent will be innocuous. The procedures described for oxidant injection will be followed to minimize the chance of accidental release.

3.4.5 Waste Management

An additional benefit of this remedy is that there will be minimal generation of wastes. The only wastes that are anticipated are soil cuttings and drilling fluids generated during the drilling of replacement groundwater monitoring wells. The soil cuttings will be drummed, labeled and characterized for disposal.

3.4.6 Measures Incorporated to Prevent Impacts to Receptors

There are no nearby ecological receptors that could be impacted by the proposed in-situ oxidation and anaerobic reductive dechlorination remedy.

3.4.7 Inspections and Monitoring

An important component of this remedy is the groundwater monitoring plan that will be used to:

- assess how rapidly the persulfate reacts (i.e., how quickly it is consumed);
- confirm that conditions favorable to anaerobic reactive dechlorination have been established at Jefferson Boulevard, and
- evaluate changes in CVOC concentrations in groundwater to determine when the project goals have been achieved.

The monitoring program includes baseline monitoring to establish groundwater characteristics before each injection event, monitoring during injection to allow Louis Berger and ES&M to anticipate conditions that may warrant a change in the injection program, and post-injection monitoring to document the attainment of a permanent solution.

The groundwater monitoring program is described in detail in Sections 4.4 and 5.4. It includes monitoring groundwater elevation (to evaluate groundwater gradients), oxidation reduction potential (ORP), and pH, and collecting groundwater samples for CVOC and sulfate laboratory analysis. Monitoring pH is important because the persulfate will be activated using a moderately strong base.

4.0 CONSTRUCTION PLANS AND SPECIFICATIONS IN-SITU OXIDATION

A set of work plans has been prepared to fully describe the in-situ oxidation program. Engineering drawings (process and instrumentation diagram, process flow diagram, well head and piping details and well layout) are included as Figures 7 and 8.

4.1 Injection Well Array

<u>North Source Area</u>
The following existing wells have been selected for repurposing as oxidant injection wells to address the north source area: E-33, E-34, E-35, E-42, E-43, E-44, and E-45. Additional wells may be added based on future groundwater monitoring data.

Three new injection wells NI-1, NI-2, and NI-3 will be installed as shown on Figure 6. These three wells will be located north of E-44 and east of wells E-42 and E-43. Each well will be installed in a borehole advanced to the surface of bedrock. A ten-foot long section of two-inch diameter 0.010-inch machine slotted PVC well screen will be inserted into the bore with 2-inch PVC riser extending to surface grade. Sand pack will be placed around the screen annulus and the remainder of the bore will be sealed with a cement/bentonite grout. The well head will be completed inside a steel road box.

South Source Area

Wells E-4, E-5, E-6, S-2, S-5, and S-8 will be used to inject oxidant into the south source area. Three new injection wells SI-1, SI-2, and SI-3 will be installed in the vicinity of groundwater monitoring well ESM-8. The locations of these wells are shown on Figure 6. Each well will be installed in a borehole advanced to the surface of bedrock. Well construction will be identical to the construction described above for wells NI-1, NI-2 and NI-3.

4.2 Oxidant Injection Equipment

Two 150-gallon polyethylene tanks will be used to mix the oxidant solution. One hundred and fifty gallons of water will be mixed with 385 pounds of sodium persulfate. The oxidant injection equipment will consist of the following:

- ½-inch and ⅜-inch diameter air hose, ball valves and a pressure regulator to connect the air compressor to the pump and to allow regulation and termination of the air supply,
- two stainless steel double diaphragm pumps with Teflon and/or Viton internal components,
- polyethylene tubing, 1-inch diameter that connects to the lower portion of the oxidant mixing tank,
- polyethylene tubing that will convey oxidant from the pump discharge to the designated injection well,
- polyethylene tubing, 1-inch diameter that will be inserted into drums of 25% w/w solution,
- Polyethylene tubing that will convey sodium hydroxide from the pump discharge to the designated injection well, and
- Pressure gauges and valves as shown on Figure 8.

Compressed air will be provided to the double diaphragm pump and the air pressure will be increased gradually until an injection rate of up to 5 gallons per minute is achieved. The injection pressure will be constantly monitored and if oxidant is forced up the well bore, the injection rate will be decreased by adjusting the air pressure regulator. The entire contents of the tank will be pumped into the designated well. After disconnecting the oxidant pump from the injection well, an aliquot of the sodium hydroxide activator will then be injected into the subsurface using the second pump. Sodium hydroxide solution will be pumped directly from manufacturer supplied carboys into the well. The procedure for injecting the anaerobic reductive dechlorination agent will be similar.

4.3 Injection Agents and Injection Plan

The following plan will be implemented to collect site-specific data to evaluate the efficacy of the remedy, document that it will not harm nearby sensitive receptors and allow evaluation and adjustment of the injection plan.

Two injection events per year will be conducted unless delayed because monitoring indicates that persulfate from the previous injection has not yet completely reacted or if it appears that remediation objectives have been achieved in the source areas.

Each injection event will include injection of up to 10,000 pounds of persulfate and 300 gallons of sodium hydroxide activator. The persulfate will be allocated in proportion to the concentration of CVOCs in the vicinity of the well. To complete the first event, 7,500 pounds of the persulfate will be injected in the north source area; evenly distributed to the 10 injection wells. Two thousand five hundred pounds of persulfate will be injected in the south source area; evenly distributed to the nine injection wells.

The persulfate will be mixed as a 23% w/w solution. Aliquots of 150 gallons of persulfate solution will be injected into designated wells followed by a 15 gallon aliquot of 25% w/w sodium hydroxide. The procedure will be repeated until each well receives the designated amount of persulfate and sodium hydroxide.

Subsequent injection events will be planned using the results of the groundwater monitoring program. For example, additional oxidant will not be injected until the groundwater monitoring results indicate that the persulfate injected during the previous event has fully reacted. Changes in dissolved CVOC concentrations will be evaluated and the injection schedule developed to add more oxidant to wells where CVOC concentrations are highest and less where the CVOC concentrations are lower.

A schedule for the first injection event includes:

<u>North Source Area</u>

• Number of injection wells:	10 (7 existing, 3 new wells)
• Total mass of sodium persulfate	7,500 pounds
• Concentration of persulfate solution	23% by weight (275 g/L)
• Total Volume of Water Added	3,270 gallons
• Total volume of NaOH	225 gallons
• Concentration of NaOH	25% by weight

<u>South Source Area</u>

• Number of injection wells:	9 (6 existing, 3 new wells)
• Total mass of sodium persulfate	2,500 pounds
• Concentration of persulfate solution	23% by weight

• Total Volume of Water Added	1,090 gallons
• Total volume of NaOH	75 gallons
• Concentration of NaOH	25% by weight

4.4 Monitoring After Injection

There are twenty-eight wells included in the monitoring program. They are as follows:

- North Source Area
    - Injection wells: E-33, E-34, E-35, E-42, E-43, E-44, E-45, NI-1, NI-2, and NI-3
    - Monitoring wells: E-32, E-36, E-46, ESM-1, ESM-2, ESM-3, and ESM-4
- South Source Area
    - Injection wells: E-4, E-5, E-6, S-2, S-5, S-8, SI-1, SI-2, and SI-3
    - Monitoring wells: ESM-8 and ESM-9

Once a month for three months after each injection event, the following field groundwater quality measurements will be taken at the twenty-eight wells:

- Dissolved oxygen, pH and ORP
- Persulfate concentrations

Four to six months after each injection event, groundwater samples will be collected from the twenty-eight wells and will be submitted for VOC analysis by EPA Method 8260.

4.5 Schedule of In-Situ Oxidation Activities

A tentative schedule for the in-situ oxidant injection program is as follows:

- Injection event spring and fall of 2016
    - Monthly monitoring
    - Groundwater samples collected 4 – 6 months after injection event
- Spring and fall injection events in 2017, thereafter.

5.0 CONSTRUCTION PLANS AND SPECIFICATIONS ANAEROBIC REDUCTIVE DECHLORINATION PROGRAM

Reductive dechlorination is the second component of the remedy. While in-situ oxidation employing activated persulfate will be used to reduce CVOC concentrations in the two source areas, it would not likely be effective, nor would it be cost effective to apply persulfate across the entire CVOC groundwater plume. Instead, conditions favorable to reductive dechlorination will be created by injecting agents into groundwater through many of the existing W-series wells. CVOCs in groundwater migrating west will be dechlorinated in the vicinity of Jefferson Avenue.

5.1 Injection Well Array

During development and groundwater sample collection from the W-series wells it was observed that most of these well were in relatively good condition, yielded sufficient water, and were likely suitable for injection of agents that would promote in-situ reductive dechlorination. The following wells will be used for EHC® liquid reagent injection: ESM-5, W-5, W-6, W-7, W-9, W-11, W-12, W-13, W-14, W-15, W-16, W-17, W-18, W-19, W-20, W-26, and W-27[1].

5.2 EHC®$_L$ Injection Equipment

The same equipment described in Section 4.2 of this RAWP and shown on Figure 8 will be used to inject the EHC®$_L$ reagents.

5.3 Injection Agents and Injection Plans

Information collected as part of the LDI was provided to PeroxyChem, distributer and patent holder for a number of specialized in-situ oxidation and reduction agents. Specifically, information collected to characterize the concentrations of CVOCs in groundwater, sulfate concentrations, nitrate concentrations, dissolved iron concentrations, groundwater pH, ORP, conductivity and observations/measurements such as soil types, well designs and layout and other site conditions were provided. Based on this information and using certain default parameters, PeroxyChem representatives designed an injection program that uses EHC® Liquid Amendment, a pH buffer and a bacteria inoculant to create a zone where conditions favorable to reductive dechlorination will persist. The basis for the recommended design is included in Appendix 4. Based on RIDEM comments on the LDI, the well injection well array has been altered; adding wells ESM-5, W-5, and W-6. To account for the additional reagents that will be injected into these three wells, the calculated mass of the three reagents EHC$_L$, pH buffer and DHC inoculum have been increased by 20%.

A total of 56,952 pounds of EHC-L (slurry), 3,340 pounds of EHC-L (dry mix), 3,420 pounds of $KHCO_3$ pH buffer solution and 65 pounds of DHC bacteria inoculum will be injected into the select W-series wells. The delivery method may be modified based on field conditions but is anticipated to include a 10-fold dilution of the EHC-L slurry with clean water, and addition of the appropriate allocation of the dry mix to the diluted solution. After thorough mixing, the solution will be injected into the select wells. Mixing and injection will continue until the entire EHC-L mass has been injected. The pH buffer solution and the DHC inoculant will be added after the EHC injection has been completed.

The following is a summary of the reductive dechlorination injection program:

Number of injection wells:	17 (all are existing wells)
Total Volume of EHC-L	6,780 gallons
Total Volume of Water Added	67,800 gallons
Total Mass of EHC (dry mix)	3,340 pounds
Total Mass of Buffer Solution	3,420 pounds
Total Mass of DHC Inoculum	65 pounds

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[1] Wells ESM-5, W-5 and W-6 have been added to the reductive dechlorination injection well array in response to RIDEM's comments on LDI.

5.4 EHC Injection Monitoring

Quarterly monitoring will be completed to assess the effectiveness of the reductive dechlorination remedy and to evaluate when additional reagents may be needed.

Monitoring Before First Injection Event

- Groundwater elevation will be monitored at select wells.
- Dissolved oxygen, pH, ORP will be measured in the field at select wells.
- Groundwater samples will be collected from select wells. The samples will be analyzed for CVOCs as well as sulfate, nitrate, dissolved iron, and alkalinity.
- A water table elevation contour map will be prepared to show the configuration of the water table under pre-injection conditions.

Monitoring After Each Injection Event (quarterly after each injection event)

- Dissolved oxygen, pH and ORP will be measured at select wells.
- Groundwater elevation will be measured at select wells.
- Every six months groundwater samples will be collected from 10 select W-series wells and possibly other select groundwater monitoring well to assess the CVOCs concentration and the effectiveness of the reductive dechlorination program.

Select Wells:

- Injection wells: ESM-5, W-5, W-6, W-7, W-9, W-11, W-12, W-13, W-14, W-15, W-16, W-17, W-18, W-19, W-20, W-26, and W-27.
- Monitoring wells: W-1, W-2, W-3, W-4, W-10, W-20A, W-22, W-24, W-25, W-28, W-29, MW-14, MW-15, MW-16, and MW-17.

Wells selected for periodic CVOC lab analysis: W-13, W-16, W-20, W-27, MW-14, MW-15, MW-16 and MW-17.

In addition, samples from wells W-13, W-16, W-20, and W-27 will be analyzed for the following:

- Dissolved gasses
  - Ethene
  - Methane
  - Ethane
- Total Organic Carbon

Other samples may be collected for analysis of other parameters including total and dissolved iron, sulfate and nitrate.

Data Evaluation

The goal will be to maintain conditions favorable to anaerobic reductive dechlorination. Dissolved oxygen concentrations must remain depressed (<1 mg/L) and ORP measurements of less than -100mV are desirable. The sample results will be evaluated to determine if conditions favorable to reductive dechlorination exist or if additional reagent is recommended. PeroxyChem estimates that the initial EHC injection will persist for 1 to 3 years.

5.5 Schedule of Anaerobic Reductive Dechlorination Activities

A tentative schedule for the anaerobic reductive dechlorination injection program is as follows:

- Spring 2016 EHC_L® reagent injection.

6.0 SPECIFIC RAWP REQUIRMENTS

A site specific health and safety plan will be prepared to educate and protect workers during installation of groundwater monitoring wells, chemical injections and collection of groundwater samples and associated groundwater monitoring. A copy of the plan will be kept on site whenever work under this plan is ongoing.

The following are the best management practices that will be employed to:

A. Prevent the infiltration/migration of Hazardous Substances at levels harmful to human health or the environment;

   Sodium persulfate will react with CVOC to ultimately form carbon dioxide and small amounts of hydrochloric and sulfuric acid. If the limited design test indicates that the persulfate should be activated, the high pH activation method will be used. The sodium hydroxide base will be neutralized by the generated acid returning the groundwater pH to near normal. Another byproduct is sulfate, which will be used as an electron acceptor in anaerobic biodegradation which will occur downgradient of the injection area.

B. Prevent direct contact with Hazardous Substances at levels harmful to human health and the environment;

   The site specific health and safety plan will describe personnel protective equipment including gloves, eye protection, and chemical resistant suits that will be used to protect workers during the injection events. The injection system design uses materials compatible with CVOCs, sodium persulfate and sodium hydroxide. The injections will be carefully performed to prevent inadvertent spilling or release of the remedial agents. In the event of a minor spill, a spill kit will be readily available to contain and recover any agent releases. Job safety analysis (JSA) will be completed for any potentially hazardous task that will be completed by the project team. An initial safety meeting and daily pre-work tailgate safety meetings will be held to ensure that all hazards are recognized and anticipated and measures are implemented to mitigate risks.

C. Eliminate volatilization and entrainment of Hazardous Substances; and

Injection of sodium persulfate at 23% w/w aqueous solution strength and use of 25%w/w sodium hydroxide will not generate significant heat. Controlling the temperature in this manner will ensure that the potential for CVOCs to volatilize from soil and groundwater is not increased. Injection of the anaerobic reductive dechlorination agent will not increase volatilization potential.

D. Minimize and manage surface runoff from the area including during and after the Remedial Action. The plan shall identify all locations of existing and/or proposed infiltration systems;

The proposed in-situ oxidation remedy will not result in any surface runoff. The chemical injections will be performed in a manner that injects the chemicals through existing wells and directly into the soil and groundwater where CVOC concentrations are greatest. The locations of the E-series wells that will be used in the remedy are shown on Figure 1.

6.1 Remediation of Impacted Groundwater

6.1.1 In-situ Oxidation

Sodium persulfate, $Na_2S_2O_8$, dissociates to form sulfate SO_4^{-2}, a relatively strong oxidant with an electron potential of 2.01 volts (Richard Brown, In-situ Chemical Oxidation – Performance, Practice and Pitfalls). Sodium persulfate is capable of destroying TCE and PCE. There is mixed information in the literature regarding the ability of persulfate to destroy 1,1,1-TCA. Activation of sodium persulfate by addition of iron, pH elevation, heat or hydrogen peroxide creates sulfate radicals, SO_4^-, which Brown has reported has an electron potential of 2.5 volts. Persulfate, activated using one of PeroxyChem's patented processes, has demonstrated ability to destroy all of the CVOCs detected in groundwater at the T. H. Baylis site including 1,1,1-TCA.

The limited design test will evaluated the performance of persulfate and pH activated persulfate and concluded that the activated persulfate should be implemented as the source area remedy for this site. Elevated pH activation was selected for the T. H. Baylis site because it is less costly than heat or peroxide activation and it has the advantage over iron activation and other activation methods in that sulfuric and hydrochloric acids (reaction by-products), will be neutralized restoring the groundwater to its natural pH.

Phillip Block PhD, director of technology with PeroxyChem, explains the activation reaction and subsequent oxidation reactions in a presentation titled "*The Science of Persulfate Activation*". PCE is used in the demonstration:

$S_2O_8^{-2} + 2H^+ + 2e^- \rightarrow 2HSO_4^-$ (activation of the persulfate anion)

$2S_2O_8^{-2} + C_2Cl_4 + 4H_2O \rightarrow 2CO_2 + 4Cl- + 4H+ 4HSO_4^-$ (persulfate oxidation of PCE)

These simplified reactions illustrate that two molecules of persulfate are required to oxidize each molecule of PCE. The weight ratio is three pounds of sodium persulfate for each pound of PCE.

If the exact mass of PCE (as well as TCE and 1,1,1-TCA) was known and if perfect contact between each molecule of CVOC and the persulfate molecules could be ensured, it would be possible to calculate the exact theoretical amount of persulfate that would need to be added to completely destroy the CVOCs. But of course, the mass of CVOCs is not known and the CVOCs in both the north and south plumes are distributed across relatively large areas. To further complicate matters, some of the persulfate will decompose, some will react with other interfering compounds in soil and groundwater and we cannot rule out that a considerable mass of CVOCs could be intermittently present as DNAPL in bedrock fractures. The oxidant mass required is therefore much greater than the theoretical amount. Our proposed approach it to perform semi-annual injections and to monitor between each event. The number of injection events cannot be calculated. Injections should be suspended when groundwater data indicates the flux of CVOCs migrating in groundwater toward the southwest has been significantly reduced such that natural attenuation will ultimately reduce the concentrations of the CVOCs in site groundwater to meet RIDEM GB Standards.

The oxidant will be delivered at a concentration of 23%w/w. Select E-series wells installed as combination sparge/vent wells will be used to inject oxidant into the source area. In the north plume 10 wells (7 existing and three new wells) will be used. In the south plumes nine wells (6 existing and 3 new) will be used.

6.1.2 Anaerobic Reductive Dechlorination

Reductive dechlorination is a natural process. The remedy goal is to add hydrogen, an electron donor, and other nutrients to increase the number and vitality of indigenous microorganisms. Enhanced reductive dechlorination can increase the rate of dechlorination by several orders of magnitude. The dechlorination reactions replace chlorine atoms with hydrogen. Perchlorothene (C_2Cl_4) is converted trichloroethylene (C_2HCL_3) which is converted to cis or trans isomers of dichloroethene ($C_2H_2Cl_2$) and further dechlorinated to vinyl chloride ($C2H_3Cl$). When the final chlorine atom is replaced, vinyl chloride is dechlorinated to form ethane (C_2H_4). The process is similar for 1,1,1-trichloroethane but because the carbon-carbon bond is a single bond, the final product is ethane (C_2H_6).

6.2 Points of Compliance

The points of compliance will be the E-series and W-series wells that are deemed to be in suitable condition for injection and will likely allow collection or representative groundwater samples and the following groundwater monitoring wells:

Existing Wells West on Jefferson Boulevard

- MW-14

- MW-15
- MW-16
- ESM-1 (east of E-42)
- ESM-2 (west of E-42)
- ESM-3 (east of W-12)
- ESM-4 (north of W-1)
- ESM-5 (south of W-7)

New Wells – South Plume
- ESM-6 (east of E-22)
- ESM-7 (west of E-22)
- ESM-8 (east of E-6)
- ESM-9 (east of E-8)

6.3 Proposed Schedule for Remediation

The remediation schedule is dependent on RIDEM's review and Order of Approval for the in-situ oxidation and anaerobic reductive dechlorination activities. After RIDEM's Order of Approval, RIDOT must prepare bid specifications to select a contractor to implement the remedies.

A tentative schedule for the in-situ oxidant injection program is as follows:
- Injection event spring and fall of 2016
    - Monthly monitoring
    - Groundwater samples collected 4 – 6 months after injection event
- Spring and fall injection events in 2017, thereafter.

A tentative schedule for the anaerobic reductive dechlorination injection program is as follows:
    - Spring 2016 EHC$_L$® reagent injection.

6.4 Contractors and/or Consultants

The consultant and contractor overseeing the remedial implementation will be Louis Berger and Environmental Strategies and Management.

6.5 Site Plan

A site plan has been included as Figure 1.

6.6 Design Standards and Technical Specification

The specific design standard and technical specifications are addressed below:

A. Identification of the materials of construction of all portions of the remedy:

All materials of construction have been selected to be compatible with the CVOCs found at this site as wells as with sodium persulfate, sodium hydroxide and the remedial agent to be selected during the LDI. The materials used to construct the oxidant injection system are shown on Figure 8.

B. The type of equipment to be used, including unit capacity and dimensions:

All equipment that will be used in the in-situ oxidation remedy is shown on Figure 8. The capacities and expected rates/pressures and other operating parameters are shown.

C. The results of any laboratory or pilot-scale tests conducted to determine the effectiveness of the proposed Remedial Action:

A limited design investigation was performed to compare the performance of persulfate and pH activated persulfate. The limited design investigation yielded information that was useful to develop well specific oxidant injection schedule and estimation of safe injection rates and expected pressures at each selected injection well.

Parameters were measured in the field and groundwater samples were submitted for laboratory analysis to evaluate the appropriate agent and the mass/volume of the agent to be injected into the W-series wells.

D. Any manufacturer's literature and/or technical guidance documents on the construction, implementation and/or operation of proposed units. These portions of the Remedial Action Work Plan shall be prepared under the supervision of a Registered Professional Engineer in the State of Rhode Island, and stamped by that engineer prior to submittal.

Information supporting the selection and use of sodium persulfate is available at the PeroxyChem (formerly FMC) website:
http://www.peroxychem.com/chemistries/persulfates/products/klozur-cr

Copies of a number of technical support documents are included in Appendix 3 (In-Situ Oxidation Program) and Appendix 4 (Anaerobic Reductive Dechlorination Program).

This RAWP has been prepared by and under the supervision of Clayton Carlisle, a registered Professional Engineer in the State of Rhode Island.

6.7 Set-up Plans

Each E-series well was developed to remove sediment and a clean water injection test was performed to evaluate the ability to inject fluids into each well. Set up for each injection event will include:

- Transportation of chemical storage trailers to the undeveloped area in the vicinity of the south plume.
- Receipt of shipment of chemicals and storage of the chemicals in the trailers
- Placement of placards signs and labels.
- Transportation of the chemical injection trailer to the site.

6.8 Effluent Disposal

The only wastes that will be generated are:

- Soil cuttings generated during well installation will be characterized and disposed appropriately.
- Groundwater generated during well development and sampling activities will be drummed, characterized and properly disposed.
- PPE and refuse will be disposed in a dumpster as ordinary trash.
- Carboys, rinsed after the sodium hydroxide contents have been used, will be returned to the chemical supplier.

6.9 Contingency Plan

Phone Numbers
The nearest telephone is the cell phone carried by the ES&M SHSO – Dana Howard.
Mr. Howard’s cell phone number is: (508) 726-7676.

Emergency Response			
Name		**Telephone**	**Verification**
Hospital	Kent Hospital 455 Toll Gate Road Warwick, Rhode Island 02886	401-737-7000 or 1-800-892-9291	CC/TS
Police	Warwick Police Department	**911**	CC/TS
Fire Department	Warwick Fire Department	**911**	CC/TS
Spill Response	Warwick Fire Department	**911**	CC/TS
Environmental Response	National Response Center (24-hour hotline)	(800) 424-8802	CC/TS
Environmental Protection	US Environmental Protection Agency (24-hour hotline)	(800) 424-9346	CC/TS
Emergency Services	Office of Emergency Services (24-hour hotline)	(800) 852-7550	CC/TS
Poison Control	U.S. National Poison Control Center (24-hour hotline)	(800) 222-1222	CC/TS
Agency / Line Locator			
National Line Locator	National 811 Call-Before-You-Dig Hotline (24-hour hotline)	811	CC/TS
State Line Locator	Dig Safe System Inc. (MA-ME-NH-RI-VT)	1-888-Dig-Safe www.digsafe.com	CC/TS
Local Public Works Department	Warwick Public Works	401-738-2000 x6500	CC/TS
Local Gas and Electric Utility	National Grid (Gas and Electric)	800-640-1595 Gas 800-465-1212 Electric	CC/TS

Project Team Phone Numbers			
	Name	Telephone	Verification
Louis Berger Project Manager	Clayton Carlisle (CC)	401-415-9442 Office	TS
		401-490-1045 Cell	
ES&M Project Manager	Tom Sneesby (TS)	508-726-2011 Cell	CC
		508-226-1800 Office	
ES&M Health & Safety Officer	Dana Howard	508-726-7676 Cell	TS
ES&M Project Staff	Dan Batchelder	508-431-8425 Cell	TS
	Matt Duclos	774-265-5326 Cell	
	Evan Cuce	508-726-7963 Cell	
ES&M Remediation Engineer	Tom Sylvia	508-226-1800 Office	TS
		508-930-0591 Cell	
Louis Berger Field Personnel	Samantha Hogan	401-415-9447 Office	CC
		401-523-1011 Cell	
RIDOT Project Manager	Jim Eng	401-222-4203 Office	CC

Emergency Response Procedures: Evacuation

In the event of an on-site or off-site emergency requiring site evacuation (e.g., fire, release, explosion, etc), the following procedures will be followed:

- Stop Work and notify the SHSO.
- Evacuate the site and go to the emergency meeting location if safe conditions exist. The generic evacuation point is the Legal Seafood parking lot on Post Road. The evacuation point will be evaluated daily. If safe conditions prevent evacuation to this location, move upwind, away from the source of the emergency. Maintain a safe distance from the source.
- Check in with the SHSO at the emergency meeting location. The SHSO will take attendance once all personnel have gathered.
- Dial the appropriate emergency response number(s). State the problem clearly and completely and remain on the line until dismissed by the operator.
- Only attempt extinguishing small fires with portable dry chemical equipment on-hand. When in doubt, emergency response personnel shall be notified.
- Do not reenter the emergency site without specific approval from emergency response personnel.

Emergency Response Procedures: Injury or Illness

If an injury or illness occurs, take the following action:

- Stop Work, stabilize the situation, and secure the site.
- Administer First Aid for the person immediately using a first aid and blood-borne pathogens kit.
- Determine if emergency response (fire/ambulance) is necessary. If so, call appropriate emergency response numbers on closest available phone. Provide the location of the injured person and other details as requested. Drive the individual to the hospital only if it makes sense.
- If emergency decontamination is required:
  - Immediately remove any contaminated personal protective equipment (PPE) or clothing.
  - If possible, wash contaminated area with mild soap and water.
  - Use eyewash station if necessary.
  - Personnel assisting the contaminated individual will don the proper PPE to avoid unnecessary exposures.
- For all injuries or illness, even minor cuts, scratches, and bruises, notify the SHSO immediately. The SHSO is responsible for initiating incident reporting procedures immediately after the victim(s)/site have been stabilized. The SHSO will assume responsibility during a medical emergency until more qualified emergency response personnel arrive at the site as needed.
- As promptly as possible following an injury or illness, ensure appropriate notification has been made to the family of the individual involved.

Injuries or Illnesses Requiring Hospital Service WITHOUT Ambulance Service

Injuries or illnesses requiring hospital service without ambulance services include minor lacerations, minor sprains, etc. The following procedures will be taken immediately:

- The SHSO will ensure prompt transportation of the injured person to a physician or hospital.
- A representative of Louis Berger or ES&M will always drive the injured employee to the medical facility and remain at the facility until the employee is ready to return.
- If the driver of the vehicle is not familiar with directions to the hospital, a second person shall accompany the driver and the injured employee and navigate the route to the hospital.
- If it is necessary for the SHSO to accompany the injured employee, provisions will be made to have another employee, properly trained and certified in First Aid, to act as the temporary SHSO.
- If the injured employee is able to return to the job site the same day, he/she will bring with him/her a statement from the doctor containing such information as:
    - Date
    - Employee's name
    - Diagnosis
    - Date he/she is able to return to work, regular or light duty
    - Date he/she is to return to doctor for follow-up appointment, if necessary
    - Signature and address of doctor
- As promptly as possible following an injury or illness, ensure appropriate notification has been made to the family of the individual involved.

Injuries or Illnesses Requiring Hospital Service WITH Ambulance Service

Injuries or illnesses requiring hospital service with ambulance services include severe head injuries, amputations, heart attacks, heat stroke, etc. The following procedures will be taken immediately:

- Call for ambulance service and notify the SHSO.
- Administer First Aid until ambulance service arrives.
- While the injured employee is being transported, the SHSO will contact the medical facility to be utilized.
- One designated representative will accompany the injured employee to the medical facility and remain at the facility until final diagnosis and other relevant information is obtained.
- As promptly as possible following an injury or illness, ensure appropriate notification has been made to the family of the individual involved.

Death of an Individual or Hospitalization of Three or More Employees

The emergency response procedures above will be followed. If the injured person dies, follow the incident reporting procedures. Notify the Human Resources Department, local officials and coroner immediately. Human Resources will notify the local OSHA office within 8 hours of the incident or fatality in the event of fatality or hospitalization of three or more employees.

Emergency Response Procedures: Spills or Cut Lines

Prevent problems by documenting the location of underground lines (e.g., product, sewer, telephone, fiber optic) before starting site work. If a line or tank is drilled through, or another leak occurs, document the event as soon as possible using the Incident Investigation Report.

In the event of a spill/release, follow this plan:

- Stop Work, stabilize the situation, and secure the site.
- Stay upwind of the spill/release.
- Wear appropriate PPE.
- Turn off equipment and other sources of ignition.
- Turn off pumps and shut valves to stop the flow/leak.
- Plug the leak or collect drippings, when possible.
- Use sorbent pads to collect product and impede its flow, if possible.
- Call Fire Department immediately if fire or emergency develops.
- Notify the SHSO to begin the incident reporting procedures. All spills/releases will be reported to the Client Project Manager within 24 hours, or sooner.
- Determine if the client wants Louis Berger/ES&M to repair the damage or if the client will use an emergency repair contractor.
- Based on agreements, contact emergency spill contractor for containment of free product. The contacts for this project will be **<u>Warwick Fire Department</u>**
- Advise the client of spill discharge notification requirements and determine who will complete and submit forms. *(Do not submit or report to agencies without the client's consent.)* Document each interaction with the client and regulators and note, in writing; name, title, authorizations, refusals, decisions, and commitments to any action.
- Do not transport or approve transportation of contaminated soils or product until proper manifests have been completed and approved. Be aware that soils / product may meet criteria for hazardous waste.
- Do not sign manifests as generator of wastes unless you have been given appropriate training and approval for signing on behalf of the generator; contact Project Manager or Waste Compliance Manager to discuss waste transportation.

The Project Manager will involve the client/generator in the Incident Investigation process. The client/generator is under obligation to report to the proper government agencies. If the spill extends into waterways, the Coast Guard and the National Response Center will be notified immediately by the client or by the Louis Berger/ES&M Project Manager with the client's permission.

Incident Reporting Procedures

This section outlines the procedures that will be followed in the event of an incident.
In the event of an incident:

1. Stop work, stabilize the situation, and secure the site.
2. Report all incidents, injuries, spills, non-conformance events, permit

exceedances and potential incidents (near losses) immediately to the ES&M SHSO or the Louis Berger representative on-site, who will then notify the Louis Berger Project Manager. If you are unsure whether or not something should be reported, Stop Work and proceed with notification anyway.

3. The Louis Berger Project Manager will make internal notifications.
4. **A:** If the incident is determined to not be reportable to RIDOT, the Louis Berger Project Manager will submit an initial copy of the Incident Investigation/Near Loss Investigation (IINLI) report to the appropriate Louis Berger incident coordinator. The final report is due within 5 business days.

   B: If the incident is determined to be reportable to RIDOT, the Louis Berger Project Manager will:
   - Notify the RIDOT Project Manager and, if requested, complete a report and other associated documentation.
   - Provide a written report of the incident. An initial copy of the report will be submitted within 24 hours, and the final will be completed within 5 business days.

6.10 Operating Log

Proposed operating logs for the chemical oxidation and anaerobic reductive dechlorination are included as Appendix 5. The logs will be included in an operation and maintenance manual that will be retained on-site.

6.11 Security Procedures

All chemicals will be stored in secure enclosures that will be locked to prevent unauthorized access. Well heads will be secured at the end of each day by bolting the covers securely in place. Aqueous chemical solutions will be injected by the end of the day such that there is no overnight storage of mixed solutions. The chemical injection trailer will be stored in an area designated by RIDOT.

Traffic and pedestrian controls will be discussed at the tailgate safety meeting each day. The controls will include cones, barricades, caution tape and any other precautions necessary to maintain a safe work environment for the workers and the public.

6.12 Shut-Down, Closure and Post-Closure Requirements

Following completion of the final injection event, groundwater samples will be collected from the designated compliance wells quarterly for one year.

All post-closure groundwater monitoring shall be done in accordance with a program meeting the requirements of Section 8.10 Compliance Sampling (B) Compliance with the Groundwater Objectives.

6.13 Institutional Controls and Notices

The need for an Environmental Land Use Restriction (ELUR) will be evaluated when data suggests that the in-situ oxidation and reductive dechlorination remedies have achieved the project objectives or these remedies have reached technological limits and institutional controls may be prudent to limit future site uses and exposures.

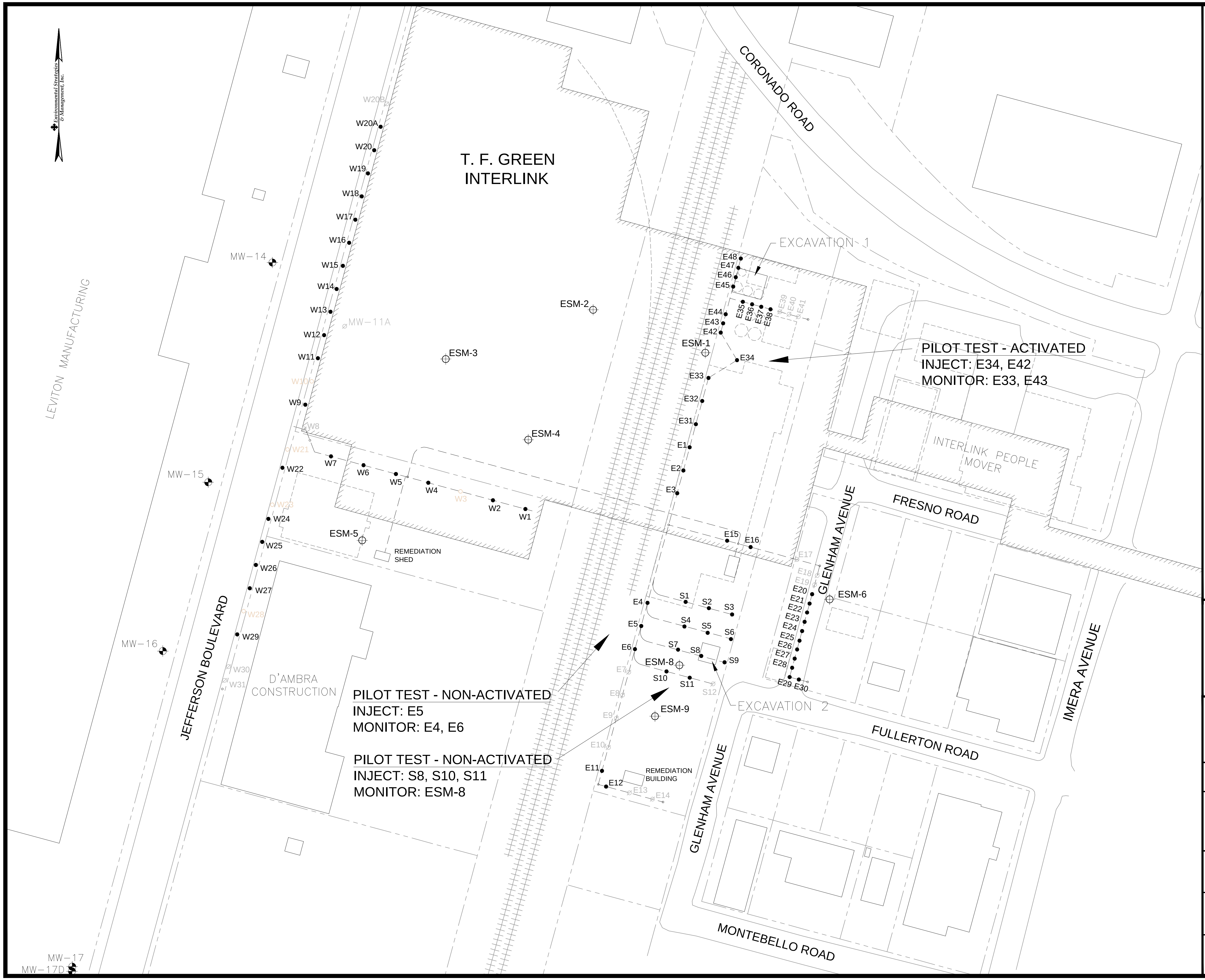
6.14 Compliance Determination

Groundwater samples collected from select E-series and W-series and from wells ESM-1 through ESM-9 and MW-14, MW-15 and MW-16 will be used to assess performance of the remedy. Ultimately for the remedy to be successful, the concentrations of CVOCs in groundwater must be reduced below the UCLs and further to concentration levels that do not pose risk to human and environmental receptors. Given the physical and chemical characteristics of the chlorinated solvents PCE, TCE and 1,1,1-TCA found in groundwater at the T. H. Baylis site, the concentrations of CVOCs must be reduced such that there is no threat on intrusion into indoor air.

6.15 Certification Requirements

Included in Appendix 6 of this Remedial Action Work Plan are Certification of Accuracy statements signed by the authorized Remedial Action Work Plan preparer and an authorized Site Owner representative.

FIGURES



PILOT TEST - ACTIVATED
INJECT: E34, E42
MONITOR: E33, E43

PILOT TEST - NON-ACTIVATED
INJECT: E5
MONITOR: E4, E6

PILOT TEST - NON-ACTIVATED
INJECT: S8, S10, S11
MONITOR: ESM-8

LEGEND

- MONITORING WELL
- ⊕ ES&M MONITORING WELL
- ○ DAMAGED WELL
- ∅ DESTROYED WELL
- ● REMEDIATION WELL
- – – – – – AIR SPARGE/VAPOR EXTRACTION LINES
- —— - - —— PROPERTY LINE
- ┼┼┼┼┼┼┼┼ RAILROAD TRACK
- - - - - - - - FORMER BUILDING, TANK OR RR

MAP SOURCES: 1) "SITE PLAN, INTERMODEAL STATION, WARWICK, RI", PREPARED BY BETA GROUP, INC., LINCOLN, RI, DATED AUGUST 29, 2011; 2] "SITE REMEDIATION AND BUILDING DEMOLITION" FIGURE PACKAGE PREPARED BY BETA GROUP, INC., LINCOLN, RI AND EDWARDS & KELCEY, PROVIDENCE, RI, DATED JULY 20, 2000; 3) GOOGLE EARTH AERIAL.

ALL FEATURES ARE APPROXIMATELY LOCATED.

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SCALE FEET

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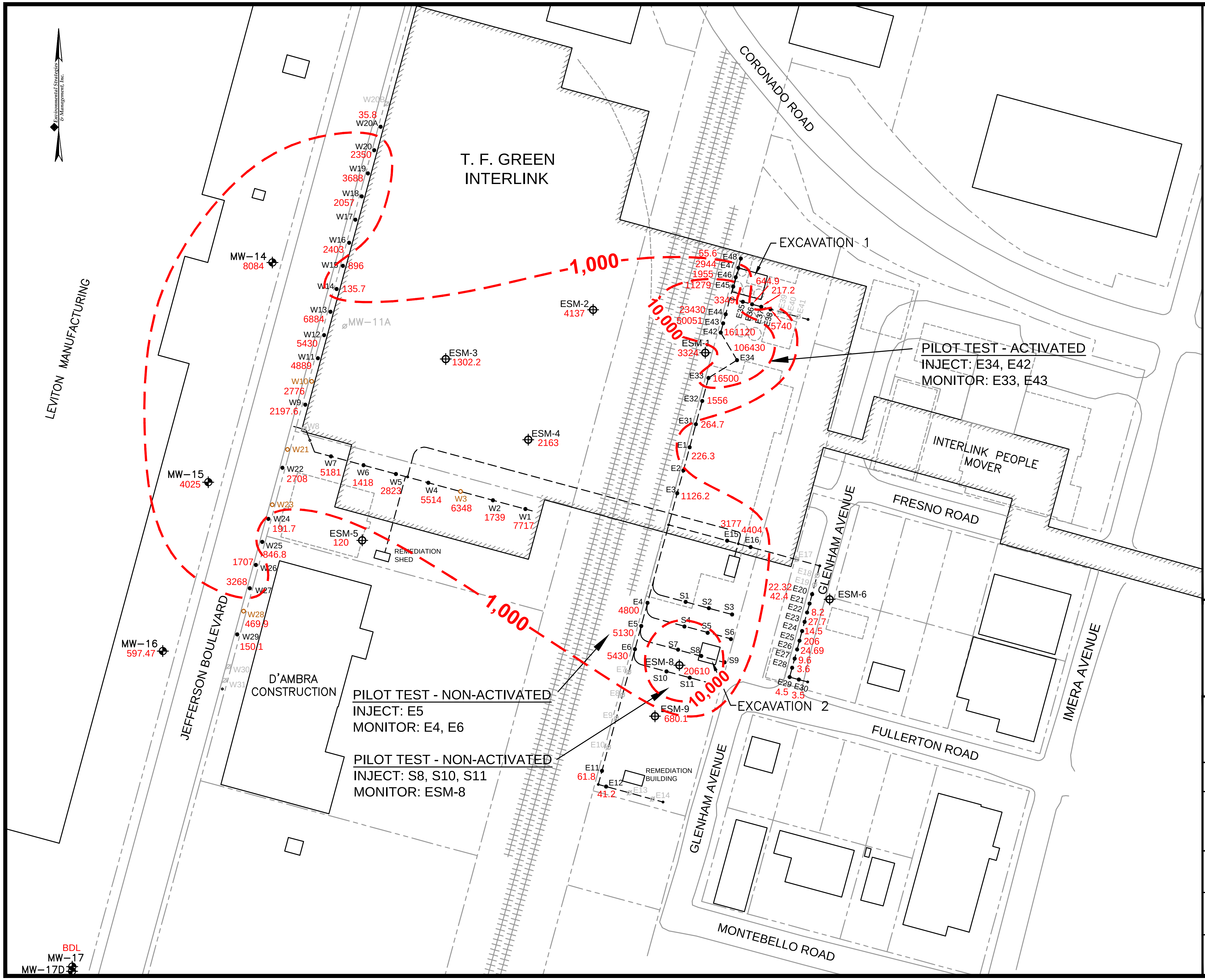
(508) 226-1800
(508) 226-1811 fax
info@esm-inc.com

GAUGING DATE:	DRAWING DATE: 7/28/15	ACAD FILE: RIDOT WARWICK 2015

SITE PLAN

CLIENT: RHODE ISLAND DEPARTMENT OF TRANSPORTATION		PM: CC
LOCATION: T. F. GREEN INTERLINK WARWICK, RHODE ISLAND		LSP: – –
RIDEM: SR-25-0109B	DWG: DMR	PROJECT NO.: 2014-001	FIGURE: 1



LEGEND

⊕	MONITORING WELL
⊕	ES&M MONITORING WELL
○	DAMAGED WELL
∅	DESTROYED WELL
•	REMEDIATION WELL
– – – – – –	AIR SPARGE/VAPOR EXTRACTION LINES
— - - —	PROPERTY LINE
┼┼┼┼┼┼┼┼	RAILROAD TRACK
- - - - - -	FORMER BUILDING, TANK OR RR
100	TOTAL VOCs IN ug/L
— — —	ISO-CONCENTRATION CONTOUR

MAP SOURCES: 1) "SITE PLAN, INTERMODEAL STATION, WARWICK, RI", PREPARED BY BETA GROUP, INC., LINCOLN, RI, DATED AUGUST 29, 2011; 2] "SITE REMEDIATION AND BUILDING DEMOLITION" FIGURE PACKAGE PREPARED BY BETA GROUP, INC., LINCOLN, RI AND EDWARDS & KELCEY, PROVIDENCE, RI, DATED JULY 20, 2000; 3) GOOGLE EARTH AERIAL.

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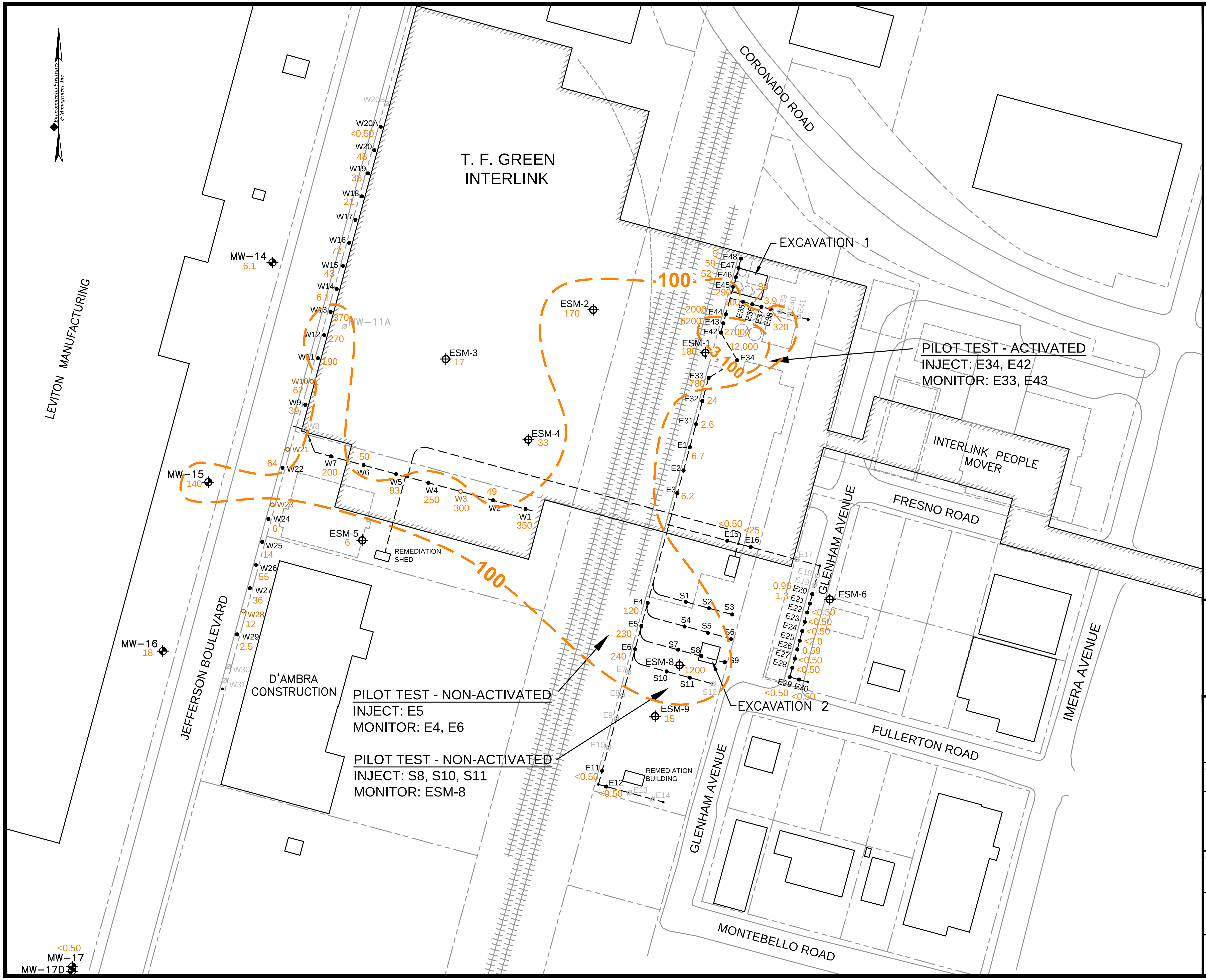
TOTAL CVOCs IN GROUNDWATER

CLIENT: RHODE ISLAND DEPARTMENT OF TRANSPORTATION	PM: CC
LOCATION: T. F. GREEN INTERLINK WARWICK, RHODE ISLAND	LSP: --

RIDEM:	DWG:	PROJECT NO.:	FIGURE:
SR-25-0109B	DMR	2014-001	2



LEGEND

- ⊕ MONITORING WELL
- ⊕ ES&M MONITORING WELL
- ○ DAMAGED WELL
- ⌀ DESTROYED WELL
- • REMEDIATION WELL
- – – – – – AIR SPARGE/VAPOR EXTRACTION LINES
- — - — PROPERTY LINE
- ┼┼┼┼┼┼ RAILROAD TRACK
- - - - - - FORMER BUILDING, TANK OR RR
- 100 1,1,1–TRICHLOROETHANE IN ug/L
- — — ISO–CONCENTRATION CONTOUR

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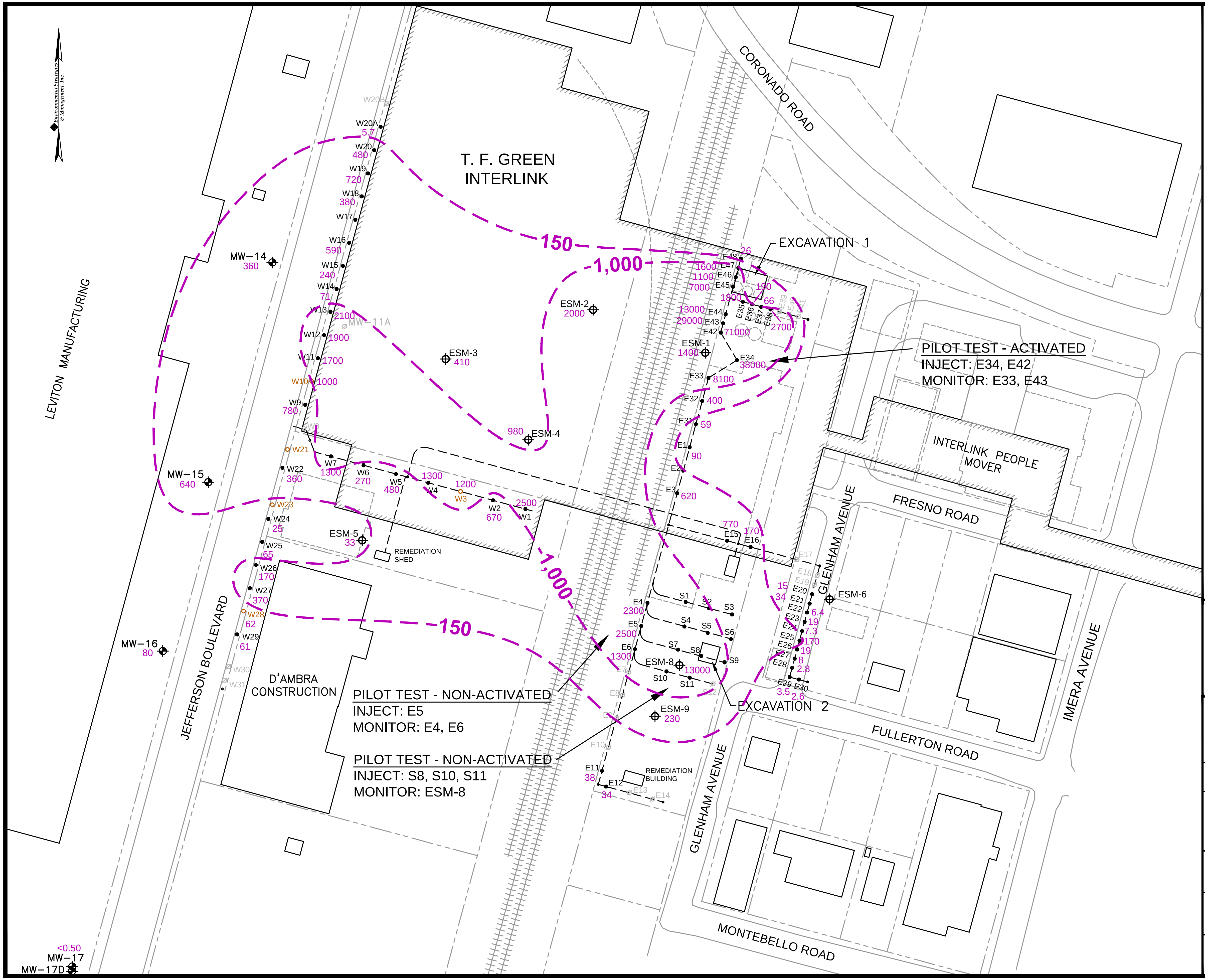
NOV 2014	7/28/15	RIDOT WARWICK 2015

1,1,1-TCA IN GROUNDWATER

CLIENT: RHODE ISLAND DEPARTMENT OF TRANSPORTATION	PM: CC
LOCATION: T. F. GREEN INTERLINK WARWICK, RHODE ISLAND	LSP: ––

RIDEM:	DWG:	PROJECT NO.:	FIGURE:
SR-25-0109B	DMR	2014–001	3



PILOT TEST - ACTIVATED
INJECT: E34, E42
MONITOR: E33, E43

PILOT TEST - NON-ACTIVATED
INJECT: E5
MONITOR: E4, E6

PILOT TEST - NON-ACTIVATED
INJECT: S8, S10, S11
MONITOR: ESM-8

LEGEND

⌖	MONITORING WELL
⌖	ES&M MONITORING WELL
○	DAMAGED WELL
⌀	DESTROYED WELL
•	REMEDIATION WELL
– – – – –	AIR SPARGE/VAPOR EXTRACTION LINES
— - —	PROPERTY LINE
┼┼┼┼┼┼	RAILROAD TRACK
- - - -	FORMER BUILDING, TANK OR RR
100	TETRACHLOROTHENE IN ug/L
— — —	ISO–CONCENTRATION CONTOUR

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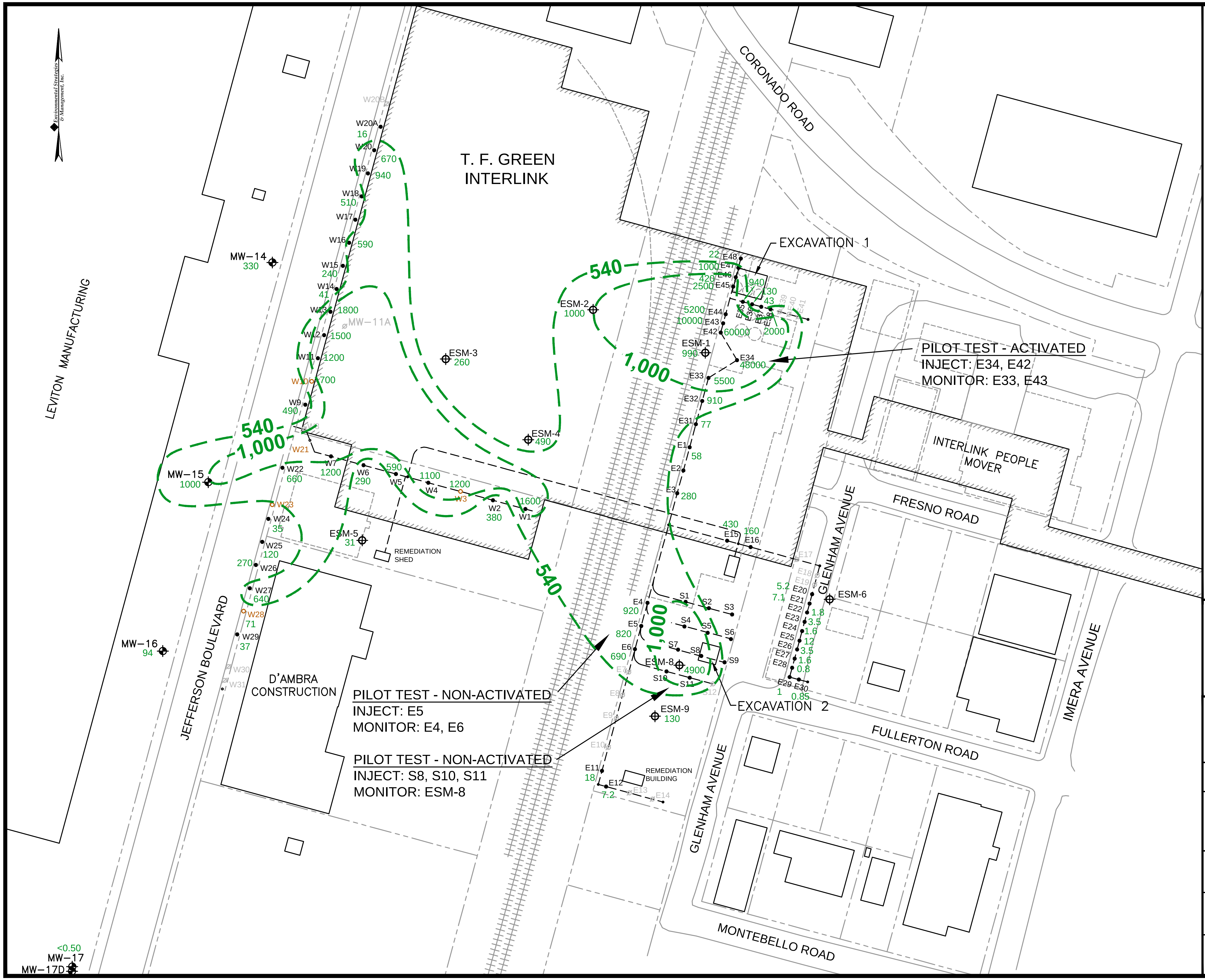
NOV 2014	7/28/15	RIDOT WARWICK 2015

PCE IN GROUNDWATER

CLIENT:	PM:
RHODE ISLAND DEPARTMENT OF TRANSPORTATION	CC

LOCATION:	LSP:
T. F. GREEN INTERLINK WARWICK, RHODE ISLAND	––

RIDEM:	DWG:	PROJECT NO.:	FIGURE:
SR-25-0109B	DMR	2014–001	4



LEGEND

⌖	MONITORING WELL
⊕	ES&M MONITORING WELL
○	DAMAGED WELL
⌀	DESTROYED WELL
•	REMEDIATION WELL
– – – – –	AIR SPARGE/VAPOR EXTRACTION LINES
—— - ——	PROPERTY LINE
┼┼┼┼┼┼	RAILROAD TRACK
- - - - -	FORMER BUILDING, TANK OR RR
100	TRICHLOROETHENE IN ug/L
— — —	ISO–CONCENTRATION CONTOUR

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TCE IN GROUNDWATER

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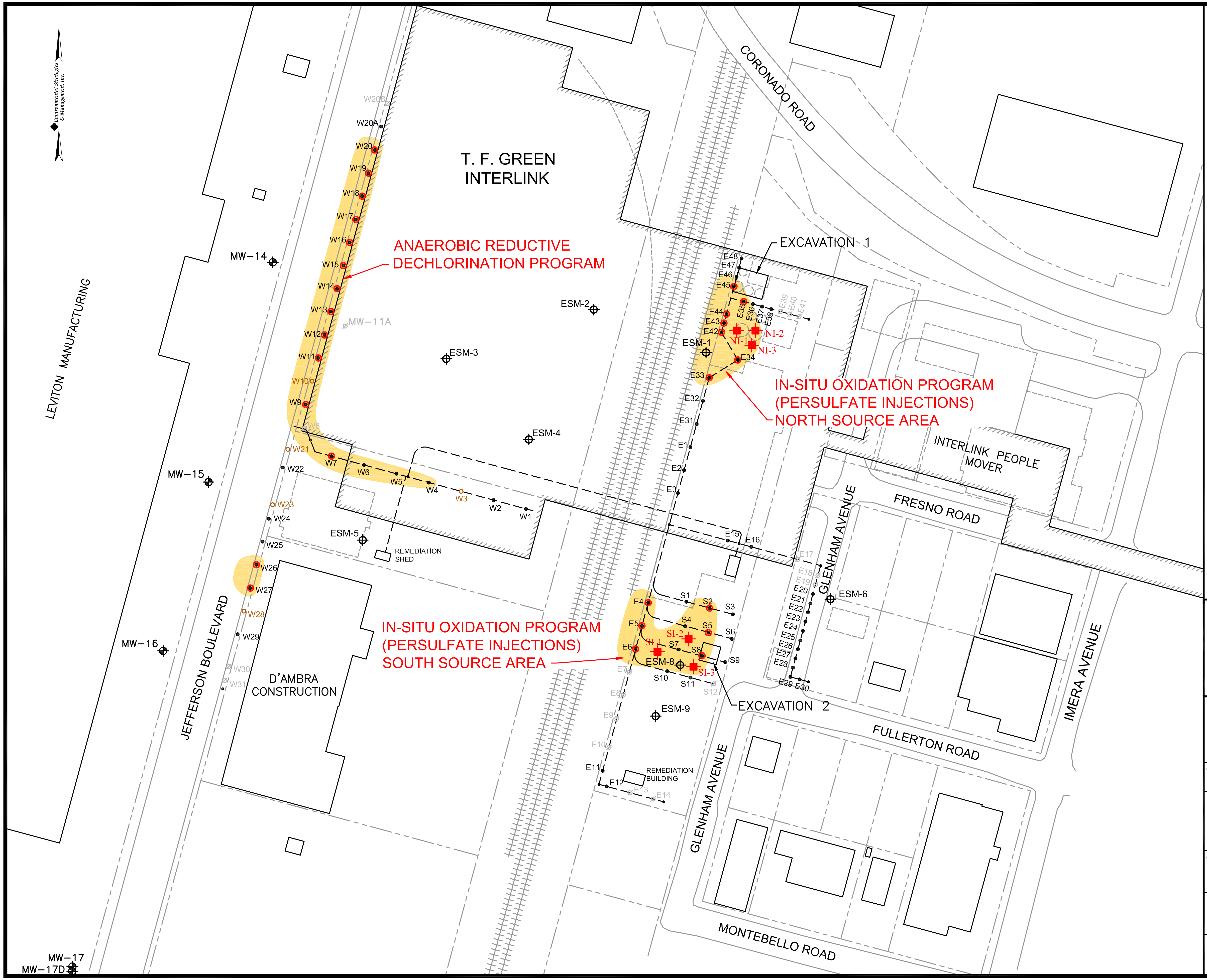
PM: CC
LOCATION: T. F. GREEN INTERLINK WARWICK, RHODE ISLAND
LSP: ––

RIDEM:	DWG:	PROJECT NO.:	FIGURE:
SR-25-0109B	DMR	2014–001	5



LEGEND

⌖	MONITORING WELL
⌖	ES&M MONITORING WELL
○	DAMAGED WELL
⌀	DESTROYED WELL
•	REMEDIATION WELL
— — — —	AIR SPARGE/VAPOR EXTRACTION LINES
—- — - —	PROPERTY LINE
┼┼┼┼┼┼┼┼	RAILROAD TRACK
- - - - - -	FORMER BUILDING, TANK OR RR
■ ○	PROPOSED INJECTION WELL
⬭	ANTICIPATED INITIAL RADIUS OF INFLUENCE

MAP SOURCES: 1) "SITE PLAN, INTERMODEAL STATION, WARWICK, RI", PREPARED BY BETA GROUP, INC., LINCOLN, RI, DATED AUGUST 29, 2011; 2] "SITE REMEDIATION AND BUILDING DEMOLITION" FIGURE PACKAGE PREPARED BY BETA GROUP, INC., LINCOLN, RI AND EDWARDS & KELCEY, PROVIDENCE, RI, DATED JULY 20, 2000; 3) GOOGLE EARTH AERIAL.

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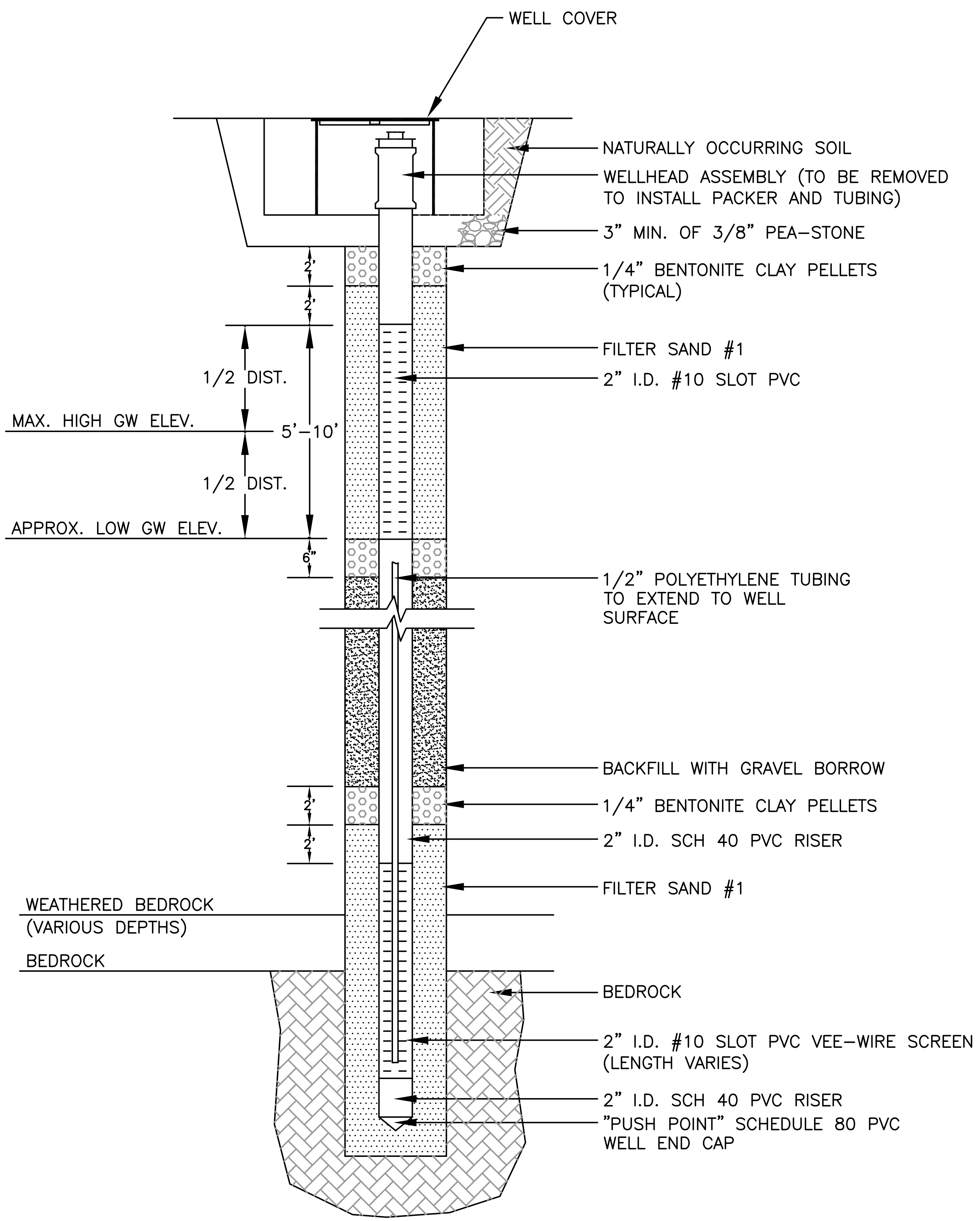
info@esm-inc.com

GAUGING DATE:	DRAWING DATE:	ACAD FILE:
	7/28/15	RIDOT WARWICK 2015

PROPOSED INJECTION WELLS AND ANTICIPATED RADII OF INFLUENCE

CLIENT: RHODE ISLAND DEPARTMENT OF TRANSPORTATION			PM: CC
LOCATION: T. F. GREEN INTERLINK WARWICK, RHODE ISLAND			LSP: — —
RIDEM: SR-25-0109B	DWG: DMR	PROJECT NO.: 2015-001	FIGURE: 6

TYPICAL INJECTION WELL CONSTRUCTION



NOT DRAWN TO SCALE

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Environmental Strategies & Management
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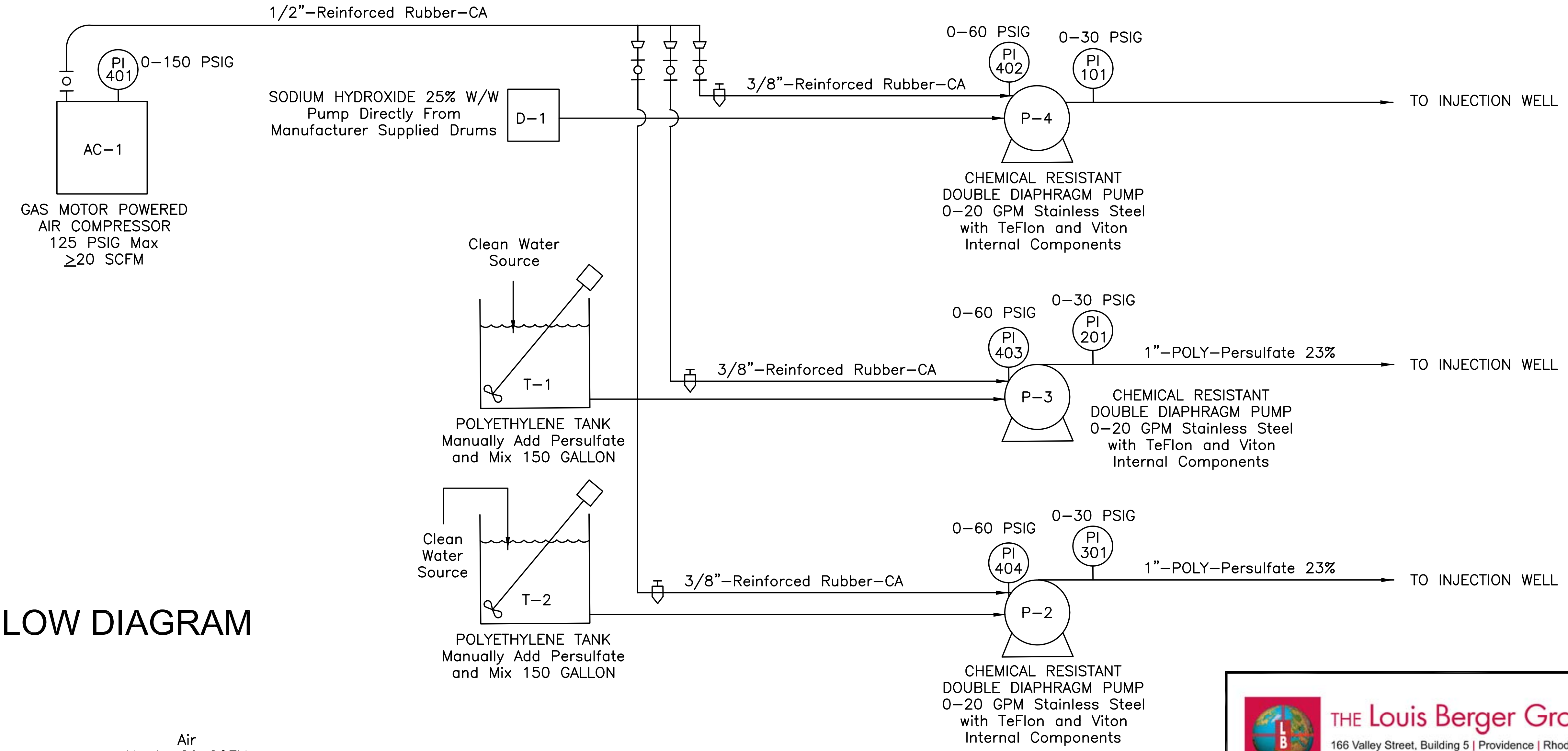
(508) 226-1811 fax
info@esm-inc.com

GAUGING DATE:
DRAWING DATE: 7/28/15
ACAD FILE: RIDOT WARWICK

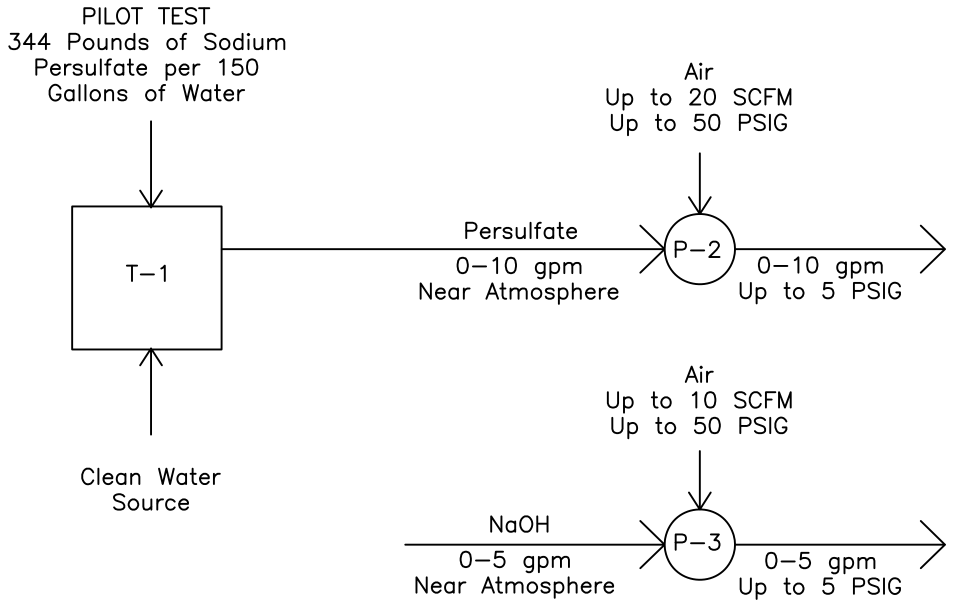
INJECTION WELL CONSTRUCTION

CLIENT: RHODE ISLAND DEPARTMENT OF TRANSPORTATION
PM: CC
LOCATION: T. F. GREEN INTERLINK
WARWICK, RHODE ISLAND
LSP: --
RIDEM: SR-25-0109B
DWG: DMR
PROJECT NO.: 2014-001
FIGURE: 7

PIPING AND INSTRUMENTATION DIAGRAM



PROCESS FLOW DIAGRAM



NOT DRAWN TO SCALE

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(508) 226–1800
(508) 226–1811 fax
info@esm–inc.com

GAUGING DATE:
DRAWING DATE: 7/28/15
ACAD FILE: RIDOT WARWICK

PIPING AND INSTRUMENTATION AND PROCESS FLOW DIAGRAMS

CLIENT: RHODE ISLAND DEPARTMENT OF TRANSPORTATION
PM: CC
LOCATION: T. F. GREEN INTERLINK
WARWICK, RHODE ISLAND
LSP: ––
RIDEM: SR–25–0109B
DWG: DMR
PROJECT NO.: 2014–001
FIGURE: 8

TABLES

TABLE 1
SUMMARY OF
GROUNDWATER ANALTYICAL RESULTS
VOCs by 8260
(Section 1)
Detections Only
T.F. Green InterLink
(Results in ug/L)

Sample ID	Date		TETRACHLOROETHENE	TRICHLOROETHENE	1,1,1-TRICHLOROETHANE	1,2-DICHLOROETHENE	CIS-1,2-DICHLOROETHENE	1,1-DICHLOROETHENE	1,1-DICHLOROETHANE	CHLOROMETHANE
E-1	11/17/14		90	58	6.7	31	31	<1.2	<1.2	<6.2
E-3	11/17/14		620	280	6.2	110	110	<5.0	<5.0	<25
E-4	07/07/15		4400	1900	70	630	630	<25	<25	<120
	01/16/15		3100	1500	57	770	770	<20	<20	<100
	11/18/14		2300	920	120	730	730	<12	<12	<62
E-5	07/07/15		2500	1000	240	100	100	<20	<20	<100
	01/16/15		760	55	140	9.7	9.7	<5.0	<5.0	120
	11/18/14		2500	820	230	790	790	<12	<12	<62
E-6	07/07/15		2300	2200	460	950	950	<20	<20	<100
	01/16/15		1800	1200	360	760	760	<12	<12	<62
	11/18/14		1300	690	240	1600	1600	<10	<10	<50
E-11	11/18/14		38	18	<0.50	2.9	2.9	<0.50	<0.50	<2.5
	11/18/14	Duplicate	88	26	1.6	3.4	3.4	<0.50	<0.50	<2.5
E-12	11/18/14		34	7.2	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5
E-15	11/18/14		770	430	<5.0	980	980	<5.0	<5.0	<25
E-16	11/18/14		170	160	<25	2000	2000	<25	<25	<120
E-20	11/18/14		15	5.2	0.96	0.58	0.58	<0.50	<0.50	<2.5
E-21	11/18/14		34	7.1	1.3	<0.50	<0.50	<0.50	<0.50	<2.5
	11/18/14	Duplicate	37	7.4	1.4	<0.50	<0.50	<0.50	<0.50	<2.5
E-22	11/18/14		6.4	1.8	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5
E-23	11/18/14		19	3.5	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5
E-24	11/18/14		7.3	1.6	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5
E-25	11/18/14		170	12	<2.0	10	10	<2.0	<2.0	<10
E-26	11/18/14		19	3.5	0.59	0.80	0.80	<0.50	<0.50	<2.5
E-27	11/18/14		8.0	1.6	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5
GB Groundwater Objectives			150	540	3100	NA	2400	7	NA	NA

NA - Not applicable

Sample ID	Date	TETRACHLOROETHENE	TRICHLOROETHENE	1,1,1-TRICHLOROETHANE	1,2-DICHLOROETHENE	CIS-1,2-DICHLOROETHENE	1,1-DICHLOROETHENE	1,1-DICHLOROETHANE	CHLOROMETHANE
E-28	11/18/14	2.8	0.80	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5
E-29	11/18/14	3.5	1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5
E-30	11/18/14	2.6	0.85	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5
E-31	11/17/14	59	77	2.6	56	56	3.6	3.6	<2.5
E-32	11/19/14	400	910	24	69	69	67	67	<25
E-33	07/07/15	8000	3400	530	450	450	<50	<50	<250
	01/16/15	4000	1100	780	130	130	<50	<50	<250
	11/17/14	8100	5500	780	860	860	150	150	<500
E-34	07/07/15	72000	29000	4800	890	890	720	720	<1200
	01/16/15	1100	1100	190	390	390	43	43	<50
	11/17/14	38000	48000	12000	2300	2300	3500	3500	<1000
E-35	11/17/14	1800	940	100	240	240	29	29	<120
E-36	11/17/14	190	130	36	98	98	4.9	4.9	<6.2
E-37	11/17/14	66	43	3.9	41	36	1.6	1.6	<2.5
E-38	11/17/14	2700	2000	320	270	270	180	180	<120
E-42	07/07/15	98000	73000	23000	580	580	780	780	<1200
	01/16/15	63000	44000	23000	560	560	480	480	<1000
	11/17/14	71000	60000	27000	740	740	1100	1100	<1200
E-43	07/07/15	51000	11000	4500	1600	1600	<200	<200	<1000
	01/16/15	45000	7300	3900	2000	2000	<200	<200	<1000
	11/17/14	29000	10000	6200	2100	2100	300	300	<250
E-44	11/17/14	13000	5200	2000	1500	1500	230	230	<620
E-45	11/17/14	7000	2500	290	710	710	69	69	<250
E-46	11/17/14	1100	420	52	180	180	23	23	<62
E-47	11/17/14	1600	1000	58	120	120	46	46	<62
E-48	11/17/14	26	22	5.0	1.3	1.3	<0.50	<0.50	<2.5
ESM-1	11/17/14	1400	990	180	290	290	32	32	<25
ESM-2	11/20/14	2000	1000	170	430	430	38	38	<100
ESM-3	11/20/14	410	280	17	270	270	8.9	8.9	<12
ESM-4	11/20/14	980	490	33	330	330	<10	<10	<50
ESM-5	11/21/14	33	31	6.0	25	25	<0.50	<0.50	<2.5
ESM-6	11/18/14	500	650	160	220	220	16	16	<25
GB Groundwater Objectives		150	540	3100	NA	2400	7	NA	NA

NA - Not applicable

Sample ID	Date		TETRACHLOROETHENE	TRICHLOROETHENE	1,1,1-TRICHLOROETHANE	1,2-DICHLOROETHENE	CIS-1,2-DICHLOROETHENE	1,1-DICHLOROETHENE	1,1-DICHLOROETHANE	CHLOROMETHANE
ESM-8	07/07/15		8300	2700	360	60	60	<50	<50	<250
	01/16/15		6600	2300	410	<50	<50	<50	<50	<250
	11/18/14		13000	4900	1200	680	680	<100	<100	<500
ESM-9	11/19/14		230	130	15	150	150	<2.5	<2.5	<12
MW-14	11/21/14		360	330	63	3600	3600	85	85	<100
MW-15	11/21/14		640	1000	140	1100	1100	28	28	<25
MW-16	11/21/14		80	94	18	200	200	3.6	3.6	<2.5
MW-17	11/21/14		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5
W-1	11/20/14		2500	1600	350	1600	1600	29	29	<100
W-2	11/20/14		670	380	49	320	320	<5.0	<5.0	<25
W-3	11/20/14		1200	1200	300	1800	1800	35	35	<62
W-4	11/20/14		1300	1100	250	1400	1400	27	27	<50
W-5	11/20/14		480	590	93	810	810	17	17	<50
W-6	11/20/14		270	290	50	400	400	8.0	8.0	<25
W-7	11/20/14		1300	1200	200	1200	1200	30	30	<50
W-9	11/19/14		780	490	39	440	440	8.6	8.6	<25
W-10	11/19/14		1000	700	62	500	500	14	14	<50
W-11	11/19/14		1700	1200	190	860	860	54	54	<62
	11/19/14	Duplicate	1700	1300	190	880	880	54	54	<62
W-12	11/19/14		1900	1500	270	820	820	84	84	<100
W-13	11/19/14		2100	1800	370	1200	1200	140	140	<62
W-14	11/19/14		71	41	6.1	7.6	7.6	2.4	2.4	<2.5
W-15	11/20/14		240	240	43	170	170	21	21	<12
	11/20/14	Duplicate	580	340	50	280	280	<5.0	<5.0	<25
W-16	11/20/14		590	590	72	510	510	66	66	<25
W-18	11/20/14		380	510	21	490	490	84	84	<25
W-19	11/20/14		720	940	38	840	840	160	160	<50
W-20	11/20/14		480	670	48	480	480	110	110	<25
W-20A	11/20/14		5.7	16	<0.50	4.9	4.9	2.4	2.4	<2.5
W-22	11/19/14		360	660	64	790	790	30	30	<25
W-24	11/19/14		25	35	6.0	62	62	1.7	1.7	<2.5
GB Groundwater Objectives			150	540	3100	NA	2400	7	NA	NA

NA - Not applicable

Sample ID	Date	TETRACHLOROETHENE	TRICHLOROETHENE	1,1,1-TRICHLOROETHANE	1,2-DICHLOROETHENE	CIS-1,2-DICHLOROETHENE	1,1-DICHLOROETHENE	1,1-DICHLOROETHANE	CHLOROMETHANE
W-25	11/19/14	65	120	14	320	320	7.8	7.8	<12
W-26	11/19/14	170	270	55	600	600	12	12	<25
W-27	11/19/14	370	640	36	1100	1100	22	22	<50
W-28	11/19/14	62	71	12	160	160	2.8	2.8	<2.5
W-29	11/19/14	61	37	2.5	24	24	<0.50	<0.50	<2.5
GB Groundwater Objectives		150	540	3100	NA	2400	7	NA	NA

NA - Not applicable

TABLE 1
SUMMARY OF
GROUNDWATER ANALTYICAL RESULTS
VOCs by 8260
(Section 2)

Detections Only
T.F. Green InterLink
(Results in ug/L)

Sample ID	Date		TETRAHYDROFURAN	TOLUENE	XYLENES	METHYL TERT BUTYL ETHER	VINYL CHLORIDE	ACETONE	CHLOROBENZENE	CHLOROFORM	TRANS-1,2-DICHLOROETHENE
E-1	11/17/14		<12	<1.9	<2.5	9.6	<2.5	<12	<1.2	<1.9	<1.9
E-3	11/17/14		<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
E-4	07/07/15		<250	<38	<50	<50	<50	<250	<25	<38	<38
	01/16/15		<200	<30	<40	<40	<40	<200	<20	<30	<30
	11/18/14		<120	<19	<25	<25	<25	<120	<12	<19	<19
E-5	07/07/15		<200	<30	<40	<40	<40	<200	<20	<30	<30
	01/16/15		<50	<7.5	<10	<10	<10	220	<5.0	7.9	<7.5
	11/18/14		<120	<19	<25	<25	<25	<120	<12	<19	<19
E-6	07/07/15		<200	<30	<40	<40	<40	<200	<20	<30	<30
	01/16/15		<120	<19	<25	<25	<25	<120	<12	<19	<19
	11/18/14		<100	<15	<20	<20	<20	<100	<10	<15	<15
E-11	11/18/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
	11/18/14	Duplicate	<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
E-12	11/18/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
E-15	11/18/14		<50	<7.5	<10	<10	17	<50	<5.0	<7.5	<7.5
E-16	11/18/14		<250	<38	<50	<50	74	<250	<25	<38	<38
E-20	11/18/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
E-21	11/18/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
	11/18/14	Duplicate	<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
E-22	11/18/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
E-23	11/18/14		<5.0	<0.75	<1.0	<1.0	<1.0	5.2	<0.50	<0.75	<0.75
E-24	11/18/14		<5.0	<0.75	<1.0	<1.0	<1.0	5.6	<0.50	<0.75	<0.75
E-25	11/18/14		<20	<3.0	<4.0	<4.0	4.0	<20	<2.0	<3.0	<3.0
E-26	11/18/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
E-27	11/18/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
GB Groundwater Objectives			NA	1700	NA	5000	NA	NA	3200	NA	2800

NA - Not applicable

Sample ID	Date	TETRAHYDROFURAN	TOLUENE	XYLENES	METHYL TERT BUTYL ETHER	VINYL CHLORIDE	ACETONE	CHLOROBENZENE	CHLOROFORM	TRANS-1,2-DICHLOROETHENE
E-28	11/18/14	<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
E-29	11/18/14	<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
E-30	11/18/14	<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
E-31	11/17/14	<5.0	<0.75	<1.0	8.5	<1.0	<5.0	<0.50	<0.75	<0.75
E-32	11/19/14	<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
E-33	07/07/15	<500	<75	<100	<100	<100	<500	<50	<75	<75
	01/16/15	<500	<75	<100	<100	<100	<500	<50	<75	<75
	11/17/14	<1000	<150	<200	<200	<200	<1000	<100	<150	<150
E-34	07/07/15	<2500	<380	<500	<500	<500	<2500	<250	<380	<380
	01/16/15	770	<15	<20	<20	<20	270	<10	<15	<15
	11/17/14	<2000	330	<400	<400	<400	<2000	<200	<300	<300
E-35	11/17/14	<250	<38	<50	<50	<50	<250	<25	<38	<38
E-36	11/17/14	<12	<1.9	<2.5	<2.5	15	46	<1.2	<1.9	<1.9
E-37	11/17/14	<5.0	<0.75	<1.0	5.4	4.0	<5.0	<0.50	<0.75	5.3
E-38	11/17/14	<250	<38	<50	<50	<50	<250	<25	<38	<38
E-42	07/07/15	<2500	530	<500	<500	<500	<2500	<250	<380	<380
	01/16/15	<2000	420	<400	<400	<400	<2000	<200	<300	<300
	11/17/14	<2500	540	<500	<500	<500	<2500	<250	<380	<380
E-43	07/07/15	<2000	<300	<400	<400	<400	<2000	<200	<300	<300
	01/16/15	<2000	<300	<400	<400	<400	<2000	<200	<300	<300
	11/17/14	<500	91	130	<100	<100	<500	<50	<75	<75
E-44	11/17/14	<1200	<190	<250	<250	<250	<1200	<120	<190	<190
E-45	11/17/14	<500	<75	<100	<100	<100	<500	<50	<75	<75
E-46	11/17/14	<120	<19	<25	<25	<25	<120	<12	<19	<19
E-47	11/17/14	<120	<19	<25	<25	<25	<120	<12	<19	<19
E-48	11/17/14	<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
ESM-1	11/17/14	<50	<7.5	<10	12	<10	<50	<5.0	<7.5	<7.5
ESM-2	11/20/14	<200	<30	<40	<40	<40	<200	<20	<30	<30
ESM-3	11/20/14	<25	<3.8	<5.0	14	<5.0	<25	5.3	<3.8	<3.8
ESM-4	11/20/14	<100	<15	<20	<20	<20	<100	<10	<15	<15
ESM-5	11/21/14	<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
ESM-6	11/18/14	<50	<7.5	<10	10	<10	<50	<5.0	<7.5	<7.5
GB Groundwater Objectives		NA	1700	NA	5000	NA	NA	3200	NA	2800

NA - Not applicable

Sample ID	Date		TETRAHYDROFURAN	TOLUENE	XYLENES	METHYL TERT BUTYL ETHER	VINYL CHLORIDE	ACETONE	CHLOROBENZENE	CHLOROFORM	TRANS-1,2-DICHLOROETHENE
ESM-8	07/07/15		<500	<75	<100	<100	<100	<500	<50	<75	<75
	01/16/15		<500	<75	<100	<100	<100	<500	<50	<75	<75
	11/18/14		<1000	<150	<200	<200	<200	<1000	<100	<150	<150
ESM-9	11/19/14		<25	<3.8	<5.0	<5.0	<5.0	<25	<2.5	5.1	<3.8
MW-14	11/21/14		<200	<30	<40	<40	<40	<200	<20	<30	<30
MW-15	11/21/14		<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
MW-16	11/21/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	1.0
MW-17	11/21/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
W-1	11/20/14		<200	<30	<40	<40	<40	<200	38	<30	<30
W-2	11/20/14		<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
W-3	11/20/14		<120	<19	<25	<25	<25	<120	13	<19	<19
W-4	11/20/14		<100	<15	<20	<20	<20	<100	37	<15	<15
W-5	11/20/14		<100	<15	<20	<20	<20	<100	23	<15	<15
W-6	11/20/14		<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
W-7	11/20/14		<100	<15	<20	<20	<20	<100	34	<15	<15
W-9	11/19/14		<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
W-10	11/19/14		<100	<15	<20	<20	<20	<100	<10	<15	<15
W-11	11/19/14		<120	<19	<25	<25	<25	<120	<12	<19	<19
	11/19/14	Duplicate	<120	<19	<25	<25	<25	<120	<12	<19	<19
W-12	11/19/14		<200	<30	<40	<40	<40	<200	<20	<30	<30
W-13	11/19/14		<120	<19	<25	<25	<25	<120	<12	<19	<19
W-14	11/19/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
W-15	11/20/14		<25	<3.8	<5.0	<5.0	<5.0	<25	<2.5	<3.8	<3.8
	11/20/14	Duplicate	<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
W-16	11/20/14		<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
W-18	11/20/14		<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
W-19	11/20/14		<100	<15	<20	<20	<20	<100	<10	<15	<15
W-20	11/20/14		<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
W-20A	11/20/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
W-22	11/19/14		<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
W-24	11/19/14		<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	<0.75
GB Groundwater Objectives			NA	1700	NA	5000	NA	NA	3200	NA	2800

NA - Not applicable

Sample ID	Date	TETRAHYDROFURAN	TOLUENE	XYLENES	METHYL TERT BUTYL ETHER	VINYL CHLORIDE	ACETONE	CHLOROBENZENE	CHLOROFORM	TRANS-1,2-DICHLOROETHENE
W-25	11/19/14	<25	<3.8	<5.0	<5.0	<5.0	<25	<2.5	<3.8	<3.8
W-26	11/19/14	<50	<7.5	<10	<10	<10	<50	<5.0	<7.5	<7.5
W-27	11/19/14	<100	<15	<20	<20	<20	<100	<10	<15	<15
W-28	11/19/14	<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	<0.75	1.0
W-29	11/19/14	<5.0	<0.75	<1.0	<1.0	<1.0	<5.0	<0.50	1.6	<0.75
GB Groundwater Objectives		NA	1700	NA	5000	NA	NA	3200	NA	2800

NA - Not applicable

APPENDIX 1

RESPONSE DOCUMENT

Environmental
Strategies
& Management

Environmental Strategies & Management, Inc.
273 West Main Street, Norton, MA 02766
Tel: (508) 226-1800 ◆ Fax: (508) 226-1811 ◆ www.esm-inc.com

The Louis Berger Group, Inc.
166 Valley Street, Building 5 | Providence | Rhode Island | 02909
Tel 401.521.5980 | fax 401.331.8956 | www.louisberger.com

RAWP COMMENT LETTER
File No. SR-35-109A
(Formerly Case No. 93-031)

DEPARTMENT COMMENTS
June 12, 2015

Limited Design Investigation report, dated February 25, 2015, received March 20, 2015
T.H. Baylis (T.F. Green Interlink)
Warwick, Rhode Island

1. Regarding Section 3.5 (Clean Water Testing) – How many gallons of water were injected into each well during the clean water injection tests?

   During the clean water injection testing, each well received the following volume of water:

   - November 24, 2014
     - E-20: five gallons
     - E-21: six gallons
     - E-22: two gallons
     - E-23: thirty-four gallons
     - ESM-6: thirty-six gallons
   - December 1, 2014
     - S-7: one gallon
     - S-8: twenty-five gallons
     - S-10: eighteen gallons
     - S-11: zero gallons
     - E-5: twenty-two gallons
     - E-34: fifty-one gallons
     - E-42: sixty-three gallons

2. Regarding Section 3.7 (Post-Injection Groundwater Monitoring):

a. In the eight (8) wells where post-injection groundwater samples were collected for volatile organic compound (VOC) laboratory analysis on January 16, 2015, were the concentrations of unreacted persulfate in groundwater measured in each well prior to sample collection?

On December 12, 2014 the following persulfate concentrations were measured: E-5 (32 g/L), E-33 (44 g/L), and ESM-8, (0 g/L). Groundwater samples were not collected for laboratory VOC analyses.

On December 31, 2014 the following persulfate concentrations were measured: E-5, (26 g/L), and E-33 (38 g/L). Groundwater samples were not collected for laboratory VOC analyses.

On January 16, 2015 the following persulfate concentrations were measured: E-33(8.5 g/L), E-34 (10.2 g/L), E-42 (5.1 g/L), E-43 (0 g/L), ESM-8 (0 g/L), E-4 (0 g/L), E-5 (8.5 g/L), and E-6 (0 g/L). Groundwater samples were collected on this date for laboratory VOC analysis.

The samples were placed on ice immediately after collection. Reductant was not added to the samples to quench residual persulfate. The concentration of persulfate injected at wells E-34 and E-42 (activated by sodium hydroxide) and injected at wells E-5, S-8, S-10 and S-11 was 308 g/L. By the time groundwater samples were collected on January 16, 2015 the persulfate concentrations had been reduced by at least 96%. CVOCs could have been oxidized in the sample vials but because the temperature of the sample was reduced and maintained at <4^{o}C, the oxidation reactions would have occurred at a slower rate than in the aquifer where the groundwater temperature was approximately 10^{o}C.

b. Were the concentrations of unreacted persulfate reported?

The concentrations of unreacted persulfate were not reported in the LDI Report.

c. Was the unreacted persulfate quenched promptly when the samples were collected?

No, the samples were preserved in accordance with the method protocol and were placed on ice. If preferred by RIDEM, future samples containing unreacted persulfate can be quenched by adding ascorbic acid to the sample vials.

3. Regarding Section 4.1 (Pilot Test #1 – activated persulfate) – The fourth bulleted item indicates that *"Five weeks after activated persulfate injection at E-34, the monitoring results indicate that persulfate and elevated pH persist at E-34."* Since the concentration of persulfate persists in E-34, how can an accurate measure of the chlorinated volatile organic compound (CVOC) reduction in groundwater be determined?

A second set of groundwater samples were collected from the Pilot Test #1 wells on July 7, 2015, more than six months after in-situ oxidation injection was completed. By the time these samples were collected persulfate was not detected in any of the water samples. The purpose of these samples was to assess the amount of concentration "rebound" a phenomenon that is common following oxidant injection events into areas where there is considerable mass of CVOCs. The results and the percentage change from the pre-test results are summarized in Table 1.

Table 1
Concentrations of CVOC
Pilot Test #1 (pH activated persulfate – North Source Area)
November 2014 – July 2015

	Pre-Test (µg/L)	6 months Post Test (µg/L)	Change
E-33			
1,1,1-TCA	780	530	-32%
1,1-DCA	250	170	-32%
1,1-DCE	150	<50	->67%
1,2-DCE	860	450	-47%
PCE	8,100	8,000	-1.2%
TCE	5,500	3,400	-38%
E-34			
1,1,1-TCA	12,000	4,800	-60%
1,1-DCA	<300	<300	

1,1-DCE	3,500	720	-80%
1,2-DCE	2,300	890	-61%
PCE	38,000	72,000	+89%
TCE	48,000	29,000	-40%
E-42			
1,1,1-TCA	27,000	23,000	-15%
1,1-DCA	<380	<380	
1,1-DCE	1,100	780	-29%
1,2-DCE	740	580	-22%
PCE	71,000	98,000	+38%
TCE	66,000	73,000	+22%
E-43			
1,1,1-TCA	27,000	23,000	-27%
1,1-DCA	<380	<380	
1,1-DCE	1,100	780	->33%
1,2-DCE	740	580	-48%
PCE	71,000	98,000	+76%
TCE	66,000	73,000	+10%

The results indicate that the PCE and TCE concentrations rebounded considerably. The pilot test results are somewhat difficult to interpret because the available well array limits our evaluation to only the injection wells and two wells located side-gradient of each injection well. Ideally, results from groundwater samples collected from wells located various distances and directions from the injection site would be evaluated.

Conclusion: The increase in PCE concentration in three of the four sample sets may be concerning. The pilot test was not designed to identify the mechanisms responsible for concentration changes only to measure the changes. It is ES&M's opinion that there is considerable mass of PCE and TCE adsorbed to soil (or trapped in soil pores) in the vicinity of injection wells E-34 and E-42. PCE/TCE was likely liberated from soil and dissolved into groundwater as a result of temporary groundwater chemistry changes and/or disturbances caused by the movement of fluids during the injection event. Since the key to successful in-situ oxidation is to encourage collisions between CVOC molecules and persulfate molecules, encouraging PCE/TCE to transfer from soil and soil pores into groundwater may be a necessary step. Molecular collisions are more likely when the CVOCs are dissolved in groundwater than when they are adsorbed to soil or trapped in soil pores. We do however, want to caution all stakeholders that the scenario described above is opinion and more study would be needed to better understand why PCE and TCE concentration increases were measured at wells E-34 (PCE only), E-42 and E-43.

4. Regarding Section 4.2 (Pilot Test #2 – persulfate without activation):
    a. The second bulleted item indicates that *"Five weeks after the persulfate injection, the concentration of CVOC's at well E-5 were 70% lower than the pre-test baseline results."* What was the concentration of persulfate in this persulfate injection well when the post-injection groundwater sample was collected?

The persulfate concentration was 8.5 g/L. A second set of post-injection groundwater samples were collected from wells E-4, E-5, E-6, and ESM-8 to evaluate possible concentrations "rebounds" in the pilot test #2 area.

A second set of groundwater samples were collected from the Pilot Test #1 wells on July 7, 2015, more than six months after the pilot test in-situ oxidation injection was completed. By the time these samples were collected persulfate was not detected in any of the water samples. The results and the percentage change from the pre-test results are summarized in Table 2.

Table 2

Concentrations of CVOC

Pilot Test #2 (un-activated persulfate – South Source Area)

November 2014 – July 2015

	Pre-Test (µg/L)	**6 Months Post Test (µg/L)**	**Change**
E-4			
1,1,1-TCA	120	70	-42%
1,1-DCA	<75	<300	

1,1-DCE	<12	<25	
1,2-DCE	730	630	-14%
PCE	2,300	4,400	+91%
TCE	920	1,900	+107%
E-5			
1,1,1-TCA	230	240	+4.3%
1,1-DCA	<19	<30	
1,1-DCE	<12	<20	
1,2-DCE	790	100	-87%
PCE	2,500	2,500	0%
TCE	820	1,000	+22%
E-6			
1,1,1-TCA	240	460	+92%
1,1-DCA	<19	<30	
1,1-DCE	<10	<20	
1,2-DCE	1,600	950	-41%
PCE	1,300	2,300	+77%
TCE	690	2,200	+219%
ESM-8			
1,1,1-TCA	1,200	860	-28%
1,1-DCA	150	<75	->50%
1,1-DCE	<150	<50	
1,2-DCE	680	60	-91%
PCE	13,000	8,300	-36%
TCE	4,700	2,700	-36%

Conclusion: The concentration reductions measured at ESM-8 are very encouraging and likely an indication that good distribution of oxidant around the monitoring well promotes good oxidant/CVOC contact and more favorable results. However, the results from the other three wells are not encouraging and ES&M is not recommending any additional application of un activated persulfate.

b. The seventh bulleted item indicates that *"Acetone, chloromethane and chloroform were detected (at low concentrations) in the post-injection groundwater sample collected from well E-5. Chloroform could be a by-product of incomplete destruction of 1,1,1-TCA. Chloromethane is a possible by-product of incomplete destruction of 1,1,1-TCA, PCE, and/or TCE. Acetone is not likely related to persulfate reactions with any of these CVOCs."* Chloroform is also a common disinfection byproduct produced during chlorination of water. Is it possible or likely that the presence of chloroform may be a residual of the clean water injection testing performed on well E-5?

Potable water, used in the clean water test to determine if the well would likely accept oxidant solution, was not submitted for laboratory analysis to determine the chloroform concentration. To determine if chloroform would be expected in the water, the 2013 Public Confidence Report for the City of Warwick public water supply (http://www.warwickri.gov/pdfs/water/2013%20Consumer%20Confidence%20Report.pdf) was consulted. Chloroform was not reported.

5. Regarding Section 5.0 (Recommended In-Situ Oxidation Approach) – This section indicates that one of the primary goals of the in-situ program is *"to reduce the concentration of all CVOC to less than RIDEM's upper concentration limits."* On October 24, 2000, the department issued an Order of Approval for the Baylis Site which specified in Item 7 that *"The groundwater remedial objective shall be to meet the Department's Method 1 GB Groundwater Objectives both on-site and downgradient of the Site, in accordance with the Remediation Regulations."* Please be reminded that the Department's Method 1 GB Groundwater Objectives are still the on-site and downgradient groundwater remedial objectives. The department's Upper Concentration Limits (UCLs) may be used as a short-term remedial goal, but the long-term remedial goal for Site remains the Method 1 GB Groundwater Objectives.

It is understood that the ultimate goal is to reduce the concentrations of all CVOCs to less than the GB standards. ES&M and Louis Berger want all stakeholders to understand that the proposed in-situ oxidation program and the down gradient anaerobic reductive dechlorination zone will not likely achieve the GB standards at all site-related groundwater monitoring wells for many years. The interim goals of the remedies are to reduce the mass of CVOCs in the two known source areas such that the flux of CVOCs migrating in groundwater away from these source areas is reduced. This will allow natural attenuation process, enhanced by the formation of an anaerobic reductive dechlorination zone in the vicinity of Jefferson Boulevard to further reduce CVOC concentrations in groundwater over time.

More aggressive application of in-situ oxidation is limited by access issues that prohibit installation of additional injection wells or injection galleries inside the parking structure or in close proximity to the railroad tracks. And more aggressive remediation is not critical because the design of the parking structure is ideal in that it minimizes potential vapor intrusion issues typically associated with CVOC releases.

6. Regarding Section 5.4 (Monitoring After Injection) – The second bulleted item indicates that “Persulfate concentrations will be monitored at five wells only.” Please clarify why persulfate will only be measured at five wells and list the five proposed wells where persulfate will be measured.

Section 4.4 covers the in-situ oxidation injections. The monitoring plan will be amended to include persulfate monitoring at all 28 wells.

Section 4.4 (Monitoring after Injection) will now state:
There are twenty-eight wells included in the monitoring program. They are as follows:

- North Source Area
    - Injection wells: E-33, E-34, E-35, E-42, E-43, E-44, E-45, NI-1, NI-2, and NI-3

  - Monitoring wells: E-32, E-36, E-46, ESM-1, ESM-2, ESM-3, and ESM-4
- South Source Area
  - Injection wells: E-4, E-5, E-6, S-2, S-5, S-8, SI-1, SI-2, and SI-3
  - Monitoring wells: ESM-8 and ESM-9

Monthly for three months after each injection event, the following field groundwater quality measurements will be taken at the twenty-eight wells:

- Dissolved oxygen, pH and ORP
- Persulfate concentrations

Groundwater samples will be collected from the twenty-eight wells and will be submitted for VOC analysis by EPA Method 8260 between oxidant injection events or at a minimum of once per year.

7. Regarding Section 5.5 (Schedule of In-Situ Oxidation Activities) - Please clarify why no groundwater laboratory analysis is proposed after injection #2 and before injection #3. Groundwater samples will be collected for laboratory analysis 4 to 6 months after each injection event. If unreacted persulfate is detected the groundwater sample set will not be collected. This is covered under Section 4.5.

8. Regarding Section 6.0 (Anaerobic Reductive Dechlorination Program) – The OWM is not familiar with Peroxychem or its EHC® Liquid Amendment, and is not aware of any Rhode Island site where it has been used. Please address the following comments and questions:

   a. Please provide documentation or case studies for other sites (preferably sites that the responder is familiar with) where the Peroxychem or its EHC® Liquid Amendment has been used successfully on similar concentrations of the CVOCs impacting groundwater at the Baylis site.

   See attached PeroxyChem information regarding the use of EHC® Liquid Amendment included in RAWP Appendix 4.

b. Please include a statement from the Professional Engineer supervising the preparation of the remedy design standards and technical specifications (see comment 9.a below) indicating that they have reviewed the proposed anaerobic reductive dechlorination program and in their professional opinion have determined that the proposed program represents a sound and appropriate remedial approach for the site and that the site conditions are conducive to anaerobic reductive dechlorination.

A statement completed by Clayton Carlisle, a Professional Engineer registered in the State of Rhode Island will be included in the revised RAWP.

c. What is the rate of groundwater velocity across the site in ft/day?

The rate of groundwater velocity across the site has not been well documented by previous consultants in any publications available to ES&M or Louis Berger. Groundwater flow direction is thought to be flowing west by southwest. In order to calculate the horizontal groundwater velocity across the site, the hydraulic gradient, hydraulic conductivity and soil porosity must be determined for the site.

Using groundwater elevations published in Table 4-3 of the "Plume Delineation Assessment" (January 1999) by Beta Engineering, Inc., a hydraulic gradient across the site can be estimated. A groundwater elevation change of 7.99 feet across a distance of 610 feet between wells MW-4 and MW-15 can be used to estimate a gradient of 0.013 feet per foot.

In the "Remedial Action Work Plan – Hydrogeological Characterization Report" (November 1999) by Beta Engineering, Inc., a series of pump tests were conducted to determine the hydraulic conductivity at several monitoring wells at the site. MW-25A, which was reportedly screened across glacial till and bedrock, was determined to have a hydraulic conductivity of 3.05 ft/day and an estimated porosity of 40%. Utilizing these values, a groundwater velocity across the site of 0.1 ft/day can be estimated.

d. Is there potential for the activated persulfate from the injection areas 1 and 2 to migrate into the proposed reductive dechlorination zone, and if so, what impact would this have?

No, given the distance between the injection areas and the anaerobic reductive dechlorination zone (nearly 400 feet) the in-situ oxidation program will not negatively impact the anaerobic reductive dechlorination program. It is possible that over time sulfate concentrations in groundwater could increase downgradient of the in-situ oxidation areas. Since sulfate can act as an electron acceptor in anaerobic degradation processes, increased sulfate concentrations in groundwater would benefit the anaerobic reductive dechlorination remedy.

e. What is the anticipated effective radius of influence of the injection reagents around each injection well?

The effective radius of influence has not been evaluated by pilot testing. The flowing calculations illustrate the theoretical cylinder around each well screen where the injected fluid will displace groundwater. After injection the fluid will move with groundwater with reactions occurring until agents area expended.

<u>In-situ Oxidation</u>

Because subsurface soils are relatively impermeable and some of the existing wells selected for repurposing as injection wells are aging. These older wells may not have perfect seals so limiting the oxidant volume by setting the solution strength at 23% w/w (275 grams/liter) increases that chances that injections can be completed without forcing fluid up the well bore. The downside is that the volume of groundwater displaced by the oxidant solution will be small. Advection, dispersion, and diffusion will help to disperse the injected oxidant. If it is determined during the first injection event that the well array can accept greater fluid volumes, it may be prudent to reduce the oxidant solution strength from to 23% w/w to 10% w/w.

Reductive Dechlorination

The proposed approach is to inject a total volume of 67,800 gallons of the recommended reagents into sixteen W-series wells and well ESM-5. Each well would therefore receive 4,000 gallons or 540 cubic feet of the EHC reagents. If the average aquifer thickness in the vicinity of the W-series wells is approximately 20 feet and the soil porosity is 30%, the injected fluid will fill the soil pores of a 20 foot tall cylinder 5.4 feet from each injection well. The forces of advection, dispersion and diffusion will distribute the reagent as groundwater moves slowly toward the west/southwest.

f. Please provide a site figure showing the anticipated extent of the proposed reductive dechlorination zone, and the extents of the two persulfate injection areas, based upon planned injection well locations and anticipated effective radii of influence.

Due to constraints with well spacing and layout the pilot test program was not designed to define a radius of influence. A figure will be prepared using professional judgement but the radii will not be based primarily on field measurements made during the pilot test.

g. Why is there no proposed injection into wells W-1 through W-6?

The anaerobic reductive dechlorination zone was intended to mitigate the flux of CVOCs from east to west across Jefferson Boulevard. Wells found to be in acceptable condition and installed on the east side of Jefferson Boulevard were included. The anaerobic reductive dechlorination zone has been expanded by injecting the remedial agent into wells ESM-5, W-5 and W-6.

h. Has the Site been thoroughly evaluated for the presence of any underground utilities or subsurface structures, in or near locations where injections are proposed, that could potentially create preferential pathways or result in unanticipated and/or uncontrolled migration of the injected reagents?

Yes, construction drawings provided by RIDOT have been reviewed.

i. It is the Department's opinion that several additional downgradient compliance groundwater monitoring points are necessary. The Department requires that groundwater monitoring wells be installed to an appropriate depth and screened interval at the following locations:

    i. North of MW-14;
    ii. Between MW-14 and MW-15; and
    iii. Between MW-15 and MW-16

    These new monitoring wells should be included in the quarterly monitoring described in Section 6.3 (Monitoring After Injection) and added to the groundwater sample VOC laboratory analysis proposed for samples collected from W-13, W-16, W-20, W-27 MW—14, MW-15, MW-16 and MW-17.

RIDOT will request access to the down gradient property for the purpose of installing groundwater monitoring wells and periodically collecting groundwater samples. At the time of the last site visit in July the area where additional wells are required was inaccessible, covered by piles of demolition rubble. It is not known if access will be granted by the current owner nor is it known when the area may be assessable.

9. The Department has reviewed the proposed remedy portion of the LDI Report, specifically Sections 5 and 6, as it would a draft Remedial Action Work Plan (RAWP) in accordance with the <u>Remedial Regulations</u>. As such the following items must be addressed in order for the Department to issue an Order of Approval:
    a. In accordance with Rule 9.10 (Design Standards and Technical Specification) all design standards and technical specifications necessary for the design of the proposed remedy must be prepared under the supervision of a Registered Professional Engineer in the State of Rhode Island, and stamped by that engineer prior to submittal.

Clayton Carlisle, P.E. will provide the certification.

b. In accordance with Rule 9.12 (Effluent Disposal) please provide details regarding the proposed management and disposal of any impacted soil, groundwater, products or by-products generated during implementations of the remedy.

The only waste material anticipated is soil from drill cuttings that may be generated if additional wells as described in question/comment 8i are installed. Soil cuttings will be placed in steel drums, labeled and secured. Soil samples will be characterized for disposal and the soil will be disposed in accordance with applicable requirements.

c. During mobilization, setup and implementation of the remedial action, brief monthly email project updates should be submitted to the Department. Once monitoring activities are initiated, Quarterly Monitoring Reports should be prepared and submitted to the Department in hard copy and electronically (PDF via either email or CD).

10. Regarding Figure 3 (Total VOCs in Groundwater), location E-30 indicates total VOCs at 264.7 µg/L, however this total concentration is not consistent with the results provided in the analytical laboratory data report for E-30 included in Appendix B. Please clarify this discrepancy and if this is a typographical or transcription error, please correct Figure 3.

Only tetrachloroethene (2.6 µg/L) and trichloroethene (0.85 µg/L) were detected in the groundwater sample collected from well E-30 on November 18, 2014. The total CVOC concentration was 3.5 µg/L and the report will be revised to reflect this correction.

11. Regarding Figure 5 (Tetrachloroethene in Groundwater), location E-25 indicates a tetrachloroethene concentration of 170 µg/L, and therefore should be included within the 150 µg/L iso-concentration contour line. Please correct Figure 5.

The tetrachloroethylene concentration reported in the groundwater sample collected from E-25 is not consistent with the result reported at other nearby E-series wells and was therefore excluded from the 170 µg/L iso-concentration contour. The figure has been revised.

12. Please submit a RAWP addendum that addresses the abovementioned comments on or before July 31, 2015.

APPENDIX 2

LABORATORY REPORT
GROUNDWATER

ANALYTICAL REPORT

Lab Number:	L1515555
Client:	Louis A. Berger & Associates 166 Valley St. Bldg 5 Providence, RI 02909
ATTN:	Clayton Carlisle
Phone:	(401) 521-5980
Project Name:	BAYLIS REMEDIATION
Project Number:	20001847.003.002
Report Date:	07/15/15

Certifications & Approvals: MA (M-MA086), NY (11148), CT (PH-0574), NH (2003), NJ NELAP (MA935), RI (LAO00065), ME (MA00086), PA (68-03671), VA (460195), MD (348), IL (200077), NC (666), TX (T104704476), DOD (L2217), USDA (Permit #P-330-11-00240).

Eight Walkup Drive, Westborough, MA 01581-1019
508-898-9220 (Fax) 508-898-9193 800-624-9220 - www.alphalab.com

Project Name:	BAYLIS REMEDIATION	**Lab Number:**	L1515555
Project Number:	20001847.003.002	**Report Date:**	07/15/15

Alpha Sample ID	Client ID	Matrix	Sample Location	Collection Date/Time	Receive Date
L1515555-01	E-4	WATER	WARWICK, RI	07/07/15 07:58	07/08/15
L1515555-02	E-5	WATER	WARWICK, RI	07/07/15 08:44	07/08/15
L1515555-03	E-6	WATER	WARWICK, RI	07/07/15 09:24	07/08/15
L1515555-04	ESM-8	WATER	WARWICK, RI	07/07/15 09:58	07/08/15
L1515555-05	E-33	WATER	WARWICK, RI	07/07/15 11:18	07/08/15
L1515555-06	E-34	WATER	WARWICK, RI	07/07/15 11:54	07/08/15
L1515555-07	E-42	WATER	WARWICK, RI	07/07/15 12:30	07/08/15
L1515555-08	E-43	WATER	WARWICK, RI	07/07/15 13:00	07/08/15
L1515555-09	TRIP BLANK	WATER	WARWICK, RI	07/07/15 00:00	07/08/15

Project Name:	BAYLIS REMEDIATION	**Lab Number:**	L1515555
Project Number:	20001847.003.002	**Report Date:**	07/15/15

Case Narrative

The samples were received in accordance with the Chain of Custody and no significant deviations were encountered during the preparation or analysis unless otherwise noted. Sample Receipt, Container Information, and the Chain of Custody are located at the back of the report.

Results contained within this report relate only to the samples submitted under this Alpha Lab Number and meet all of the requirements of NELAC, for all NELAC accredited parameters. The data presented in this report is organized by parameter (i.e. VOC, SVOC, etc.). Sample specific Quality Control data (i.e. Surrogate Spike Recovery) is reported at the end of the target analyte list for each individual sample, followed by the Laboratory Batch Quality Control at the end of each parameter. Tentatively Identified Compounds (TICs), if requested, are reported for compounds identified to be present and are not part of the method/program Target Compound List, even if only a subset of the TCL are being reported. If a sample was re-analyzed or re-extracted due to a required quality control corrective action and if both sets of data are reported, the Laboratory ID of the re-analysis or re-extraction is designated with an "R" or "RE", respectively. When multiple Batch Quality Control elements are reported (e.g. more than one LCS), the associated samples for each element are noted in the grey shaded header line of each data table. Any Laboratory Batch, Sample Specific % recovery or RPD value that is outside the listed Acceptance Criteria is bolded in the report. All specific QC information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications. Soil/sediments, solids and tissues are reported on a dry weight basis unless otherwise noted. Definitions of all data qualifiers and acronyms used in this report are provided in the Glossary located at the back of the report.

In reference to questions H (CAM) or 4 (RCP) when "NO" is checked, the performance criteria for CAM and RCP methods allow for some quality control failures to occur and still be within method compliance. In these instances the specific failure is not narrated but noted in the associated QC table. The information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications.

Please see the associated ADEx data file for a comparison of laboratory reporting limits that were achieved with the regulatory Numerical Standards requested on the Chain of Custody.

HOLD POLICY

For samples submitted on hold, Alpha's policy is to hold samples (with the exception of Air canisters) free of charge for 21 calendar days from the date the project is completed. After 21 calendar days, we will dispose of all samples submitted including those put on hold unless you have contacted your Client Service Representative and made arrangements for Alpha to continue to hold the samples. Air canisters will be disposed after 3 business days from the date the project is completed.

Please contact Client Services at 800-624-9220 with any questions.

I, the undersigned, attest under the pains and penalties of perjury that, to the best of my knowledge and belief and based upon my personal inquiry of those responsible for providing the information contained in this analytical report, such information is accurate and complete. This certificate of analysis is not complete unless this page accompanies any and all pages of this report.

Authorized Signature: Lisa l. Westerlind Lisa Westerlind

Title: Technical Director/Representative

Date: 07/15/15

ORGANICS

VOLATILES

SAMPLE RESULTS

Lab ID:	L1515555-01	D	Date Collected:	07/07/15 07:58
Client ID:	E-4		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified
Matrix:	Water			
Analytical Method:	1,8260C			
Analytical Date:	07/10/15 18:19			
Analyst:	PD			

Parameter	**Result**	**Qualifier**	**Units**	**RL**	**MDL**	**Dilution Factor**
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	150	--	50
1,1-Dichloroethane	ND		ug/l	38	--	50
Chloroform	ND		ug/l	38	--	50
Carbon tetrachloride	ND		ug/l	25	--	50
1,2-Dichloropropane	ND		ug/l	88	--	50
Dibromochloromethane	ND		ug/l	25	--	50
1,1,2-Trichloroethane	ND		ug/l	38	--	50
Tetrachloroethene	4400		ug/l	25	--	50
Chlorobenzene	ND		ug/l	25	--	50
Trichlorofluoromethane	ND		ug/l	120	--	50
1,2-Dichloroethane	ND		ug/l	25	--	50
1,1,1-Trichloroethane	70		ug/l	25	--	50
Bromodichloromethane	ND		ug/l	25	--	50
trans-1,3-Dichloropropene	ND		ug/l	25	--	50
cis-1,3-Dichloropropene	ND		ug/l	25	--	50
1,3-Dichloropropene, Total	ND		ug/l	25	--	50
1,1-Dichloropropene	ND		ug/l	120	--	50
Bromoform	ND		ug/l	100	--	50
1,1,2,2-Tetrachloroethane	ND		ug/l	25	--	50
Benzene	ND		ug/l	25	--	50
Toluene	ND		ug/l	38	--	50
Ethylbenzene	ND		ug/l	25	--	50
Chloromethane	ND		ug/l	120	--	50
Bromomethane	ND		ug/l	50	--	50
Vinyl chloride	ND		ug/l	50	--	50
Chloroethane	ND		ug/l	50	--	50
1,1-Dichloroethene	ND		ug/l	25	--	50
trans-1,2-Dichloroethene	ND		ug/l	38	--	50
1,2-Dichloroethene, Total	630		ug/l	25	--	50
Trichloroethene	1900		ug/l	25	--	50

Project Name:	BAYLIS REMEDIATION	**Lab Number:**	L1515555
Project Number:	20001847.003.002	**Report Date:**	07/15/15

SAMPLE RESULTS

Lab ID:	L1515555-01	D	Date Collected:	07/07/15 07:58
Client ID:	E-4		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2-Dichlorobenzene	ND		ug/l	120	--	50
1,3-Dichlorobenzene	ND		ug/l	120	--	50
1,4-Dichlorobenzene	ND		ug/l	120	--	50
Methyl tert butyl ether	ND		ug/l	50	--	50
p/m-Xylene	ND		ug/l	50	--	50
o-Xylene	ND		ug/l	50	--	50
Xylenes, Total	ND		ug/l	50	--	50
cis-1,2-Dichloroethene	630		ug/l	25	--	50
Dibromomethane	ND		ug/l	250	--	50
1,4-Dichlorobutane	ND		ug/l	250	--	50
1,2,3-Trichloropropane	ND		ug/l	250	--	50
Styrene	ND		ug/l	50	--	50
Dichlorodifluoromethane	ND		ug/l	250	--	50
Acetone	ND		ug/l	250	--	50
Carbon disulfide	ND		ug/l	250	--	50
2-Butanone	ND		ug/l	250	--	50
Vinyl acetate	ND		ug/l	250	--	50
4-Methyl-2-pentanone	ND		ug/l	250	--	50
2-Hexanone	ND		ug/l	250	--	50
Ethyl methacrylate	ND		ug/l	250	--	50
Acrylonitrile	ND		ug/l	250	--	50
Bromochloromethane	ND		ug/l	120	--	50
Tetrahydrofuran	ND		ug/l	250	--	50
2,2-Dichloropropane	ND		ug/l	120	--	50
1,2-Dibromoethane	ND		ug/l	100	--	50
1,3-Dichloropropane	ND		ug/l	120	--	50
1,1,1,2-Tetrachloroethane	ND		ug/l	25	--	50
Bromobenzene	ND		ug/l	120	--	50
n-Butylbenzene	ND		ug/l	25	--	50
sec-Butylbenzene	ND		ug/l	25	--	50
tert-Butylbenzene	ND		ug/l	120	--	50
o-Chlorotoluene	ND		ug/l	120	--	50
p-Chlorotoluene	ND		ug/l	120	--	50
1,2-Dibromo-3-chloropropane	ND		ug/l	120	--	50
Hexachlorobutadiene	ND		ug/l	25	--	50
Isopropylbenzene	ND		ug/l	25	--	50
p-Isopropyltoluene	ND		ug/l	25	--	50
Naphthalene	ND		ug/l	120	--	50
n-Propylbenzene	ND		ug/l	25	--	50

Project Name:	BAYLIS REMEDIATION	**Lab Number:**	L1515555
Project Number:	20001847.003.002	**Report Date:**	07/15/15

SAMPLE RESULTS

Lab ID:	L1515555-01 D	Date Collected:	07/07/15 07:58
Client ID:	E-4	Date Received:	07/08/15
Sample Location:	WARWICK, RI	Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2,3-Trichlorobenzene	ND		ug/l	120	--	50
1,2,4-Trichlorobenzene	ND		ug/l	120	--	50
1,3,5-Trimethylbenzene	ND		ug/l	120	--	50
1,2,4-Trimethylbenzene	ND		ug/l	120	--	50
trans-1,4-Dichloro-2-butene	ND		ug/l	120	--	50
Ethyl ether	ND		ug/l	120	--	50

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	102		70-130
Toluene-d8	101		70-130
4-Bromofluorobenzene	106		70-130
Dibromofluoromethane	91		70-130

SAMPLE RESULTS

Lab ID:	L1515555-02	D	Date Collected:	07/07/15 08:44
Client ID:	E-5		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified
Matrix:	Water			
Analytical Method:	1,8260C			
Analytical Date:	07/10/15 18:54			
Analyst:	PD			

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	120	--	40
1,1-Dichloroethane	ND		ug/l	30	--	40
Chloroform	ND		ug/l	30	--	40
Carbon tetrachloride	ND		ug/l	20	--	40
1,2-Dichloropropane	ND		ug/l	70	--	40
Dibromochloromethane	ND		ug/l	20	--	40
1,1,2-Trichloroethane	ND		ug/l	30	--	40
Tetrachloroethene	2500		ug/l	20	--	40
Chlorobenzene	ND		ug/l	20	--	40
Trichlorofluoromethane	ND		ug/l	100	--	40
1,2-Dichloroethane	ND		ug/l	20	--	40
1,1,1-Trichloroethane	240		ug/l	20	--	40
Bromodichloromethane	ND		ug/l	20	--	40
trans-1,3-Dichloropropene	ND		ug/l	20	--	40
cis-1,3-Dichloropropene	ND		ug/l	20	--	40
1,3-Dichloropropene, Total	ND		ug/l	20	--	40
1,1-Dichloropropene	ND		ug/l	100	--	40
Bromoform	ND		ug/l	80	--	40
1,1,2,2-Tetrachloroethane	ND		ug/l	20	--	40
Benzene	ND		ug/l	20	--	40
Toluene	ND		ug/l	30	--	40
Ethylbenzene	ND		ug/l	20	--	40
Chloromethane	ND		ug/l	100	--	40
Bromomethane	ND		ug/l	40	--	40
Vinyl chloride	ND		ug/l	40	--	40
Chloroethane	ND		ug/l	40	--	40
1,1-Dichloroethene	ND		ug/l	20	--	40
trans-1,2-Dichloroethene	ND		ug/l	30	--	40
1,2-Dichloroethene, Total	100		ug/l	20	--	40
Trichloroethene	1000		ug/l	20	--	40

SAMPLE RESULTS

Lab ID: L1515555-02 D
Client ID: E-5
Sample Location: WARWICK, RI
Date Collected: 07/07/15 08:44
Date Received: 07/08/15
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2-Dichlorobenzene	ND		ug/l	100	--	40
1,3-Dichlorobenzene	ND		ug/l	100	--	40
1,4-Dichlorobenzene	ND		ug/l	100	--	40
Methyl tert butyl ether	ND		ug/l	40	--	40
p/m-Xylene	ND		ug/l	40	--	40
o-Xylene	ND		ug/l	40	--	40
Xylenes, Total	ND		ug/l	40	--	40
cis-1,2-Dichloroethene	100		ug/l	20	--	40
Dibromomethane	ND		ug/l	200	--	40
1,4-Dichlorobutane	ND		ug/l	200	--	40
1,2,3-Trichloropropane	ND		ug/l	200	--	40
Styrene	ND		ug/l	40	--	40
Dichlorodifluoromethane	ND		ug/l	200	--	40
Acetone	ND		ug/l	200	--	40
Carbon disulfide	ND		ug/l	200	--	40
2-Butanone	ND		ug/l	200	--	40
Vinyl acetate	ND		ug/l	200	--	40
4-Methyl-2-pentanone	ND		ug/l	200	--	40
2-Hexanone	ND		ug/l	200	--	40
Ethyl methacrylate	ND		ug/l	200	--	40
Acrylonitrile	ND		ug/l	200	--	40
Bromochloromethane	ND		ug/l	100	--	40
Tetrahydrofuran	ND		ug/l	200	--	40
2,2-Dichloropropane	ND		ug/l	100	--	40
1,2-Dibromoethane	ND		ug/l	80	--	40
1,3-Dichloropropane	ND		ug/l	100	--	40
1,1,1,2-Tetrachloroethane	ND		ug/l	20	--	40
Bromobenzene	ND		ug/l	100	--	40
n-Butylbenzene	ND		ug/l	20	--	40
sec-Butylbenzene	ND		ug/l	20	--	40
tert-Butylbenzene	ND		ug/l	100	--	40
o-Chlorotoluene	ND		ug/l	100	--	40
p-Chlorotoluene	ND		ug/l	100	--	40
1,2-Dibromo-3-chloropropane	ND		ug/l	100	--	40
Hexachlorobutadiene	ND		ug/l	20	--	40
Isopropylbenzene	ND		ug/l	20	--	40
p-Isopropyltoluene	ND		ug/l	20	--	40
Naphthalene	ND		ug/l	100	--	40
n-Propylbenzene	ND		ug/l	20	--	40

Project Name:	BAYLIS REMEDIATION	**Lab Number:**	L1515555
Project Number:	20001847.003.002	**Report Date:**	07/15/15

SAMPLE RESULTS

Lab ID:	L1515555-02	D	Date Collected:	07/07/15 08:44
Client ID:	E-5		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2,3-Trichlorobenzene	ND		ug/l	100	--	40
1,2,4-Trichlorobenzene	ND		ug/l	100	--	40
1,3,5-Trimethylbenzene	ND		ug/l	100	--	40
1,2,4-Trimethylbenzene	ND		ug/l	100	--	40
trans-1,4-Dichloro-2-butene	ND		ug/l	100	--	40
Ethyl ether	ND		ug/l	100	--	40

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	103		70-130
Toluene-d8	100		70-130
4-Bromofluorobenzene	106		70-130
Dibromofluoromethane	92		70-130

SAMPLE RESULTS

Lab ID:	L1515555-03	D	Date Collected:	07/07/15 09:24
Client ID:	E-6		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified
Matrix:	Water			
Analytical Method:	1,8260C			
Analytical Date:	07/10/15 19:28			
Analyst:	PD			

Parameter	**Result**	**Qualifier**	**Units**	**RL**	**MDL**	**Dilution Factor**
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	120	--	40
1,1-Dichloroethane	ND		ug/l	30	--	40
Chloroform	ND		ug/l	30	--	40
Carbon tetrachloride	ND		ug/l	20	--	40
1,2-Dichloropropane	ND		ug/l	70	--	40
Dibromochloromethane	ND		ug/l	20	--	40
1,1,2-Trichloroethane	ND		ug/l	30	--	40
Tetrachloroethene	2300		ug/l	20	--	40
Chlorobenzene	ND		ug/l	20	--	40
Trichlorofluoromethane	ND		ug/l	100	--	40
1,2-Dichloroethane	ND		ug/l	20	--	40
1,1,1-Trichloroethane	460		ug/l	20	--	40
Bromodichloromethane	ND		ug/l	20	--	40
trans-1,3-Dichloropropene	ND		ug/l	20	--	40
cis-1,3-Dichloropropene	ND		ug/l	20	--	40
1,3-Dichloropropene, Total	ND		ug/l	20	--	40
1,1-Dichloropropene	ND		ug/l	100	--	40
Bromoform	ND		ug/l	80	--	40
1,1,2,2-Tetrachloroethane	ND		ug/l	20	--	40
Benzene	ND		ug/l	20	--	40
Toluene	ND		ug/l	30	--	40
Ethylbenzene	ND		ug/l	20	--	40
Chloromethane	ND		ug/l	100	--	40
Bromomethane	ND		ug/l	40	--	40
Vinyl chloride	ND		ug/l	40	--	40
Chloroethane	ND		ug/l	40	--	40
1,1-Dichloroethene	ND		ug/l	20	--	40
trans-1,2-Dichloroethene	ND		ug/l	30	--	40
1,2-Dichloroethene, Total	950		ug/l	20	--	40
Trichloroethene	2200		ug/l	20	--	40

SAMPLE RESULTS

Lab ID:	L1515555-03	D	Date Collected:	07/07/15 09:24
Client ID:	E-6		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2-Dichlorobenzene	ND		ug/l	100	--	40
1,3-Dichlorobenzene	ND		ug/l	100	--	40
1,4-Dichlorobenzene	ND		ug/l	100	--	40
Methyl tert butyl ether	ND		ug/l	40	--	40
p/m-Xylene	ND		ug/l	40	--	40
o-Xylene	ND		ug/l	40	--	40
Xylenes, Total	ND		ug/l	40	--	40
cis-1,2-Dichloroethene	950		ug/l	20	--	40
Dibromomethane	ND		ug/l	200	--	40
1,4-Dichlorobutane	ND		ug/l	200	--	40
1,2,3-Trichloropropane	ND		ug/l	200	--	40
Styrene	ND		ug/l	40	--	40
Dichlorodifluoromethane	ND		ug/l	200	--	40
Acetone	ND		ug/l	200	--	40
Carbon disulfide	ND		ug/l	200	--	40
2-Butanone	ND		ug/l	200	--	40
Vinyl acetate	ND		ug/l	200	--	40
4-Methyl-2-pentanone	ND		ug/l	200	--	40
2-Hexanone	ND		ug/l	200	--	40
Ethyl methacrylate	ND		ug/l	200	--	40
Acrylonitrile	ND		ug/l	200	--	40
Bromochloromethane	ND		ug/l	100	--	40
Tetrahydrofuran	ND		ug/l	200	--	40
2,2-Dichloropropane	ND		ug/l	100	--	40
1,2-Dibromoethane	ND		ug/l	80	--	40
1,3-Dichloropropane	ND		ug/l	100	--	40
1,1,1,2-Tetrachloroethane	ND		ug/l	20	--	40
Bromobenzene	ND		ug/l	100	--	40
n-Butylbenzene	ND		ug/l	20	--	40
sec-Butylbenzene	ND		ug/l	20	--	40
tert-Butylbenzene	ND		ug/l	100	--	40
o-Chlorotoluene	ND		ug/l	100	--	40
p-Chlorotoluene	ND		ug/l	100	--	40
1,2-Dibromo-3-chloropropane	ND		ug/l	100	--	40
Hexachlorobutadiene	ND		ug/l	20	--	40
Isopropylbenzene	ND		ug/l	20	--	40
p-Isopropyltoluene	ND		ug/l	20	--	40
Naphthalene	ND		ug/l	100	--	40
n-Propylbenzene	ND		ug/l	20	--	40

SAMPLE RESULTS

Lab ID:	L1515555-03	D	Date Collected:	07/07/15 09:24
Client ID:	E-6		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2,3-Trichlorobenzene	ND		ug/l	100	--	40
1,2,4-Trichlorobenzene	ND		ug/l	100	--	40
1,3,5-Trimethylbenzene	ND		ug/l	100	--	40
1,2,4-Trimethylbenzene	ND		ug/l	100	--	40
trans-1,4-Dichloro-2-butene	ND		ug/l	100	--	40
Ethyl ether	ND		ug/l	100	--	40

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	101		70-130
Toluene-d8	100		70-130
4-Bromofluorobenzene	107		70-130
Dibromofluoromethane	91		70-130

SAMPLE RESULTS

Lab ID:	L1515555-04 D	Date Collected:	07/07/15 09:58
Client ID:	ESM-8	Date Received:	07/08/15
Sample Location:	WARWICK, RI	Field Prep:	Not Specified
Matrix:	Water		
Analytical Method:	1,8260C		
Analytical Date:	07/10/15 20:02		
Analyst:	PD		

Parameter	**Result**	**Qualifier**	**Units**	**RL**	**MDL**	**Dilution Factor**
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	300	--	100
1,1-Dichloroethane	ND		ug/l	75	--	100
Chloroform	ND		ug/l	75	--	100
Carbon tetrachloride	ND		ug/l	50	--	100
1,2-Dichloropropane	ND		ug/l	180	--	100
Dibromochloromethane	ND		ug/l	50	--	100
1,1,2-Trichloroethane	ND		ug/l	75	--	100
Tetrachloroethene	8300		ug/l	50	--	100
Chlorobenzene	ND		ug/l	50	--	100
Trichlorofluoromethane	ND		ug/l	250	--	100
1,2-Dichloroethane	ND		ug/l	50	--	100
1,1,1-Trichloroethane	360		ug/l	50	--	100
Bromodichloromethane	ND		ug/l	50	--	100
trans-1,3-Dichloropropene	ND		ug/l	50	--	100
cis-1,3-Dichloropropene	ND		ug/l	50	--	100
1,3-Dichloropropene, Total	ND		ug/l	50	--	100
1,1-Dichloropropene	ND		ug/l	250	--	100
Bromoform	ND		ug/l	200	--	100
1,1,2,2-Tetrachloroethane	ND		ug/l	50	--	100
Benzene	ND		ug/l	50	--	100
Toluene	ND		ug/l	75	--	100
Ethylbenzene	ND		ug/l	50	--	100
Chloromethane	ND		ug/l	250	--	100
Bromomethane	ND		ug/l	100	--	100
Vinyl chloride	ND		ug/l	100	--	100
Chloroethane	ND		ug/l	100	--	100
1,1-Dichloroethene	ND		ug/l	50	--	100
trans-1,2-Dichloroethene	ND		ug/l	75	--	100
1,2-Dichloroethene, Total	60		ug/l	50	--	100
Trichloroethene	2700		ug/l	50	--	100

SAMPLE RESULTS

Lab ID:	L1515555-04	D	Date Collected:	07/07/15 09:58
Client ID:	ESM-8		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	**Result**	**Qualifier**	**Units**	**RL**	**MDL**	**Dilution Factor**
Volatile Organics by GC/MS - Westborough Lab						
1,2-Dichlorobenzene	ND		ug/l	250	--	100
1,3-Dichlorobenzene	ND		ug/l	250	--	100
1,4-Dichlorobenzene	ND		ug/l	250	--	100
Methyl tert butyl ether	ND		ug/l	100	--	100
p/m-Xylene	ND		ug/l	100	--	100
o-Xylene	ND		ug/l	100	--	100
Xylenes, Total	ND		ug/l	100	--	100
cis-1,2-Dichloroethene	60		ug/l	50	--	100
Dibromomethane	ND		ug/l	500	--	100
1,4-Dichlorobutane	ND		ug/l	500	--	100
1,2,3-Trichloropropane	ND		ug/l	500	--	100
Styrene	ND		ug/l	100	--	100
Dichlorodifluoromethane	ND		ug/l	500	--	100
Acetone	ND		ug/l	500	--	100
Carbon disulfide	ND		ug/l	500	--	100
2-Butanone	ND		ug/l	500	--	100
Vinyl acetate	ND		ug/l	500	--	100
4-Methyl-2-pentanone	ND		ug/l	500	--	100
2-Hexanone	ND		ug/l	500	--	100
Ethyl methacrylate	ND		ug/l	500	--	100
Acrylonitrile	ND		ug/l	500	--	100
Bromochloromethane	ND		ug/l	250	--	100
Tetrahydrofuran	ND		ug/l	500	--	100
2,2-Dichloropropane	ND		ug/l	250	--	100
1,2-Dibromoethane	ND		ug/l	200	--	100
1,3-Dichloropropane	ND		ug/l	250	--	100
1,1,1,2-Tetrachloroethane	ND		ug/l	50	--	100
Bromobenzene	ND		ug/l	250	--	100
n-Butylbenzene	ND		ug/l	50	--	100
sec-Butylbenzene	ND		ug/l	50	--	100
tert-Butylbenzene	ND		ug/l	250	--	100
o-Chlorotoluene	ND		ug/l	250	--	100
p-Chlorotoluene	ND		ug/l	250	--	100
1,2-Dibromo-3-chloropropane	ND		ug/l	250	--	100
Hexachlorobutadiene	ND		ug/l	50	--	100
Isopropylbenzene	ND		ug/l	50	--	100
p-Isopropyltoluene	ND		ug/l	50	--	100
Naphthalene	ND		ug/l	250	--	100
n-Propylbenzene	ND		ug/l	50	--	100

SAMPLE RESULTS

Lab ID:	L1515555-04	D	Date Collected:	07/07/15 09:58
Client ID:	ESM-8		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2,3-Trichlorobenzene	ND		ug/l	250	--	100
1,2,4-Trichlorobenzene	ND		ug/l	250	--	100
1,3,5-Trimethylbenzene	ND		ug/l	250	--	100
1,2,4-Trimethylbenzene	ND		ug/l	250	--	100
trans-1,4-Dichloro-2-butene	ND		ug/l	250	--	100
Ethyl ether	ND		ug/l	250	--	100

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	103		70-130
Toluene-d8	100		70-130
4-Bromofluorobenzene	106		70-130
Dibromofluoromethane	89		70-130

SAMPLE RESULTS

Lab ID:	L1515555-05	D	Date Collected:	07/07/15 11:18
Client ID:	E-33		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified
Matrix:	Water			
Analytical Method:	1,8260C			
Analytical Date:	07/10/15 20:36			
Analyst:	PD			

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	300	--	100
1,1-Dichloroethane	170		ug/l	75	--	100
Chloroform	ND		ug/l	75	--	100
Carbon tetrachloride	ND		ug/l	50	--	100
1,2-Dichloropropane	ND		ug/l	180	--	100
Dibromochloromethane	ND		ug/l	50	--	100
1,1,2-Trichloroethane	ND		ug/l	75	--	100
Tetrachloroethene	8000		ug/l	50	--	100
Chlorobenzene	ND		ug/l	50	--	100
Trichlorofluoromethane	ND		ug/l	250	--	100
1,2-Dichloroethane	ND		ug/l	50	--	100
1,1,1-Trichloroethane	530		ug/l	50	--	100
Bromodichloromethane	ND		ug/l	50	--	100
trans-1,3-Dichloropropene	ND		ug/l	50	--	100
cis-1,3-Dichloropropene	ND		ug/l	50	--	100
1,3-Dichloropropene, Total	ND		ug/l	50	--	100
1,1-Dichloropropene	ND		ug/l	250	--	100
Bromoform	ND		ug/l	200	--	100
1,1,2,2-Tetrachloroethane	ND		ug/l	50	--	100
Benzene	ND		ug/l	50	--	100
Toluene	ND		ug/l	75	--	100
Ethylbenzene	ND		ug/l	50	--	100
Chloromethane	ND		ug/l	250	--	100
Bromomethane	ND		ug/l	100	--	100
Vinyl chloride	ND		ug/l	100	--	100
Chloroethane	ND		ug/l	100	--	100
1,1-Dichloroethene	ND		ug/l	50	--	100
trans-1,2-Dichloroethene	ND		ug/l	75	--	100
1,2-Dichloroethene, Total	450		ug/l	50	--	100
Trichloroethene	3400		ug/l	50	--	100

SAMPLE RESULTS

Lab ID:	L1515555-05	D	Date Collected:	07/07/15 11:18
Client ID:	E-33		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2-Dichlorobenzene	ND		ug/l	250	--	100
1,3-Dichlorobenzene	ND		ug/l	250	--	100
1,4-Dichlorobenzene	ND		ug/l	250	--	100
Methyl tert butyl ether	ND		ug/l	100	--	100
p/m-Xylene	ND		ug/l	100	--	100
o-Xylene	ND		ug/l	100	--	100
Xylenes, Total	ND		ug/l	100	--	100
cis-1,2-Dichloroethene	450		ug/l	50	--	100
Dibromomethane	ND		ug/l	500	--	100
1,4-Dichlorobutane	ND		ug/l	500	--	100
1,2,3-Trichloropropane	ND		ug/l	500	--	100
Styrene	ND		ug/l	100	--	100
Dichlorodifluoromethane	ND		ug/l	500	--	100
Acetone	ND		ug/l	500	--	100
Carbon disulfide	ND		ug/l	500	--	100
2-Butanone	ND		ug/l	500	--	100
Vinyl acetate	ND		ug/l	500	--	100
4-Methyl-2-pentanone	ND		ug/l	500	--	100
2-Hexanone	ND		ug/l	500	--	100
Ethyl methacrylate	ND		ug/l	500	--	100
Acrylonitrile	ND		ug/l	500	--	100
Bromochloromethane	ND		ug/l	250	--	100
Tetrahydrofuran	ND		ug/l	500	--	100
2,2-Dichloropropane	ND		ug/l	250	--	100
1,2-Dibromoethane	ND		ug/l	200	--	100
1,3-Dichloropropane	ND		ug/l	250	--	100
1,1,1,2-Tetrachloroethane	ND		ug/l	50	--	100
Bromobenzene	ND		ug/l	250	--	100
n-Butylbenzene	ND		ug/l	50	--	100
sec-Butylbenzene	ND		ug/l	50	--	100
tert-Butylbenzene	ND		ug/l	250	--	100
o-Chlorotoluene	ND		ug/l	250	--	100
p-Chlorotoluene	ND		ug/l	250	--	100
1,2-Dibromo-3-chloropropane	ND		ug/l	250	--	100
Hexachlorobutadiene	ND		ug/l	50	--	100
Isopropylbenzene	ND		ug/l	50	--	100
p-Isopropyltoluene	ND		ug/l	50	--	100
Naphthalene	ND		ug/l	250	--	100
n-Propylbenzene	ND		ug/l	50	--	100

SAMPLE RESULTS

Lab ID:	L1515555-05 D	Date Collected:	07/07/15 11:18
Client ID:	E-33	Date Received:	07/08/15
Sample Location:	WARWICK, RI	Field Prep:	Not Specified

Parameter	**Result**	**Qualifier**	**Units**	**RL**	**MDL**	**Dilution Factor**
Volatile Organics by GC/MS - Westborough Lab						
1,2,3-Trichlorobenzene	ND		ug/l	250	--	100
1,2,4-Trichlorobenzene	ND		ug/l	250	--	100
1,3,5-Trimethylbenzene	ND		ug/l	250	--	100
1,2,4-Trimethylbenzene	ND		ug/l	250	--	100
trans-1,4-Dichloro-2-butene	ND		ug/l	250	--	100
Ethyl ether	ND		ug/l	250	--	100

Surrogate	**% Recovery**	**Qualifier**	**Acceptance Criteria**
1,2-Dichloroethane-d4	102		70-130
Toluene-d8	99		70-130
4-Bromofluorobenzene	107		70-130
Dibromofluoromethane	92		70-130

SAMPLE RESULTS

Lab ID:	L1515555-06	D	Date Collected:	07/07/15 11:54
Client ID:	E-34		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified
Matrix:	Water			
Analytical Method:	1,8260C			
Analytical Date:	07/10/15 21:11			
Analyst:	PD			

Parameter	**Result**	**Qualifier**	**Units**	**RL**	**MDL**	**Dilution Factor**
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	1500	--	500
1,1-Dichloroethane	ND		ug/l	380	--	500
Chloroform	ND		ug/l	380	--	500
Carbon tetrachloride	ND		ug/l	250	--	500
1,2-Dichloropropane	ND		ug/l	880	--	500
Dibromochloromethane	ND		ug/l	250	--	500
1,1,2-Trichloroethane	ND		ug/l	380	--	500
Tetrachloroethene	72000		ug/l	250	--	500
Chlorobenzene	ND		ug/l	250	--	500
Trichlorofluoromethane	ND		ug/l	1200	--	500
1,2-Dichloroethane	ND		ug/l	250	--	500
1,1,1-Trichloroethane	4800		ug/l	250	--	500
Bromodichloromethane	ND		ug/l	250	--	500
trans-1,3-Dichloropropene	ND		ug/l	250	--	500
cis-1,3-Dichloropropene	ND		ug/l	250	--	500
1,3-Dichloropropene, Total	ND		ug/l	250	--	500
1,1-Dichloropropene	ND		ug/l	1200	--	500
Bromoform	ND		ug/l	1000	--	500
1,1,2,2-Tetrachloroethane	ND		ug/l	250	--	500
Benzene	ND		ug/l	250	--	500
Toluene	ND		ug/l	380	--	500
Ethylbenzene	ND		ug/l	250	--	500
Chloromethane	ND		ug/l	1200	--	500
Bromomethane	ND		ug/l	500	--	500
Vinyl chloride	ND		ug/l	500	--	500
Chloroethane	ND		ug/l	500	--	500
1,1-Dichloroethene	720		ug/l	250	--	500
trans-1,2-Dichloroethene	ND		ug/l	380	--	500
1,2-Dichloroethene, Total	890		ug/l	250	--	500
Trichloroethene	29000		ug/l	250	--	500

Project Name:	BAYLIS REMEDIATION	**Lab Number:**	L1515555
Project Number:	20001847.003.002	**Report Date:**	07/15/15

SAMPLE RESULTS

Lab ID:	L1515555-06	D	Date Collected:	07/07/15 11:54
Client ID:	E-34		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Volatile Organics by GC/MS - Westborough Lab

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
1,2-Dichlorobenzene	ND		ug/l	1200	--	500
1,3-Dichlorobenzene	ND		ug/l	1200	--	500
1,4-Dichlorobenzene	ND		ug/l	1200	--	500
Methyl tert butyl ether	ND		ug/l	500	--	500
p/m-Xylene	ND		ug/l	500	--	500
o-Xylene	ND		ug/l	500	--	500
Xylenes, Total	ND		ug/l	500	--	500
cis-1,2-Dichloroethene	890		ug/l	250	--	500
Dibromomethane	ND		ug/l	2500	--	500
1,4-Dichlorobutane	ND		ug/l	2500	--	500
1,2,3-Trichloropropane	ND		ug/l	2500	--	500
Styrene	ND		ug/l	500	--	500
Dichlorodifluoromethane	ND		ug/l	2500	--	500
Acetone	ND		ug/l	2500	--	500
Carbon disulfide	ND		ug/l	2500	--	500
2-Butanone	ND		ug/l	2500	--	500
Vinyl acetate	ND		ug/l	2500	--	500
4-Methyl-2-pentanone	ND		ug/l	2500	--	500
2-Hexanone	ND		ug/l	2500	--	500
Ethyl methacrylate	ND		ug/l	2500	--	500
Acrylonitrile	ND		ug/l	2500	--	500
Bromochloromethane	ND		ug/l	1200	--	500
Tetrahydrofuran	ND		ug/l	2500	--	500
2,2-Dichloropropane	ND		ug/l	1200	--	500
1,2-Dibromoethane	ND		ug/l	1000	--	500
1,3-Dichloropropane	ND		ug/l	1200	--	500
1,1,1,2-Tetrachloroethane	ND		ug/l	250	--	500
Bromobenzene	ND		ug/l	1200	--	500
n-Butylbenzene	ND		ug/l	250	--	500
sec-Butylbenzene	ND		ug/l	250	--	500
tert-Butylbenzene	ND		ug/l	1200	--	500
o-Chlorotoluene	ND		ug/l	1200	--	500
p-Chlorotoluene	ND		ug/l	1200	--	500
1,2-Dibromo-3-chloropropane	ND		ug/l	1200	--	500
Hexachlorobutadiene	ND		ug/l	250	--	500
Isopropylbenzene	ND		ug/l	250	--	500
p-Isopropyltoluene	ND		ug/l	250	--	500
Naphthalene	ND		ug/l	1200	--	500
n-Propylbenzene	ND		ug/l	250	--	500

SAMPLE RESULTS

Lab ID:	L1515555-06	D	Date Collected:	07/07/15 11:54
Client ID:	E-34		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2,3-Trichlorobenzene	ND		ug/l	1200	--	500
1,2,4-Trichlorobenzene	ND		ug/l	1200	--	500
1,3,5-Trimethylbenzene	ND		ug/l	1200	--	500
1,2,4-Trimethylbenzene	ND		ug/l	1200	--	500
trans-1,4-Dichloro-2-butene	ND		ug/l	1200	--	500
Ethyl ether	ND		ug/l	1200	--	500

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	102		70-130
Toluene-d8	99		70-130
4-Bromofluorobenzene	105		70-130
Dibromofluoromethane	91		70-130

SAMPLE RESULTS

Lab ID:	L1515555-07 D		Date Collected:	07/07/15 12:30
Client ID:	E-42		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified
Matrix:	Water			
Analytical Method:	1,8260C			
Analytical Date:	07/10/15 21:46			
Analyst:	PD			

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	1500	--	500
1,1-Dichloroethane	ND		ug/l	380	--	500
Chloroform	ND		ug/l	380	--	500
Carbon tetrachloride	ND		ug/l	250	--	500
1,2-Dichloropropane	ND		ug/l	880	--	500
Dibromochloromethane	ND		ug/l	250	--	500
1,1,2-Trichloroethane	ND		ug/l	380	--	500
Tetrachloroethene	98000		ug/l	250	--	500
Chlorobenzene	ND		ug/l	250	--	500
Trichlorofluoromethane	ND		ug/l	1200	--	500
1,2-Dichloroethane	ND		ug/l	250	--	500
1,1,1-Trichloroethane	23000		ug/l	250	--	500
Bromodichloromethane	ND		ug/l	250	--	500
trans-1,3-Dichloropropene	ND		ug/l	250	--	500
cis-1,3-Dichloropropene	ND		ug/l	250	--	500
1,3-Dichloropropene, Total	ND		ug/l	250	--	500
1,1-Dichloropropene	ND		ug/l	1200	--	500
Bromoform	ND		ug/l	1000	--	500
1,1,2,2-Tetrachloroethane	ND		ug/l	250	--	500
Benzene	ND		ug/l	250	--	500
Toluene	530		ug/l	380	--	500
Ethylbenzene	ND		ug/l	250	--	500
Chloromethane	ND		ug/l	1200	--	500
Bromomethane	ND		ug/l	500	--	500
Vinyl chloride	ND		ug/l	500	--	500
Chloroethane	ND		ug/l	500	--	500
1,1-Dichloroethene	780		ug/l	250	--	500
trans-1,2-Dichloroethene	ND		ug/l	380	--	500
1,2-Dichloroethene, Total	580		ug/l	250	--	500
Trichloroethene	73000		ug/l	250	--	500

SAMPLE RESULTS

Lab ID:	L1515555-07	D	Date Collected:	07/07/15 12:30
Client ID:	E-42		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	**Result**	**Qualifier**	**Units**	**RL**	**MDL**	**Dilution Factor**
Volatile Organics by GC/MS - Westborough Lab						
1,2-Dichlorobenzene	ND		ug/l	1200	--	500
1,3-Dichlorobenzene	ND		ug/l	1200	--	500
1,4-Dichlorobenzene	ND		ug/l	1200	--	500
Methyl tert butyl ether	ND		ug/l	500	--	500
p/m-Xylene	ND		ug/l	500	--	500
o-Xylene	ND		ug/l	500	--	500
Xylenes, Total	ND		ug/l	500	--	500
cis-1,2-Dichloroethene	580		ug/l	250	--	500
Dibromomethane	ND		ug/l	2500	--	500
1,4-Dichlorobutane	ND		ug/l	2500	--	500
1,2,3-Trichloropropane	ND		ug/l	2500	--	500
Styrene	ND		ug/l	500	--	500
Dichlorodifluoromethane	ND		ug/l	2500	--	500
Acetone	ND		ug/l	2500	--	500
Carbon disulfide	ND		ug/l	2500	--	500
2-Butanone	ND		ug/l	2500	--	500
Vinyl acetate	ND		ug/l	2500	--	500
4-Methyl-2-pentanone	ND		ug/l	2500	--	500
2-Hexanone	ND		ug/l	2500	--	500
Ethyl methacrylate	ND		ug/l	2500	--	500
Acrylonitrile	ND		ug/l	2500	--	500
Bromochloromethane	ND		ug/l	1200	--	500
Tetrahydrofuran	ND		ug/l	2500	--	500
2,2-Dichloropropane	ND		ug/l	1200	--	500
1,2-Dibromoethane	ND		ug/l	1000	--	500
1,3-Dichloropropane	ND		ug/l	1200	--	500
1,1,1,2-Tetrachloroethane	ND		ug/l	250	--	500
Bromobenzene	ND		ug/l	1200	--	500
n-Butylbenzene	ND		ug/l	250	--	500
sec-Butylbenzene	ND		ug/l	250	--	500
tert-Butylbenzene	ND		ug/l	1200	--	500
o-Chlorotoluene	ND		ug/l	1200	--	500
p-Chlorotoluene	ND		ug/l	1200	--	500
1,2-Dibromo-3-chloropropane	ND		ug/l	1200	--	500
Hexachlorobutadiene	ND		ug/l	250	--	500
Isopropylbenzene	ND		ug/l	250	--	500
p-Isopropyltoluene	ND		ug/l	250	--	500
Naphthalene	ND		ug/l	1200	--	500
n-Propylbenzene	ND		ug/l	250	--	500

SAMPLE RESULTS

Lab ID:	L1515555-07	D	Date Collected:	07/07/15 12:30
Client ID:	E-42		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2,3-Trichlorobenzene	ND		ug/l	1200	--	500
1,2,4-Trichlorobenzene	ND		ug/l	1200	--	500
1,3,5-Trimethylbenzene	ND		ug/l	1200	--	500
1,2,4-Trimethylbenzene	ND		ug/l	1200	--	500
trans-1,4-Dichloro-2-butene	ND		ug/l	1200	--	500
Ethyl ether	ND		ug/l	1200	--	500

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	103		70-130
Toluene-d8	100		70-130
4-Bromofluorobenzene	106		70-130
Dibromofluoromethane	89		70-130

Project Name:	BAYLIS REMEDIATION	**Lab Number:**	L1515555
Project Number:	20001847.003.002	**Report Date:**	07/15/15

SAMPLE RESULTS

Lab ID: L1515555-08 D

Client ID: E-43

Sample Location: WARWICK, RI

Matrix: Water

Analytical Method: 1,8260C

Analytical Date: 07/10/15 22:20

Analyst: PD

Date Collected: 07/07/15 13:00

Date Received: 07/08/15

Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	1200	--	400
1,1-Dichloroethane	ND		ug/l	300	--	400
Chloroform	ND		ug/l	300	--	400
Carbon tetrachloride	ND		ug/l	200	--	400
1,2-Dichloropropane	ND		ug/l	700	--	400
Dibromochloromethane	ND		ug/l	200	--	400
1,1,2-Trichloroethane	ND		ug/l	300	--	400
Tetrachloroethene	51000		ug/l	200	--	400
Chlorobenzene	ND		ug/l	200	--	400
Trichlorofluoromethane	ND		ug/l	1000	--	400
1,2-Dichloroethane	ND		ug/l	200	--	400
1,1,1-Trichloroethane	4500		ug/l	200	--	400
Bromodichloromethane	ND		ug/l	200	--	400
trans-1,3-Dichloropropene	ND		ug/l	200	--	400
cis-1,3-Dichloropropene	ND		ug/l	200	--	400
1,3-Dichloropropene, Total	ND		ug/l	200	--	400
1,1-Dichloropropene	ND		ug/l	1000	--	400
Bromoform	ND		ug/l	800	--	400
1,1,2,2-Tetrachloroethane	ND		ug/l	200	--	400
Benzene	ND		ug/l	200	--	400
Toluene	ND		ug/l	300	--	400
Ethylbenzene	ND		ug/l	200	--	400
Chloromethane	ND		ug/l	1000	--	400
Bromomethane	ND		ug/l	400	--	400
Vinyl chloride	ND		ug/l	400	--	400
Chloroethane	ND		ug/l	400	--	400
1,1-Dichloroethene	ND		ug/l	200	--	400
trans-1,2-Dichloroethene	ND		ug/l	300	--	400
1,2-Dichloroethene, Total	1600		ug/l	200	--	400
Trichloroethene	11000		ug/l	200	--	400

SAMPLE RESULTS

Lab ID:	L1515555-08	D	Date Collected:	07/07/15 13:00
Client ID:	E-43		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2-Dichlorobenzene	ND		ug/l	1000	--	400
1,3-Dichlorobenzene	ND		ug/l	1000	--	400
1,4-Dichlorobenzene	ND		ug/l	1000	--	400
Methyl tert butyl ether	ND		ug/l	400	--	400
p/m-Xylene	ND		ug/l	400	--	400
o-Xylene	ND		ug/l	400	--	400
Xylenes, Total	ND		ug/l	400	--	400
cis-1,2-Dichloroethene	1600		ug/l	200	--	400
Dibromomethane	ND		ug/l	2000	--	400
1,4-Dichlorobutane	ND		ug/l	2000	--	400
1,2,3-Trichloropropane	ND		ug/l	2000	--	400
Styrene	ND		ug/l	400	--	400
Dichlorodifluoromethane	ND		ug/l	2000	--	400
Acetone	ND		ug/l	2000	--	400
Carbon disulfide	ND		ug/l	2000	--	400
2-Butanone	ND		ug/l	2000	--	400
Vinyl acetate	ND		ug/l	2000	--	400
4-Methyl-2-pentanone	ND		ug/l	2000	--	400
2-Hexanone	ND		ug/l	2000	--	400
Ethyl methacrylate	ND		ug/l	2000	--	400
Acrylonitrile	ND		ug/l	2000	--	400
Bromochloromethane	ND		ug/l	1000	--	400
Tetrahydrofuran	ND		ug/l	2000	--	400
2,2-Dichloropropane	ND		ug/l	1000	--	400
1,2-Dibromoethane	ND		ug/l	800	--	400
1,3-Dichloropropane	ND		ug/l	1000	--	400
1,1,1,2-Tetrachloroethane	ND		ug/l	200	--	400
Bromobenzene	ND		ug/l	1000	--	400
n-Butylbenzene	ND		ug/l	200	--	400
sec-Butylbenzene	ND		ug/l	200	--	400
tert-Butylbenzene	ND		ug/l	1000	--	400
o-Chlorotoluene	ND		ug/l	1000	--	400
p-Chlorotoluene	ND		ug/l	1000	--	400
1,2-Dibromo-3-chloropropane	ND		ug/l	1000	--	400
Hexachlorobutadiene	ND		ug/l	200	--	400
Isopropylbenzene	ND		ug/l	200	--	400
p-Isopropyltoluene	ND		ug/l	200	--	400
Naphthalene	ND		ug/l	1000	--	400
n-Propylbenzene	ND		ug/l	200	--	400

SAMPLE RESULTS

Lab ID:	L1515555-08	D	Date Collected:	07/07/15 13:00
Client ID:	E-43		Date Received:	07/08/15
Sample Location:	WARWICK, RI		Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2,3-Trichlorobenzene	ND		ug/l	1000	--	400
1,2,4-Trichlorobenzene	ND		ug/l	1000	--	400
1,3,5-Trimethylbenzene	ND		ug/l	1000	--	400
1,2,4-Trimethylbenzene	ND		ug/l	1000	--	400
trans-1,4-Dichloro-2-butene	ND		ug/l	1000	--	400
Ethyl ether	ND		ug/l	1000	--	400

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	104		70-130
Toluene-d8	100		70-130
4-Bromofluorobenzene	107		70-130
Dibromofluoromethane	92		70-130

SAMPLE RESULTS

Lab ID:	L1515555-09	Date Collected:	07/07/15 00:00
Client ID:	TRIP BLANK	Date Received:	07/08/15
Sample Location:	WARWICK, RI	Field Prep:	Not Specified
Matrix:	Water		
Analytical Method:	1,8260C		
Analytical Date:	07/10/15 16:35		
Analyst:	PD		

Parameter	**Result**	**Qualifier**	**Units**	**RL**	**MDL**	**Dilution Factor**
Volatile Organics by GC/MS - Westborough Lab						
Methylene chloride	ND		ug/l	3.0	--	1
1,1-Dichloroethane	ND		ug/l	0.75	--	1
Chloroform	ND		ug/l	0.75	--	1
Carbon tetrachloride	ND		ug/l	0.50	--	1
1,2-Dichloropropane	ND		ug/l	1.8	--	1
Dibromochloromethane	ND		ug/l	0.50	--	1
1,1,2-Trichloroethane	ND		ug/l	0.75	--	1
Tetrachloroethene	ND		ug/l	0.50	--	1
Chlorobenzene	ND		ug/l	0.50	--	1
Trichlorofluoromethane	ND		ug/l	2.5	--	1
1,2-Dichloroethane	ND		ug/l	0.50	--	1
1,1,1-Trichloroethane	ND		ug/l	0.50	--	1
Bromodichloromethane	ND		ug/l	0.50	--	1
trans-1,3-Dichloropropene	ND		ug/l	0.50	--	1
cis-1,3-Dichloropropene	ND		ug/l	0.50	--	1
1,3-Dichloropropene, Total	ND		ug/l	0.50	--	1
1,1-Dichloropropene	ND		ug/l	2.5	--	1
Bromoform	ND		ug/l	2.0	--	1
1,1,2,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Benzene	ND		ug/l	0.50	--	1
Toluene	ND		ug/l	0.75	--	1
Ethylbenzene	ND		ug/l	0.50	--	1
Chloromethane	ND		ug/l	2.5	--	1
Bromomethane	ND		ug/l	1.0	--	1
Vinyl chloride	ND		ug/l	1.0	--	1
Chloroethane	ND		ug/l	1.0	--	1
1,1-Dichloroethene	ND		ug/l	0.50	--	1
trans-1,2-Dichloroethene	ND		ug/l	0.75	--	1
1,2-Dichloroethene, Total	ND		ug/l	0.50	--	1
Trichloroethene	ND		ug/l	0.50	--	1

SAMPLE RESULTS

Lab ID:	L1515555-09	Date Collected:	07/07/15 00:00
Client ID:	TRIP BLANK	Date Received:	07/08/15
Sample Location:	WARWICK, RI	Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2-Dichlorobenzene	ND		ug/l	2.5	--	1
1,3-Dichlorobenzene	ND		ug/l	2.5	--	1
1,4-Dichlorobenzene	ND		ug/l	2.5	--	1
Methyl tert butyl ether	ND		ug/l	1.0	--	1
p/m-Xylene	ND		ug/l	1.0	--	1
o-Xylene	ND		ug/l	1.0	--	1
Xylenes, Total	ND		ug/l	1.0	--	1
cis-1,2-Dichloroethene	ND		ug/l	0.50	--	1
Dibromomethane	ND		ug/l	5.0	--	1
1,4-Dichlorobutane	ND		ug/l	5.0	--	1
1,2,3-Trichloropropane	ND		ug/l	5.0	--	1
Styrene	ND		ug/l	1.0	--	1
Dichlorodifluoromethane	ND		ug/l	5.0	--	1
Acetone	ND		ug/l	5.0	--	1
Carbon disulfide	ND		ug/l	5.0	--	1
2-Butanone	ND		ug/l	5.0	--	1
Vinyl acetate	ND		ug/l	5.0	--	1
4-Methyl-2-pentanone	ND		ug/l	5.0	--	1
2-Hexanone	ND		ug/l	5.0	--	1
Ethyl methacrylate	ND		ug/l	5.0	--	1
Acrylonitrile	ND		ug/l	5.0	--	1
Bromochloromethane	ND		ug/l	2.5	--	1
Tetrahydrofuran	ND		ug/l	5.0	--	1
2,2-Dichloropropane	ND		ug/l	2.5	--	1
1,2-Dibromoethane	ND		ug/l	2.0	--	1
1,3-Dichloropropane	ND		ug/l	2.5	--	1
1,1,1,2-Tetrachloroethane	ND		ug/l	0.50	--	1
Bromobenzene	ND		ug/l	2.5	--	1
n-Butylbenzene	ND		ug/l	0.50	--	1
sec-Butylbenzene	ND		ug/l	0.50	--	1
tert-Butylbenzene	ND		ug/l	2.5	--	1
o-Chlorotoluene	ND		ug/l	2.5	--	1
p-Chlorotoluene	ND		ug/l	2.5	--	1
1,2-Dibromo-3-chloropropane	ND		ug/l	2.5	--	1
Hexachlorobutadiene	ND		ug/l	0.50	--	1
Isopropylbenzene	ND		ug/l	0.50	--	1
p-Isopropyltoluene	ND		ug/l	0.50	--	1
Naphthalene	ND		ug/l	2.5	--	1
n-Propylbenzene	ND		ug/l	0.50	--	1

SAMPLE RESULTS

Lab ID:	L1515555-09	Date Collected:	07/07/15 00:00
Client ID:	TRIP BLANK	Date Received:	07/08/15
Sample Location:	WARWICK, RI	Field Prep:	Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor
Volatile Organics by GC/MS - Westborough Lab						
1,2,3-Trichlorobenzene	ND		ug/l	2.5	--	1
1,2,4-Trichlorobenzene	ND		ug/l	2.5	--	1
1,3,5-Trimethylbenzene	ND		ug/l	2.5	--	1
1,2,4-Trimethylbenzene	ND		ug/l	2.5	--	1
trans-1,4-Dichloro-2-butene	ND		ug/l	2.5	--	1
Ethyl ether	ND		ug/l	2.5	--	1

Surrogate	% Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	100		70-130
Toluene-d8	101		70-130
4-Bromofluorobenzene	106		70-130
Dibromofluoromethane	91		70-130

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8260C
Analytical Date: 07/10/15 13:43
Analyst: PD

Parameter	Result	Qualifier	Units	RL	MDL
Volatile Organics by GC/MS - Westborough Lab for sample(s): 01-09 Batch: WG801753-3					
Methylene chloride	ND		ug/l	3.0	--
1,1-Dichloroethane	ND		ug/l	0.75	--
Chloroform	ND		ug/l	0.75	--
Carbon tetrachloride	ND		ug/l	0.50	--
1,2-Dichloropropane	ND		ug/l	1.8	--
Dibromochloromethane	ND		ug/l	0.50	--
1,1,2-Trichloroethane	ND		ug/l	0.75	--
Tetrachloroethene	ND		ug/l	0.50	--
Chlorobenzene	ND		ug/l	0.50	--
Trichlorofluoromethane	ND		ug/l	2.5	--
1,2-Dichloroethane	ND		ug/l	0.50	--
1,1,1-Trichloroethane	ND		ug/l	0.50	--
Bromodichloromethane	ND		ug/l	0.50	--
trans-1,3-Dichloropropene	ND		ug/l	0.50	--
cis-1,3-Dichloropropene	ND		ug/l	0.50	--
1,3-Dichloropropene, Total	ND		ug/l	0.50	--
1,1-Dichloropropene	ND		ug/l	2.5	--
Bromoform	ND		ug/l	2.0	--
1,1,2,2-Tetrachloroethane	ND		ug/l	0.50	--
Benzene	ND		ug/l	0.50	--
Toluene	ND		ug/l	0.75	--
Ethylbenzene	ND		ug/l	0.50	--
Chloromethane	ND		ug/l	2.5	--
Bromomethane	ND		ug/l	1.0	--
Vinyl chloride	ND		ug/l	1.0	--
Chloroethane	ND		ug/l	1.0	--
1,1-Dichloroethene	ND		ug/l	0.50	--
trans-1,2-Dichloroethene	ND		ug/l	0.75	--
1,2-Dichloroethene (total)	ND		ug/l	0.50	--

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8260C
Analytical Date: 07/10/15 13:43
Analyst: PD

Parameter	Result	Qualifier	Units	RL	MDL
Volatile Organics by GC/MS - Westborough Lab for sample(s): 01-09 Batch: WG801753-3					
Trichloroethene	ND		ug/l	0.50	--
1,2-Dichlorobenzene	ND		ug/l	2.5	--
1,3-Dichlorobenzene	ND		ug/l	2.5	--
1,4-Dichlorobenzene	ND		ug/l	2.5	--
Methyl tert butyl ether	ND		ug/l	1.0	--
p/m-Xylene	ND		ug/l	1.0	--
o-Xylene	ND		ug/l	1.0	--
Xylene (Total)	ND		ug/l	1.0	--
cis-1,2-Dichloroethene	ND		ug/l	0.50	--
Dibromomethane	ND		ug/l	5.0	--
1,4-Dichlorobutane	ND		ug/l	5.0	--
1,2,3-Trichloropropane	ND		ug/l	5.0	--
Styrene	ND		ug/l	1.0	--
Dichlorodifluoromethane	ND		ug/l	5.0	--
Acetone	ND		ug/l	5.0	--
Carbon disulfide	ND		ug/l	5.0	--
2-Butanone	ND		ug/l	5.0	--
Vinyl acetate	ND		ug/l	5.0	--
4-Methyl-2-pentanone	ND		ug/l	5.0	--
2-Hexanone	ND		ug/l	5.0	--
Ethyl methacrylate	ND		ug/l	5.0	--
Acrylonitrile	ND		ug/l	5.0	--
Bromochloromethane	ND		ug/l	2.5	--
Tetrahydrofuran	ND		ug/l	5.0	--
2,2-Dichloropropane	ND		ug/l	2.5	--
1,2-Dibromoethane	ND		ug/l	2.0	--
1,3-Dichloropropane	ND		ug/l	2.5	--
1,1,1,2-Tetrachloroethane	ND		ug/l	0.50	--
Bromobenzene	ND		ug/l	2.5	--

Method Blank Analysis
Batch Quality Control

Analytical Method: 1,8260C
Analytical Date: 07/10/15 13:43
Analyst: PD

Parameter	Result	Qualifier	Units	RL	MDL
Volatile Organics by GC/MS - Westborough Lab for sample(s): 01-09 Batch: WG801753-3					
n-Butylbenzene	ND		ug/l	0.50	--
sec-Butylbenzene	ND		ug/l	0.50	--
tert-Butylbenzene	ND		ug/l	2.5	--
o-Chlorotoluene	ND		ug/l	2.5	--
p-Chlorotoluene	ND		ug/l	2.5	--
1,2-Dibromo-3-chloropropane	ND		ug/l	2.5	--
Hexachlorobutadiene	ND		ug/l	0.50	--
Isopropylbenzene	ND		ug/l	0.50	--
p-Isopropyltoluene	ND		ug/l	0.50	--
Naphthalene	ND		ug/l	2.5	--
n-Propylbenzene	ND		ug/l	0.50	--
1,2,3-Trichlorobenzene	ND		ug/l	2.5	--
1,2,4-Trichlorobenzene	ND		ug/l	2.5	--
1,3,5-Trimethylbenzene	ND		ug/l	2.5	--
1,2,4-Trimethylbenzene	ND		ug/l	2.5	--
trans-1,4-Dichloro-2-butene	ND		ug/l	2.5	--
Ethyl ether	ND		ug/l	2.5	--

Surrogate	%Recovery	Qualifier	Acceptance Criteria
1,2-Dichloroethane-d4	102		70-130
Toluene-d8	102		70-130
4-Bromofluorobenzene	106		70-130
Dibromofluoromethane	93		70-130

Lab Control Sample Analysis

Batch Quality Control

Project Name: BAYLIS REMEDIATION

Project Number: 20001847.003.002

Lab Number: L1515555

Report Date: 07/15/15

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Volatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-09 Batch: WG801753-1 WG801753-2								
Methylene chloride	97		95		70-130	2		20
1,1-Dichloroethane	100		96		70-130	4		20
Chloroform	99		94		70-130	5		20
Carbon tetrachloride	98		95		63-132	3		20
1,2-Dichloropropane	99		96		70-130	3		20
Dibromochloromethane	79		75		63-130	5		20
1,1,2-Trichloroethane	98		97		70-130	1		20
Tetrachloroethene	92		87		70-130	6		20
Chlorobenzene	93		88		75-130	6		25
Trichlorofluoromethane	107		100		62-150	7		20
1,2-Dichloroethane	100		98		70-130	2		20
1,1,1-Trichloroethane	82		79		67-130	4		20
Bromodichloromethane	86		82		67-130	5		20
trans-1,3-Dichloropropene	77		76		70-130	1		20
cis-1,3-Dichloropropene	78		77		70-130	1		20
1,1-Dichloropropene	98		94		70-130	4		20
Bromoform	103		98		54-136	5		20
1,1,2,2-Tetrachloroethane	103		101		67-130	2		20
Benzene	96		92		70-130	4		25
Toluene	96		90		70-130	6		25
Ethylbenzene	96		92		70-130	4		20

Lab Control Sample Analysis
Batch Quality Control

Project Name: BAYLIS REMEDIATION
Project Number: 20001847.003.002

Lab Number: L1515555
Report Date: 07/15/15

Volatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-09 Batch: WG801753-1 WG801753-2

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Chloromethane	87		89		64-130	2		20
Bromomethane	54		58		39-139	7		20
Vinyl chloride	106		106		55-140	0		20
Chloroethane	113		113		55-138	0		20
1,1-Dichloroethene	98		90		61-145	9		25
trans-1,2-Dichloroethene	97		91		70-130	6		20
Trichloroethene	94		89		70-130	5		25
1,2-Dichlorobenzene	92		90		70-130	2		20
1,3-Dichlorobenzene	92		88		70-130	4		20
1,4-Dichlorobenzene	91		88		70-130	3		20
Methyl tert butyl ether	90		95		63-130	5		20
p/m-Xylene	96		91		70-130	5		20
o-Xylene	95		91		70-130	4		20
cis-1,2-Dichloroethene	95		86		70-130	10		20
Dibromomethane	95		93		70-130	2		20
1,4-Dichlorobutane	104		102		70-130	2		20
1,2,3-Trichloropropane	102		100		64-130	2		20
Styrene	96		93		70-130	3		20
Dichlorodifluoromethane	98		96		36-147	2		20
Acetone	120		118		58-148	2		20
Carbon disulfide	101		91		51-130	10		20

Lab Control Sample Analysis
Batch Quality Control

Project Name: BAYLIS REMEDIATION
Project Number: 20001847.003.002

Lab Number: L1515555
Report Date: 07/15/15

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Volatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-09 Batch: WG801753-1 WG801753-2								
2-Butanone	108		114		63-138	5		20
Vinyl acetate	101		110		70-130	9		20
4-Methyl-2-pentanone	96		100		59-130	4		20
2-Hexanone	101		106		57-130	5		20
Ethyl methacrylate	77		81		70-130	5		20
Acrylonitrile	103		104		70-130	1		20
Bromochloromethane	101		98		70-130	3		20
Tetrahydrofuran	102		100		58-130	2		20
2,2-Dichloropropane	102		104		63-133	2		20
1,2-Dibromoethane	97		96		70-130	1		20
1,3-Dichloropropane	98		96		70-130	2		20
1,1,1,2-Tetrachloroethane	79		75		64-130	5		20
Bromobenzene	95		91		70-130	4		20
n-Butylbenzene	99		93		53-136	6		20
sec-Butylbenzene	100		94		70-130	6		20
tert-Butylbenzene	98		91		70-130	7		20
o-Chlorotoluene	100		93		70-130	7		20
p-Chlorotoluene	98		93		70-130	5		20
1,2-Dibromo-3-chloropropane	80		86		41-144	7		20
Hexachlorobutadiene	93		88		63-130	6		20
Isopropylbenzene	93		89		70-130	4		20

Lab Control Sample Analysis

Batch Quality Control

Project Name: BAYLIS REMEDIATION

Project Number: 20001847.003.002

Lab Number: L1515555

Report Date: 07/15/15

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
Volatile Organics by GC/MS - Westborough Lab Associated sample(s): 01-09 Batch: WG801753-1 WG801753-2								
p-Isopropyltoluene	98		91		70-130	7		20
Naphthalene	76		78		70-130	3		20
n-Propylbenzene	103		97		69-130	6		20
1,2,3-Trichlorobenzene	80		81		70-130	1		20
1,2,4-Trichlorobenzene	83		82		70-130	1		20
1,3,5-Trimethylbenzene	100		93		64-130	7		20
1,2,4-Trimethylbenzene	97		93		70-130	4		20
trans-1,4-Dichloro-2-butene	101		99		70-130	2		20
Ethyl ether	94		94		59-134	0		20

Surrogate	LCS %Recovery	Qual	LCSD %Recovery	Qual	Acceptance Criteria
1,2-Dichloroethane-d4	102		99		70-130
Toluene-d8	101		101		70-130
4-Bromofluorobenzene	107		105		70-130
Dibromofluoromethane	99		96		70-130

Sample Receipt and Container Information

Were project specific reporting limits specified? YES

Reagent H2O Preserved Vials Frozen on: NA

Cooler Information

Cooler	**Custody Seal**
A	Absent

Container Information

Container ID	Container Type	Cooler	pH	Temp deg C	Pres	Seal	Analysis(*)
L1515555-01A	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-01B	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-01C	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-02A	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-02B	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-02C	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-03A	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-03B	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-03C	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-04A	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-04B	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-04C	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-05A	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-05B	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-05C	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-06A	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-06B	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-06C	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-07A	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-07B	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-07C	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-08A	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-08B	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-08C	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-09A	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)
L1515555-09B	Vial HCl preserved	A	N/A	2.9	Y	Absent	8260(14)

*Values in parentheses indicate holding time in days

GLOSSARY

Acronyms

EDL - Estimated Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The EDL includes any adjustments from dilutions, concentrations or moisture content, where applicable. The use of EDLs is specific to the analysis of PAHs using Solid-Phase Microextraction (SPME).

EPA - Environmental Protection Agency.

LCS - Laboratory Control Sample: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.

LCSD - Laboratory Control Sample Duplicate: Refer to LCS.

LFB - Laboratory Fortified Blank: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.

MDL - Method Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The MDL includes any adjustments from dilutions, concentrations or moisture content, where applicable.

MS - Matrix Spike Sample: A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.

MSD - Matrix Spike Sample Duplicate: Refer to MS.

NA - Not Applicable.

NC - Not Calculated: Term is utilized when one or more of the results utilized in the calculation are non-detect at the parameter's reporting unit.

NI - Not Ignitable.

NP - Non-Plastic: Term is utilized for the analysis of Atterberg Limits in soil.

RL - Reporting Limit: The value at which an instrument can accurately measure an analyte at a specific concentration. The RL includes any adjustments from dilutions, concentrations or moisture content, where applicable.

RPD - Relative Percent Difference: The results from matrix and/or matrix spike duplicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD). Values which are less than five times the reporting limit for any individual parameter are evaluated by utilizing the absolute difference between the values; although the RPD value will be provided in the report.

SRM - Standard Reference Material: A reference sample of a known or certified value that is of the same or similar matrix as the associated field samples.

TIC - Tentatively Identified Compound: A compound that has been identified to be present and is not part of the target compound list (TCL) for the method and/or program. All TICs are qualitatively identified and reported as estimated concentrations.

Footnotes

1 - The reference for this analyte should be considered modified since this analyte is absent from the target analyte list of the original method.

Terms

Total: With respect to Organic analyses, a 'Total' result is defined as the summation of results for individual isomers or Aroclors. If a 'Total' result is requested, the results of its individual components will also be reported. This is applicable to 'Total' results for methods 8260, 8081 and 8082.

Analytical Method: Both the document from which the method originates and the analytical reference method. (Example: EPA 8260B is shown as 1,8260B.) The codes for the reference method documents are provided in the References section of the Addendum.

Data Qualifiers

A - Spectra identified as "Aldol Condensation Product".

B - The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For MCP-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For DOD-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank AND the analyte was detected above one-half the reporting limit (or above the reporting limit for common lab contaminants) in the associated method blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit. For NJ-related projects (excluding Air), flag only applies to associated field samples that have detectable concentrations of the analyte, which was detected above the reporting limit in the associated method blank or above five times the reporting limit for common lab contaminants (Phthalates, Acetone, Methylene Chloride, 2-Butanone).

C - Co-elution: The target analyte co-elutes with a known lab standard (i.e. surrogate, internal standards, etc.) for co-extracted analyses.

Data Qualifiers

D	- Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.
E	- Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.
G	- The concentration may be biased high due to matrix interferences (i.e, co-elution) with non-target compound(s). The result should be considered estimated.
H	- The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.
I	- The lower value for the two columns has been reported due to obvious interference.
M	- Reporting Limit (RL) exceeds the MCP CAM Reporting Limit for this analyte.
NJ	- Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where the identification is based on a mass spectral library search.
P	- The RPD between the results for the two columns exceeds the method-specified criteria.
Q	- The quality control sample exceeds the associated acceptance criteria. For DOD-related projects, LCS and/or Continuing Calibration Standard exceedences are also qualified on all associated sample results. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)
R	- Analytical results are from sample re-analysis.
RE	- Analytical results are from sample re-extraction.
S	- Analytical results are from modified screening analysis.
J	- Estimated value. This represents an estimated concentration for Tentatively Identified Compounds (TICs).
ND	- Not detected at the reporting limit (RL) for the sample.

REFERENCES

1 Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. EPA SW-846. Third Edition. Updates I - IV, 2007.

LIMITATION OF LIABILITIES

Certification Information

Last revised December 16, 2014

The following analytes are not included in our NELAP Scope of Accreditation:

Westborough Facility
EPA 524.2: Acetone, 2-Butanone (Methyl ethyl ketone (MEK)), Tert-butyl alcohol, 2-Hexanone, Tetrahydrofuran, 1,3,5-Trichlorobenzene, 4-Methyl-2-pentanone (MIBK), Carbon disulfide, Diethyl ether.
EPA 8260C: 1,2,4,5-Tetramethylbenzene, 4-Ethyltoluene, Iodomethane (methyl iodide), Methyl methacrylate, Azobenzene.
EPA 8270D: 1-Methylnaphthalene, Dimethylnaphthalene,1,4-Diphenylhydrazine.
EPA 625: 4-Chloroaniline, 4-Methylphenol.
SM4500: Soil: Total Phosphorus, TKN, NO2, NO3.
EPA 9071: Total Petroleum Hydrocarbons, Oil & Grease.

Mansfield Facility
EPA 8270D: Biphenyl.
EPA 2540D: TSS
EPA TO-15: Halothane, 2,4,4-Trimethyl-2-pentene, 2,4,4-Trimethyl-1-pentene, Thiophene, 2-Methylthiophene, 3-Methylthiophene, 2-Ethylthiophene, 1,2,3-Trimethylbenzene, Indan, Indene, 1,2,4,5-Tetramethylbenzene, Benzothiophene, 1-Methylnaphthalene.

The following analytes are included in our Massachusetts DEP Scope of Accreditation, Westborough Facility:

Drinking Water
EPA 200.8: Sb,As,Ba,Be,Cd,Cr,Cu,Pb,Ni,Se,Tl; **EPA 200.7**: Ba,Be,Ca,Cd,Cr,Cu,Na; **EPA 245.1:** Mercury;
EPA 300.0: Nitrate-N, Fluoride, Sulfate; **EPA 353.2**: Nitrate-N, Nitrite-N; **SM4500NO3-F**: Nitrate-N, Nitrite-N; **SM4500F-C, SM4500CN-CE, EPA 180.1, SM2130B, SM4500Cl-D, SM2320B, SM2540C, SM4500H-B**
EPA 332: Perchlorate.
Microbiology: **SM9215B; SM9223-P/A, SM9223B-Colilert-QT, Enterolert-QT.**

Non-Potable Water
EPA 200.8: Al,Sb,As,Be,Cd,Cr,Cu,Pb,Mn,Ni,Se,Ag,Tl,Zn;
EPA 200.7: Al,Sb,As,Be,Cd,Ca,Cr,Co,Cu,Fe,Pb,Mg,Mn,Mo,Ni,K,Se,Ag,Na,Sr,Ti,Tl,V,Zn;
EPA 245.1, SM4500H,B, EPA 120.1, SM2510B, SM2540C, SM2340B, SM2320B, SM4500CL-E, SM4500F-BC, SM426C, SM4500NH3-BH, **EPA 350.1**: Ammonia-N, **LACHAT 10-107-06-1-B**: Ammonia-N, **SM4500NO3-F, EPA 353.2**: Nitrate-N**, SM4500NH3-BC-NES, EPA 351.1, SM4500P-E, SM4500P-B, E, SM5220D, EPA 410.4, SM5210B, SM5310C, SM4500CL-D, EPA 1664, SM14 510AC, EPA 420.1, SM4500-CN-CE, SM2540D.**
EPA 624: Volatile Halocarbons & Aromatics,
EPA 608: Chlordane, Toxaphene, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, Dieldrin, DDD, DDE, DDT, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, PCBs
EPA 625: SVOC (Acid/Base/Neutral Extractables), **EPA 600/4-81-045**: PCB-Oil.
Microbiology: **SM9223B-Colilert-QT; Enterolert-QT, SM9222D-MF**.

For a complete listing of analytes and methods, please contact your Alpha Project Manager.

ALPHA ANALYTICAL
World Class Chemistry

CHAIN OF CUSTODY

PAGE 1 OF 1

Date Rec'd in Lab: 7-8-15

ALPHA Job #: L1515555

Westborough, MA
TEL: 508-898-9220
FAX: 508-898-9193

Mansfield, MA
TEL: 508-822-9300
FAX: 508-822-3288

Project Information

Project Name: Baylis Remediation
Project Location: Warwick, RI
Project #: 20001847.003.002
Project Manager: Clayton Carlisle
ALPHA Quote #:

Client Information

Client: Louis Berger
Address: 166 Valley St. Bldg. 5
Providence, RI 02909
Phone: (401) 415-9447
Fax:
Email: shogan@louisberger.com

☐ These samples have been Previously analyzed by Alpha

Turn-Around Time

☐ Standard ☐ Rush (ONLY IF PRE-APPROVED)

Due Date: Time:

Other Project Specific Requirements/Comments/Detection Limits:

Report Information Data Deliverables

☐ FAX ☐ EMAIL
☒ ADEx ☐ Add'l Deliverables

Billing Information

☒ Same as Client info
PO #:

Regulatory Requirements/Report Limits

State/Fed Program:
Criteria:

ANALYSIS

SAMPLE HANDLING
Filtration
☐ Done
☐ Not Needed
☐ Lab to do
Preservation
☐ Lab to do
(Please specify below)

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler's Initials	VOC												Sample Specific Comments	TOTAL # BOTTLES
15555-01	E-4	7/7/15	7:58	GW	SH	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		3
02	E-5		8:44			☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		
03	E-6		9:24			☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		
04	ESM-8		9:58			☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		
05	E-33		11:18			☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		
06	E-34		11:54			☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		
07	E-42		12:30			☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		
08	E-43		1:00			☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		
09	Trip Blan					☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		2
						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		

Container Type	✓	-	-	-	-	-	-	-	-	-	-
Preservative	-	-	-	-	-	-	-	-	-	-	-

Relinquished By:	Date/Time	Received By:	Date/Time
	7/8/15 1057		7-8-15 1100
	7/8/15 1350		7-8-15 1350

Please print clearly, legibly and completely. Samples can not be logged in and turnaround time clock will not start until any ambiguities are resolved. All samples submitted are subject to Alpha's Payment Terms.

FORM NO: 01-01(I-NJ)
(rev. 5-JAN-12)

APPENDIX 3

SUPPORTING DOCUMENTS IN-SITU OXIDATION PROGRAM

FMC
ENVIRONMENTAL SOLUTIONS

Klozur® Persulfate

In Situ Chemical Oxidation

The Ideal ISCO Solution to address soil and groundwater contamination

Klozur® Persulfate offers a unique combination of power and versatility. It is one of the most cost-effective technologies in the market. Klozur® Persulfate is ideal for *in situ* chemical oxidation of contaminated source zones and hot spots that require rapid treatment.

Successful field applications of Klozur® Activated Persulfate have been performed globally. These applications demonstrate the ability of Klozur activated persulfate to treat diverse organic contaminants of concern including: chlorinated ethenes (TCE, PCE, DCE and vinyl chloride), chlorinated ethanes (TCA and DCA), chlorinated methanes (carbon tetrachloride and methylene chloride), BTEX, MTBE, polyaromatic hydrocarbons (PAHs), petroleum hydrocarbons (TPHs, GRO, DRO), 1,4-dioxane and pesticides.

$$S_2O_8^{-2} \rightarrow SO_4\bullet^{-}, OH\bullet^{-}$$

Benefits include:

Power
- Multi-radical attack
- Rapid destruction of recalcitrant compounds

Versatility
- Flexible activation basted on site conditions
- Multiple methods of delivery
- Highly soluble (up to 40 wt%)

Stability
- Persistent in the subsurface, providing an extended radius of influence
- Safe to handle – does not generate heat or gas under normal use

Potential Applications:

Direct push injection

Fixed well injection

Soil blending

Examples of Contaminants of Concern
CHLORINATED SOLVENTS PCE, TCE, DCE, VC, TCA, DCA, Methylene Chloride, Carbon Tetrachloride, Chlorobenzene
PETROLEUM TPH, BTEX, DRO, GRO
PAHs Creosote, MGP residuals 1,4-dioxane, MTBE, TBA, energetics, Chlorinated pesticides

For more information and detailed case studies, please visit our website.

ADVENTUS

SOIL & GROUNDWATER REMEDIATION

Procedure for Activating Klozur® Persulfate with a 25% Sodium Hydroxide Solution

Background

For alkaline activation of Klozur Persulfate, the pH of the soil and groundwater will need to be maintained between 10.5 and 12. Sodium Hydroxide (NaOH, caustic soda) can be used to achieve the pH target range. The NaOH demand arises from two sources; 1) soil and groundwater acidity, and 2) the generation of acid formed during the decomposition of Klozur Persulfate. The amount of the NaOH needed to raise soil and groundwater pH must be determined experimentally (see procedure below). In addition, to address the persulfate generated acid, 2 moles of NaOH per mole of Klozur Persulfate must be added to neutralize the persulfate-generated acid.

Total NaOH Demand = NaOH needed to raise soil and groundwater to target pH 10.5-12 +
2 moles NaOH / mole Klozur persulfate

Safety and Handling

Sodium Hydroxide is a corrosive chemical and can cause severe chemical burns to body tissue if mishandled. Therefore, appropriate Personal Protective Equipment (PPE), including chemical goggles and face shield, is required when handling and transferring NaOH. **Review the MSDS with all workers prior to handling this chemical.**

Sodium Hydroxide is sold commercially in a variety of concentrations. Common concentrations include; 50%, 73%, and solid flakes or pellets (100%). These highly concentrated forms of NaOH may generate extreme exothermic reactions upon dilution. In certain circumstances, so much heat may be liberated that it can boil the solution causing steam eruptions, loss of product containment and damage to equipment. Use of concentrated NaOH require very long dilution times and/or heat exchange equipment with agitation or good mixing.

FMC recommends NaOH solutions of no more than 25% by weight be used to activate Klozur persulfate.

This will help to minimize the generation of heat upon mixing the NaOH with water. FMC does not permit use of NaOH concentrations greater than 25% in its Klozur mixing rental equipment.

Use of NaOH solutions in excess of 25 wt% or in solid form may increase the risk of injury, loss of product containment and equipment damage.

FMC
ENVIRONMENTAL SOLUTIONS

Klozur® Persulfate
Activation Procedure

Activation Procedures

Part A: Soil Titration Method for 25% NaOH determination

1. Take a 500 gram (1.1 lb) sample of the soil from an area that is representative of the contaminated site.
2. Take a 1500 gram (3.31 lb) sample of the ground water.
3. Place these samples in a clean glass or plastic container and mix thoroughly for 5 minutes.
4. Determine and record the pH of the water.
5. Take 100 ml aliquot of the mixed soil/ water slurry in a clean glass beaker. Insert a pH probe to measure the pH as NaOH is added.
6. Set up a burette with 25% NaOH solution.
7. Slowly dose 25% NaOH into the beaker until the pH reaches 10.5 and maintains 10.5 for 30 minutes. Add more 25% NaOH if the pH drops during the test.
8. Record the ml's of 25% NaOH required to neutralize 100 ml's of soil slurry.
9. Calculate and scale up the amount of NaOH to Field scale conditions based on total treatment soil volume.

Note: 3785 ml's (3.785 L) = 1 gallon.

Part B: Determine the amount of 25% NaOH to neutralize the Persulfate- Generated Acid

1. Determine total Klozur® requirement in lbs
2. Multiply lbs of Klozur® by 0.1267 to determine gallons of 25% NaOH required

Note: 2 lb-moles NaOH required / lb-mole persulfate persulfate → 1.344 lb of 25 wt% NaOH / lb of Klozur persulfate Density of 25 wt% NaOH = 10.61 lb / gal → 126.67 gal 25 wt% NaOH / 1000 lb Klozur persulfate

The total 25 wt% NaOH demand = amount from Part A + amount from Part B

Applying Klozur solution and 25% NaOH activator to a contaminated site

1. 25% NaOH solution can be:

- applied to a site prior to addition of the Klozur persulfate solution
- applied to a site post addition of the Klozur persulfate solution
- applied to a site simultaneous to the addition of the Klozur persulfate solution

2. It is recommended that if the Klozur persulfate and 25 wt% NaOH solution are added simultaneously

- No more than **0.2 gallons** of 25% NaOH should be added per gallon of 30% Klozur solution
- No more than **0.4 gallons** of 25% NaOH should be added per gallon of 20% Klozur solution
- No more than **0.6 gallons** of 25% NaOH should be added per gallon o 10% Klozur solution

Mixing of NaOH and persulfate solutions in ratios greater than mentioned above may lead to increases in solution temperature.

ADVENTUS

SOIL & GROUNDWATER REMEDIATION

Corrosion and Material Compatibility
Technical Bulletin

Background

Klozur® Persulfate solutions are used to treat contaminated soil and groundwater and can remediate a wide range of organic contaminants. However, Klozur Persulfate is a very strong oxidant, and its solutions may be very acidic (pH ≤ 2) under many conditions, resulting in a corrosive environment for many metals and materials. In this bulletin, results from corrosion studies using un-activated and activated persulfate solutions are presented and recommendations regarding materials of compatibility are made. For additional information regarding the safety of Klozur Persulfate, please refer to the Material Safety Data Sheet (MSDS), which is available from FMC.

Corrosion

Laboratory tests were conducted to evaluate the performance of commonly-used engineering materials exposed to Klozur Persulfate solutions (both activated and un-activated). The tests were performed at two different persulfate solution concentrations: 20 wt% representing typical make-up solutions being injected, and 40 g / L representing typical in situ ground water concentrations. These tests were conducted per the guidelines outlined in ASTM G31-72.
Corrosion rates for metallic coupons were calculated based on changes in weight over the exposure time. Non-metallic coupons were observed for visual changes and changes in physical properties. Structural properties of concrete and non-metallics were not measured.

Results

For un-activated Klozur Persulfate solutions, no observable corrosion on stainless steel (304L and 316L) was observed during the testing. However, for carbon steel, copper and brass, severe corrosion was observed shortly after the testing was initiated, for both the concentrated (20 wt%) and diluted persulfate solutions. The corrosion rates for carbon steel and brass were observed to decrease when evaluated after one and two months as compared to the one week exposure. However, the rates were sufficiently high to indicate that general corrosion was on going throughout the two month period, indicating that there was no formation of a protective corrosion-product layer. Kynar® and FRP demonstrated satisfactory performance over the one month exposure with no noticeable weight gain or softening observed. Concrete, natural rubber and synthetic rubber showed indications of degradation with long-term exposure to the concentrated persulfate solution.

In general, the impact of the Fe-EDTA activated persulfate solution was similar to the unactivated persulfate solution. No significant increases in corrosion were observed due to the presence of the activator system or subsequent formation of sulfate radicals.

For high pH activated persulfate solutions, sodium hydroxide was added to raise the pH to above 10 and to neutralize sulfuric acid formed upon persulfate decomposition. Significant decreases in corrosion rates were observed for high pH activated persulfate in contact with copper, brass and carbon steel. Negligible corrosion was observed for these metals after one month exposure, even at the 20% persulfate concentration. In addition, no noticeable corrosion was observed for stainless steel. Significant reaction with concrete was observed, however. Significant weight gain (5 – 10%) and bleaching were observed for the concrete after one month exposure to the high pH activated persulfate solution, and some dissolution of the concrete was noted during the test.

Table 1: Results for Un-Activated Klozur® Persulfate Solutions (20 wt%) at room temperature after 1 week and 1 months exposure time

mpy – milli-inches per year; ✓- compatible material, Θ - non-compatible material

Material	1 week	1 month	Comments
Stainless steels (304L, 316L)	✓	✓	< 1 mpy. No noticeable corrosion over 2 months
Copper Brass	> 100 mpy Θ	20 – 50 mpy Θ	Severe general corrosion, corrosion rate decreases with time.
Carbon steel	> 200 mpy Θ	50 – 100 mpy Θ	Severe general corrosion, etching at welds, corrosion rate decreases with time.
Kynar® (PVDF)	✓	✓	No noticeable changes after 2 months exposure
FRP (fiber-reinforced plastic)	✓	✓	No noticeable changes after 2 months exposure
Concrete	Weight gain, bleached appearance	Weight gain (5 –10%), bleached appearance	Increasing weight gain over time. Some dissolution observed as residue in test chamber.
Natural Rubber	Slight weight gain	Slight weight gain	Cracks and blisters observed after 1 month exposure
Synthetic rubber (neoprene)	Slight weight gain	Slight weight gain	Cracks and blisters observed after 1 month exposure

Table 2: Results for Un-Activated Klozur® Persulfate Solutions (40 g / L) at room temperature after 1 week and 2 months exposure time

mpy – milli-inches per year; ✓- compatible material, Θ - non-compatible material

Material	1 week	1 month	Comments
Stainless steels (304L, 316L)	✓	✓	< 1 mpy. No noticeable corrosion over 2 months
Copper Brass	> 50 mpy Θ	< 20 mpy Θ	Severe general corrosion, corrosion rate decreases with time.
Carbon steel	> 50 mpy Θ	< 20 mpy Θ	Several general corrosion, etching at welds, corrosion rate decreases with time.
Kynar® (PVDF)	✓	✓	No noticeable changes after 1 month exposure
FRP (fiber-reinforced plastic)	✓	✓	No noticeable changes after 1 month exposure
Concrete	Weight gain, bleached appearance	Weight gain (5 –10%), bleached appearance	Increasing weight gain over time. Some dissolution observed as residue in test chamber.
Natural Rubber	Slight weight gain	Slight weight gain	
Synthetic rubber (neoprene)	Slight weight gain	Slight weight gain	

Table 3: Results for Fe-EDTA Klozur® Persulfate Solutions, 20 wt% and 40 g / L at room temperature after 1 month exposure time

mpy – milli-inches per year; ✓- compatible material, ⊝ - non-compatible material

Material	20 wt% concentration	40 g / L	Comments
Stainless steels (304L, 316L)	✓	✓	< 1 mpy. No noticeable corrosion over 1 month
Copper Brass	20 – 50 mpy ⊝	< 20 mpy ⊝	Severe general corrosion, corrosion rate decreases with time.
Carbon steel	> 50 mpy ⊝	20 – 50 mpy ⊝	Several general corrosion, etching at welds.
Kynar® (PVDF)	✓	✓	No noticeable changes after 1 month exposure
FRP (fiber-reinforced plastic)	✓	✓	No noticeable changes after 1 month exposure
Concrete	Weight gain, bleached appearance	Weight gain (5 –10%), bleached appearance	Increasing weight gain over time. Some dissolution observed as residue in test chamber.
Natural Rubber	Slight weight gain	Slight weight gain	
Synthetic rubber (neoprene)	Slight weight gain	Slight weight gain	

Table 4: Results for high pH activate Klozur® Persulfate Solutions, 20 wt% and 40 g / L at room temperature after 1 month exposure time

mpy – milli-inches per year; ✓- compatible material, ⊝ - non-compatible material

Material	20 wt% concentration	40 g / L	Comments
Stainless steels (304L, 316L)	✓	✓	< 1 mpy. No noticeable corrosion over 1 month
Copper Brass	✓	✓	Negligible general corrosion (< 2 mpy). Black film formation observed.
Carbon steel	✓	✓	Negligible general corrosion (< 2 mpy). Isolated rust spots observed
Concrete	Weight gain, bleached appearance	Weight gain (5 –10%), bleached appearance	Bleached appearance, increasing weight gain over time, some dissolution observed as residue in test container.

Material Compatibility

Recommend and Compatible Materials:

- Butyl rubber
- EPDM
- FRP (fiber reinforced plastic)
- Glass
- Neoprene
- Plexiglas®
- Polyethylene
- PVC
- Stainless steel (304L and 316L) for all mixing, conveyance and storage equipment
- Teflon®
- Viton

Incompatible Materials:

- Aluminum
- Carbon steel
- Galvanized pipe
- Monel
- Nitrile rubbers
- Brass
- Copper
- Iron
- Nickel

Well Construction:
- Use compatible materials, such as PVC or Stainless Steel (304L, 316L)

Pumps:
- Check compatibility of all seals, gaskets, tubing and hoses

Geoprobe® Rods:
- Threaded joints of rods are very susceptible to corrosion. To help reduce corrosion, several practical measures can be taken, such as applying a barrier layer like Loctite® or Teflon® grease to the threads, or utilizing the High pH activation system to reduce acidic corrosion.

Subsurface Utilities:
- Always check for location and compatibility of subsurface utilities.

Hosing:

- Klozur® persulfate solutions: 20 – 40%, neutral to mildly acidic conditions, moderate to low pressure

Master-Flex 300 EPDM or Equivalent

Specs (diameter)	Max Allowable Working Pressure (PSI)
1”	80
2”	60
3”	50
4”	45
6”	35

  - -30F to +140F
  - EPDM black inner liner of hosing with polyethylene helix
  - Reinforced and a Type G (PVC) cover
  - Medium oil resistance

- Klozur® persulfate solutions: 20 – 40%, mildly acidic conditions, high pressure

Alfagomma (Italian Company)
  - Model T 505 4-4 SP
  - 6 BAF (240 PSI)
  - XLPE chemical S&D

Transporter Ultrachem (brand name)
  - 250 PSI water pressure

- Fittings

304 Stainless – Schedule 40
CPVC – Schedule 80 preferred (could lose strength when heated)
PVC (may become embrittled with continued use)

MATERIAL SAFETY DATA SHEET

Klozur®

MSDS Ref. No.: 7775-27-1-12
Date Approved: 05/13/2009
Revision No.: 5

This document has been prepared to meet the requirements of the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200 and Canada's Workplace Hazardous Materials Information System (WHMIS) requirements.

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1. PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME:	Klozur®
SYNONYMS:	Sodium Persulfate, Sodium Peroxydisulfate; Disodium Peroxydisulfate
GENERAL USE:	In situ and ex situ chemical oxidation of contaminants and compounds of concern for environmental remediation applications.

MANUFACTURER

FMC CORPORATION
FMC Peroxygens
1735 Market Street
Philadelphia, PA 19103
(215) 299-6000 (General Information)
msdsinfo@fmc.com (Email - General Information)

EMERGENCY TELEPHONE NUMBERS

(303) 595-9048 (Medical - U.S. - Call Collect)

For leak, fire, spill, or accident emergencies, call:
(800) 424-9300 (CHEMTREC - U.S.A. & Canada)

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2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:

- White, odorless, crystals
- Oxidizer.
- Decomposes in storage under conditions of moisture (water/water vapor) and/or excessive heat causing release of oxides of sulfur and oxygen that supports combustion. Decomposition could form a high temperature melt. See Section 10 ("Stability and Reactivity").

POTENTIAL HEALTH EFFECTS: Airborne persulfate dust may be irritating to eyes, nose, lungs, throat and skin upon contact. Exposure to high levels of persulfate dust may cause difficulty in breathing in sensitive persons.

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3. COMPOSITION / INFORMATION ON INGREDIENTS

Chemical Name	CAS#	Wt.%	EC No.	EC Class
Sodium Persulfate	7775-27-1	>99	231-892-1	Xn-O; R8-R22-R36/37/38-R42/43

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4. FIRST AID MEASURES

EYES: Flush with plenty of water. Get medical attention if irritation occurs and persists.

SKIN: Wash with plenty of soap and water. Get medical attention if irritation occurs and persists.

INGESTION: Rinse mouth with water. Dilute by giving 1 or 2 glasses of water. Do not induce vomiting. Never give anything by mouth to an unconscious person. See a medical doctor immediately.

INHALATION: Remove to fresh air. If breathing difficulty or discomfort occurs and persists, contact a medical doctor.

NOTES TO MEDICAL DOCTOR: This product has low oral toxicity and is not irritating to the eyes and skin. Flooding of exposed areas with water is suggested. For gastric lavage or emesis induction, consider the possible aggravation of esophageal injury, and the expected absence of system effects. Treatment is controlled removal of exposure followed by symptomatic and supportive care.

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5. FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA: Deluge with water.

FIRE / EXPLOSION HAZARDS: Product is non-combustible. On decomposition releases oxygen which may intensify fire. Presence of water accelerates decomposition.

FIRE FIGHTING PROCEDURES: Do not use carbon dioxide or other gas filled fire extinguishers; they will have no effect on decomposing persulfates. Wear full protective clothing and self-contained breathing apparatus.

FLAMMABLE LIMITS: Non-combustible

SENSITIVITY TO IMPACT: No data available

SENSITIVITY TO STATIC DISCHARGE: Not available

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6. ACCIDENTAL RELEASE MEASURES

RELEASE NOTES: Spilled material should be collected and put in approved DOT container and isolated for disposal. Isolated material should be monitored for signs of decomposition (fuming/smoking). If spilled material is wet, dissolve with large quantity of water and dispose as a hazardous waste. All disposals should be carried out according to regulatory agencies procedures.

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7. HANDLING AND STORAGE

HANDLING: Use adequate ventilation when transferring product from bags or drums. Wear respiratory protection if ventilation is inadequate or not available. Use eye and skin protection. Use clean plastic or stainless steel scoops only.

STORAGE: Store (unopened) in a cool, clean, dry place away from point sources of heat, e.g. radiant heaters or steam pipes. Use first in, first out storage system. Avoid contamination of opened product. In case of fire or decomposition (fuming/smoking) deluge with plenty of water to control decomposition. For storage, refer to NFPA Bulletin 430 on storage of liquid and solid oxidizing materials.

COMMENTS: VENTILATION: Provide mechanical general and/or local exhaust ventilation to prevent release of dust into work environment. Spills should be collected into suitable containers to prevent dispersion into the air.

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8. EXPOSURE CONTROLS / PERSONAL PROTECTION

EXPOSURE LIMITS

Chemical Name	ACGIH	OSHA	Supplier
Sodium Persulfate	0.1 mg/m^3 (TWA)		

ENGINEERING CONTROLS: Provide mechanical local general room ventilation to prevent release of dust into the work environment. Remove contaminated clothing immediately and wash before reuse.

PERSONAL PROTECTIVE EQUIPMENT

EYES AND FACE: Use cup type chemical goggles. Full face shield may be used.

RESPIRATORY: Use approved dust respirator when airborne dust is expected.

PROTECTIVE CLOTHING: Normal work clothes. Rubber or neoprene footwear.

GLOVES: Rubber or neoprene gloves. Thoroughly wash the outside of gloves with soap and water prior to removal. Inspect regularly for leaks.

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9. PHYSICAL AND CHEMICAL PROPERTIES

ODOR:	None
APPEARANCE:	White crystals
AUTOIGNITION TEMPERATURE:	Not applicable. No evidence of combustion up to 800°C. Decomposition will occur upon heating.
BOILING POINT:	Not applicable
COEFFICIENT OF OIL / WATER:	Not applicable
DENSITY / WEIGHT PER VOLUME:	Not available
EVAPORATION RATE:	Not applicable (Butyl Acetate = 1)
FLASH POINT:	Non-combustible
MELTING POINT:	Decomposes
ODOR THRESHOLD:	Not applicable
OXIDIZING PROPERTIES:	Oxidizer
PERCENT VOLATILE:	Not applicable
pH:	typically 5.0 - 7.0 @ 25 °C (1% solution)
SOLUBILITY IN WATER:	73 % @ 25 °C (by wt.)
SPECIFIC GRAVITY:	2.6 (H_2O=1)
VAPOR DENSITY:	Not applicable (Air = 1)
VAPOR PRESSURE:	Not applicable

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10. STABILITY AND REACTIVITY

CONDITIONS TO AVOID:	Heat, moisture and contamination.
STABILITY:	Stable (becomes unstable in presence of heat, moisture and/or contamination).
POLYMERIZATION:	Will not occur
INCOMPATIBLE MATERIALS:	Acids, alkalis, halides (fluorides, chlorides, bromides and iodides), combustible materials, most metals and heavy metals, oxidizable materials, other oxidizers, reducing agents, cleaners, and organic or carbon containing compounds. Contact

	with incompatible materials can result in a material decomposition or other uncontrolled reactions.
HAZARDOUS DECOMPOSITION PRODUCTS:	Oxygen that supports combustion and oxides of sulfur.

COMMENTS: PRECAUTIONARY STATEMENT: Pumping and transport of Klozur persulfate requires appropriate precautions and design considerations for pressure and thermal relief.

Decomposing persulfates will evolve large volumes of gas and/or vapor, can accelerate exponentially with heat generation, and create significant and hazardous pressures if contained and not properly controlled or mitigated.

Use with alcohols in the presence of water has been demonstrated to generate conditions that require rigorous adherence to process safety methods and standards to prevent escalation to an uncontrolled reaction.

11. TOXICOLOGICAL INFORMATION

EYE EFFECTS: Non-irritating (rabbit) [FMC Ref. ICG/T-79.029]

SKIN EFFECTS: Non-irritating (rabbit) [FMC Ref. ICG/T-79.029]

DERMAL LD_{50}: > 10 g/kg [FMC Ref. ICG/T-79.029]

ORAL LD_{50}: 895 mg/kg (rat) [FMC Ref. ICG/T-79.029]

INHALATION LC_{50}: 5.1 mg/l (rat) [FMC Ref. I95-2017]

SENSITIZATION: May be sensitizing to allergic persons. [FMC Ref. ICG/T-79.029]

TARGET ORGANS: Eyes, skin, respiratory passages

ACUTE EFFECTS FROM OVEREXPOSURE: Dust may be harmful and irritating. May be harmful if swallowed.

CHRONIC EFFECTS FROM OVEREXPOSURE: Sensitive persons may develop dermatitis and asthma [Respiration 38:144, 1979]. Groups of male and female rats were fed 0, 300 or 3000 ppm sodium persulfate in the diet for 13 weeks, followed by 5000 ppm for 5 weeks. Microscopic examination of tissues revealed some injury to the gastrointestinal tract at the high dose (3000 ppm) only. This effect is not unexpected for an oxidizer at high concentrations. [Ref. FMC I90-1151, Toxicologist 1:149, 1981].

CARCINOGENICITY:

NTP:	Not listed
IARC:	Not listed
OSHA:	Not listed
OTHER:	ACGIH: Not listed

12. ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION:

Bluegill sunfish, 96-hour LC_{50} = 771 mg/L [FMC Study I92-1250]
Rainbow trout, 96-hour LC_{50} = 163 mg/L [FMC Study I92-1251]
Daphnia, 48-hour LC_{50} = 133 mg/L [FMC Study I92-1252]
Grass shrimp, 96-hour LC_{50} = 519 mg/L [FMC Study I92-1253]

CHEMICAL FATE INFORMATION: Biodegradability does not apply to inorganic substances.

13. DISPOSAL CONSIDERATIONS

DISPOSAL METHOD: Dispose as a hazardous waste in accordance with local, state and federal regulatory agencies.

14. TRANSPORT INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION (DOT)

PROPER SHIPPING NAME:	Sodium Persulfate
PRIMARY HAZARD CLASS / DIVISION:	5.1 (Oxidizer)
UN/NA NUMBER:	UN 1505
PACKING GROUP:	III
LABEL(S):	5.1 (Oxidizer)
PLACARD(S):	5.1 (Oxidizer)
MARKING(S):	Sodium Persulfate, UN 1505
ADDITIONAL INFORMATION:	Hazardous Substance/RQ: Not applicable

49 STCC Number: 4918733

This material is shipped in 225 lb. fiber drums, 55 lb. poly bags and 1000 - 2200 lb. IBC's (supersacks).

INTERNATIONAL MARITIME DANGEROUS GOODS (IMDG)

PROPER SHIPPING NAME:	Sodium Persulfate

INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) / INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)

PROPER SHIPPING NAME:	Sodium Persulfate

OTHER INFORMATION:

Protect from physical damage. Do not store near acids, moisture or heat.

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15. REGULATORY INFORMATION

UNITED STATES

SARA TITLE III (SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT)

SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355, APPENDIX A):

Not applicable

SECTION 311 HAZARD CATEGORIES (40 CFR 370):

Fire Hazard, Immediate (Acute) Health Hazard

SECTION 312 THRESHOLD PLANNING QUANTITY (40 CFR 370):

The Threshold Planning Quantity (TPQ) for this product, if treated as a mixture, is 10,000 lbs; however, this product contains the following ingredients with a TPQ of less than 10,000 lbs.: None

SECTION 313 REPORTABLE INGREDIENTS (40 CFR 372):

There are no ingredients in this product, which are subject to Section 313 reporting requirements.

CERCLA (COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT)

CERCLA DESIGNATION & REPORTABLE QUANTITIES (RQ) (40 CFR 302.4):

Unlisted, RQ = 100 lbs., Ignitability

TSCA (TOXIC SUBSTANCE CONTROL ACT)

TSCA INVENTORY STATUS (40 CFR 710):

All components are listed or exempt.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

RCRA IDENTIFICATION OF HAZARDOUS WASTE (40 CFR 261):

Waste Number: D001

CANADA

WHMIS (WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM):

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

Hazard Classification / Division:	C D2A D2B
Domestic Substance List:	All components are listed or exempt.

INTERNATIONAL LISTINGS

Australia (AICS): Listed
China: Listed
Japan (ENCS): (1)-1131
Korea: KE-12369
Philippines (PICCS): Listed

HAZARD AND RISK PHRASE DESCRIPTIONS:

EC Symbols:	Xn	(Harmful)
	O	(Oxidizer)
EC Risk Phrases:	R8	(Contact with combustible material may cause fire)
	R22	(Harmful if swallowed.)
	R36/37/38	(Irritating to eyes, respiratory system and skin.)
	R42/43	(May cause sensitization by inhalation or by skin contact.)

16. OTHER INFORMATION

HMIS

Health	1
Flammability	0
Physical Hazard	1
Personal Protection (PPE)	J

Protection = J (Safety goggles, gloves, apron & combination dust & vapor respirator)

HMIS = Hazardous Materials Identification System

Degree of Hazard Code:
4 = Severe
3 = Serious
2 = Moderate
1 = Slight
0 = Minimal

NFPA

Health	1
Flammability	0
Reactivity	1
Special	OX

SPECIAL = OX (Oxidizer)

NFPA (National Fire Protection Association)

Degree of Hazard Code:
4 = Extreme
3 = High
2 = Moderate
1 = Slight
0 = Insignificant

REVISION SUMMARY:
This MSDS replaces Revision #4, dated September 18, 2006.
Changes in information are as follows:
Section 1 (Product and Company Identification)
Section 3 (Composition / Information on Ingredients)
Section 15 (Regulatory Information)
Section 16 (Other Information)

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APPENDIX 4

SUPPORTING DOCUMENTS

ANAEROBIC DECHLORINATION PROGRAM

EHC-L® Liquid ISCR Reagent Demand Calculations

PeroxyChem

5-Feb-2015

Customer:	**ES&M**	**Prepared by:**	
Contact:	**Daniel Batchelder**	**Ravi Srirangam, PhD**	
Site Location:	**T.F. Green InterLink, Warwick,**	**1-312-480-5250**	
Proposal Number:	**PeroxyChem-0**	**Ravi.Srirangam@peroxychem.com**	

PRODUCT OVERVIEW

EHC-L® is a cold-water soluble formulation of EHC® that is specially designed for injection via existing wells or hydraulic injection networks for the treatment of a wide range of groundwater contaminants. The base composition is controlled-release organic carbon with an organo-iron compound (both food-grade).


Part 1

Packaging:

EHC-L is delivered in 2 parts and mixed together with water in the field.

Part 1: Liquid emulsion delivered in 55-USG drums, filled with 50 USG / 420 lbs per drum.
Part 2: Water soluble powder with the organo-iron compound and other additives delivered in 24.6 lb bags.


Part 2

SITE INFORMATION / ASSUMPTIONS

	Value	Unit	Comment
Treatment Area Dimensions:			
Width of targeted zone (perpendicular to gw flow)	600	ft	customer supplied
Length of targeted zone (parallel to gw flow)	15	ft	customer supplied
Depth to top of treatment zone	20	ft bgs	customer supplied
Treatment zone thickness	25	ft	customer supplied
Treatment volume	225,000	ft3	calculated value
Total Porosity	42	%	default value
Groundwater volume	94,500	ft3	calculated value
Soil bulk density	90	lbs/ft3	default value
Soil mass	10,125	ton	calculated value
Transport characteristics:			
Treatment time / design life for one application	1	years	default value
Linear groundwater flow velocity	69	ft/year	calculated value
Distance of inflowing gw over design life	69	ft	calculated value
Effective porosity for groundwater flow	41	%	default value
Volume of water passing region over design life	417469	ft3	calculated value
Soil type	medium		customer supplied

Fraction organic carbon in soil, foc	0.005	estimated value

CONTAMINANTS OF CONCERN (COCs)

Constituent	**GW (mg/L)**	**Soil* (mg/kg)**	**Total COI Mass** (lb)**
PCE	0.723	0.950745	42.4
TCE	0.649	0.347215	27.8
TCA	0.105	0.096075	5.3

*Unless provided, sorbed concentrations were roughly estimated based on expected groundwater concentrations, foc and Koc values. For a more refined estimate, it is recommended that actual values be verified via direct sampling of the targeted treatment interval.

**The total COI mass was estimated based on concentrations in soil and groundwater within the targeted area plus expected contributions from inflowing groundwater over the projected design life.

GEOCHEMICAL DATA

Competing Electron Acceptors	**GW (mg/L)**	
Dissolved oxygen	3	customer provided
Nitrate (as N)	0	customer provided
Manganese (estimated conc. Mn(II) generated)*	10	default value
Iron (estimated conc. Fe(II) generated)*	10	default value
Sulfate	50	customer provided

*An estimated projection of dissolved concentrations of Mn and Fe following ERD/ISCR were used to estimate H demand from the reduction of oxidized Fe and Mn minerals (typically only a portion of actual soil concentrations will be reduced).

ORP (mV)	50	
pH	6.4	Note: It is recommended to inject a pH buffer together with the EHC-L to adjust the pH to around 7

STOICHIOMETRIC DEMAND CALCULATIONS

	GW (mg/L)	**Soil (mg/kg)**
H2 Demand from COIs	0.07	0.07
H2 Demand from Competing Electron Acceptors	4.89	0.00
Total H2 Demand	4.96	0.07

H2 Demand from Soil within Targeted Area	1.34	lb
H2 Demand from GW within Targeted Area	29.24	lb
H2 Demand from Influx over Design Life	129.19	lb
Total Estimated H2 Demand	159.77	lb

EHC-L DEMAND CALCULATIONS

The Stoichiometric demand for the targeted area was calculated using available data presented above, noting that the Stoichiometric demand represents minimum requirements and require a complete geochemical data set to be calculated accurately. Therefore, the resulting EHC dosing required to meet the estimated Stoichiometric demand was compared to our minimum guidelines for the selected type of application, selecting the higher number.

Application type: Injection PRB

	Value	Unit
Concentration EHC-L in GW to meet H2 demand	310.2	mg/L
Minimum target conc. TOC in pore water*	2,000	mg/L
Recommended conc. of EHC-L in pore water	8,000	mg/L
Mass of EHC-L required	47,204	lbs
Mass EHC-L per container	420	lbs
Number of Containers / Bags of Mix	113	containers
Mass EHC-L (rounded up based on container size)	47,460	lbs
Mass of EHC-L Mix (dry component)	2,783	lbs

*Our general recommended minimum guideline for the proposed application exceeds the dose rate required based on hydrogen demand calculations and was therefore used for the purpose of this dosing calculation.

OPTIONAL pH BUFFER

If groundwater pH is below 6.5 or inoculants are to be applied together with the EHC-L, we recommend that the EHC-L injection solution be pH buffered to create optimal conditions for microbial growth. Based on laboratory tests, potassium bicarbonate, a fully soluble buffer, applied at a rate of 25 lbs / 11 kg per drum (420 lb) of EHC-L will buffer the pH of the injectate solution to circum-neutral. If baseline pH conditions were to be below 6, additional pH buffer will be needed to raise the pH of the groundwater to 7. The amount of buffer required to raise the pH of the groundwater to 7 will depend on the site-specific buffering capacity of the soil and will have to be determined by conducting a pH titration test.

Total $KHCO_3$ demand = amount $KHCO_3$ to neutralize EHC-L solution + amount needed to raise ground water / soil to a pH of 7

Soil buffering amount = KHCO3 for ground water / soil pH adjustment, which can be determined in the laboratory via titration.

	Value	Unit	
Mass $KHCO_3$ to neutralize EHC-L solution	2,825	lbs	default value
Estimated soil buffering amount	0	lbs	estimated value
Total $KHCO_3$ demand	2,825	lbs	

OPTIONAL DHC INOCULANT

Although not typically required for ISCR, DHC inoculants have shown to improve removal kinetics, in particular for potential daughter products such as cis-DCE and VC. The DHC will be added after EHC-L application, once favorable redox conditions (ORP < -75 mV, DO <0.2 mg/L, pH between 6 and 8.5) have been attained. The DHC inoculant will contain at least 5 x10E10 cfu/L of live bacteria including high numbers of dehalococcoides species with known abilities to biodegrade DCE. The target density of DHC cells in the treated aquifer is 1x10E6 cfu/L.

	Value	Unit
Dechlorinating consortium concentration in inoculant	5.00E+10	DHC/L
Design final concentration after dilution in aquifer	1.00E+06	DHC/L
Volume of Inoculant Required	54	L

COST ESTIMATE

Item	Quantity	Unit	Price	Cost
EHC-L [1, 2]	47,460	lbs	$1.58	$74,987
Shipping Estimate [3]	1	lump sum	$9,500	$9,500
Sub Total Cost				**$84,487**
Optional items:				
pH Buffer ($KHCO_3$) [4]	2,850	lbs	$2.70	$7,695
DHC Inoculum (incl. minimum) [4]	54	L	$90	$4,860
TOTAL COST [5]				**$97,042**

1) Price valid for 90 days from date at top of document. Terms: net 30 days.

2) Any applicable taxes not included. Please provide a copy of your tax exempt certificate or resale tax number when placing your order. In accordance with the law, applicable state and local taxes will be applied at the time of invoicing if PeroxyChem has not been presented with your fully executed tax exemption documentation.

3) Shipping rate provided is an estimate. Standard delivery time can vary from 1-3 weeks from time of order, depending upon volume. Expedited transport can be arranged at extra cost. Unless requested otherwise, costs assume standard ground transport via truck, with no need for a lift gate or pallet jack.

4) Price excludes shipping and the mass/volume has been rounded up to nearest container size.

5) All sales are per PeroxyChem's Terms and Conditions.

Disclaimer:

The estimated dosage and recommended application methodology described in this document are based on the site information provided to us, but are not meant to constitute a guaranty of performance or a predictor of the speed at which a given site is remediated. The calculations in the Cost Estimate regarding the amount of product to be used in your project are based on stoichiometry or default minimum guideline values, and do not take into account the kinetics, or speed of the reaction. Note that the Stoichiometric mass represents the minimum anticipated amount needed to address the constituents of concern (COCs). As a result, these calculations should be used as a general approximation for purposes of an initial economic assessment. PeroxyChem recommends that you or your consultants complete a comprehensive remedial design that takes into consideration the precise nature of the COC impact and actual site conditions.

INSTALLATION

The EHC-L will be delivered as two components, which will be mixed together in the field. The first component, a 25% liquid emulsion of carbon substrate, will be provided in 55-USG drums, with 50 USG/190 litres per drum. The second component is the EHC-L mix which contains the ferrous iron powder, and is delivered as a dry powder and added to the liquid component in the field. The EHC-L mix is proportioned so that one bag (24.5 lbs / 11.1 kg) of EHC L mix is added per drum.

Depending on the application method, between 10% and 100% of the effective porosity is normally targeted during EHC-L injection, with a higher percent pore fill normally targeted during low-flow injections into wells and injection networks. This is in contrast to applications via direct push technology (DPT) where normally around 10 to 15% is targeted. To facilitate the desired injection volume, the EHC-L components will be diluted in the field.

The below table shows examples of mixing recipes for a 55-USG drum of EHC-L and the resulting total injection volume and percent pore fill. Alternative packaging options are available upon request and the below mixing recipe may be scaled depending on mix batch and packaging size.

EHC-L Mixing Recipe (per 50 USG drum)

Dilution:	**3-fold**	**10-fold**	**25-fold**
Volume EHC-L emulsion per drum (USG)	50	50	50
Mass EHC-L mix (lbs)	24.6	24.6	24.6
Volume water (USG)	100	450	1,200
Resulting total volume (USG)	150	500	1,250
Resulting EHC-L conc. (organic carbon + Fe mix)	9.7%	2.9%	1.2%
Total volume water (USG)	11,300	50,850	135,600
Total injection volume (USG)	16,950	56,500	141,250
Resulting injection volume to total pore volume	2.4%	8.0%	20.0%

Injection recommendations (can be altered):

The EHC-L solution could be injected via fixed wells or using direct push. The injection spacing would be determined based on the radius of influence achieved for the specific implementation method and lithology.

	Value	**Unit**	**Comment**
Dilution of EHC-L emulsion (can be altered)	6		can be altered
Total volume of water required	28,419	U.S. gallons	calculated value
Approximate volume of solution to inject	34,103	U.S. gallons	calculated value

Injection spacing	22.2	ft	customer provided
Number of injection points	18	locations	calculated value
Injection volume per point	1,895	U.S. gallons	calculated value
Injection volume per vertical foot	76	U.S. gallons	calculated value
Injection volume to total pore space volume	5	percent	calculated value

Note that the construction estimates presented above can be readily modified in the field or per recommendations from the injection contractor as required (for example, the concentration of the EHC-L solution could be changed to modify the total injection volume or the injections spacing could be altered based on installation technology).

FREQUENTLY ASKED QUESTIONS – EHC-L®

GENERAL TECHNOLOGY

1. What is EHC-L?

EHC-L® is a stable, concentrated, buffered, microemulsion of controlled-release, food-grade carbon, nutrients, and iron designed for ISCR of recalcitrant organics in soil and groundwater. It is a cold water miscible, liquid formulation of our established EHC® product

2. What are the differences between EHC and EHC-L?

Both EHC and EHC-L are iron/carbon based amendments. However, EHC-L is a liquid variant of our standard EHC product that extends the use of ISCR to a wide variety of applications.

3. What is the role of reduced iron in EHC-L?

It is established that all abiotic reactions are mediated at direct interfaces to achieve electron transfer. As the dissolved ferrous iron in EHC-L travels into areas with higher redox potential, it will precipitate out forming minerals including, but not limited to, to iron oxides and iron sulfides. Such ferrous iron precipitates are well-proven to be reactive to reducible contaminants like chlorinated organic and redox-reactive heavy metals. As a result, they provide a reactive surface stimulating direct chemical abiotic dechlorination in an extended zone downgradient of the points of application. The central point here is that iron-mediated reduction works by direct contact-enabled electron transfer. The advantage conferred by use of EHC-L is that new and reactive mineral surfaces are formed in the aquifer where they can support long term dehalogenation processes and help to eliminate the need for repeated product applications. Furthermore, they are also regenerable with regards to the ferrous-ferric cycle.

The organic moiety is a secondary form of carbon, whose fermentation will occur in a different time frame relative to lecithin, and thereby offer a more complex profile of hydrogen production. The secondary iron minerals will be formed over time as the organic components of EHC-L are degraded and ferrous iron is released. Encapsulation of ferrous iron is by design and not inhibitory: encapsulation protects ferrous iron from premature conversion to ferric form (i.e., avoids precipitation during mixing and injection). In the final analysis, a patina of ferrous minerals will be deposited on the aquifer matrix, support dehalogenation, and due to ferrous-ferric cycling can do so for a very long time.

The abiotic degradation via EHC-L authigenic iron minerals (a reference to crystallization after deposition) is considered a secondary mechanism of treatment. The reported amounts of those phases required to create a significant cVOC remediation component is relatively low.

4. **What is the iron content in EHC-L?**

EHC-L is prepared by mixing a liquid (EHC-L base) and a powder component (EHC-L mix). As noted in the EHC-L mix MSDS the iron salt content is 92% to 97% by weight. For a typical application, prior to dilution for injection, the finished EHC-L emulsion (EHC-L base + EHC-L mix) contains approximately 0.75% ferrous iron (i.e., 7,500 mg Fe/L).

5. **What are the synergistic advantages of combining organic and soluble iron substrate?**

Lower Eh → more complete and rapid degradation:

More strongly reducing conditions are established through combined chemical and biological oxygen scavenging. It is established that all abiotic reactions are mediated at direct interfaces to achieve electron transfer. As the dissolved ferrous iron in EHC-L travels into areas with higher redox potential, it will precipitate out forming minerals including, but not limited to, to iron oxides and iron sulfides. Such ferrous iron precipitates are well-proven to be reactive to reducible contaminants. As a result, they provide a reactive surface stimulating direct chemical abiotic dechlorination in an extended zone downgradient of the points of application. The central point here is that iron-mediated reduction works by direct contact-enabled electron transfer. The advantage conferred by use of EHC-L is that new and reactive mineral surfaces are formed in the aquifer where they can support long term dehalogenation processes and help to eliminate the need for repeated product applications. Furthermore, they are also regenerable with regards to the ferrous-ferric cycle (Weber et al., 2006).

The organic moiety is a secondary form of carbon, whose fermentation will occur in a different time frame relative to lecithin, and thereby offer a more complex profile of hydrogen production. The secondary iron minerals will be formed over time as the organic components of EHC-L are degraded and ferrous iron is released. Encapsulation of ferrous iron is by design and not inhibitory: encapsulation protects ferrous iron from premature conversion to ferric form (i.e., avoids precipitation during mixing and injection). In the final analysis, a patina of ferrous minerals will be deposited on the aquifer matrix, support dehalogenation, and due to ferrous-ferric cycling can do so for a very long time.

Please refer to EHC-L technical background.

6. **What are the main differences between EHC-L and comparable market alternatives?**

The main component of EHC-L (lecithin) facilitates surface activity, which is beneficial in driving remedial processes. In addition to being an excellent slow release electron donor, the emulsification property of lecithin enables broad distribution in the aquifer. The emulsifying capacity can promote DNAPL desorption and dissolution of the non-dissolved components so they can be destroyed by biotic and abiotic mechanisms. Finally, EHC-L promotes abiotic degradation that other comparable liquid amendments do not.

7. How is EHC-L emulsion different from emulsified oils which usually contain lactate?

EHC-L is an emulsion, but it is not an emulsified oil and it does not contain any simple electron donors such as lactate. In addition to the phospholipids that are its main component, however, lecithin does contain between 3% and 5% w/w of carbohydrates, including sucrose, raffinose (trisaccharide) and stachyose (tetrasaccharide). These complex carbohydrates provide carbon sources that are more rapidly metabolized than phospholipids, offering and initial “kick start” in concert with cysteine and, in fact, should last much longer than lactate.

A common method of evaluating efficiency of an electron donor is by using the theoretical hydrogen production from complete fermentation (oxidation) of the substrate. Based on this method of evaluation, and realizing its inherent limitations, the lecithin-based carbon component in EHC-L is among the most potent electron donor substrates currently available for groundwater remediation (see below).

Compound	**Electron-Donor (Oxidation) Reaction**	**Mol. Weight (g/mole)**	**Moles of H_2 produced per Mole Substrate**	**Ratio of H_2 produced to Substrate (g/g)**
Lecithin[1]	$C_{42}H_{82}NO_8P + 83H_2O \rightarrow 42CO_2 +$ $122H_2 + NO_3^- + PO_4^{3-} + 4H^+$	760.1	122	0.321
Linoleic Acid (soybean oil)[2]	$C_{18}H_{32}O_2 + 34H_2O \rightarrow 18CO_2 + 50H_2$	280.5	50	0.359
Lactate[2]	$C_3H_5O_3^- + 2H_2O + \rightarrow C_2H3O_2^- + CO_2$ $+ H_2O + 2H_2$	89.1	2	0.045

[1] Example phosphatidylcholine formula shown, [2] From ESTCP, 2010

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8. What contaminants are amenable to EHC-L treatment?

The rate and extent of removal of all organic compounds that are biodegraded under anaerobic conditions are usually enhanced via the addition of carbon source. Organic compounds including chlorinated solvents, pesticides, explosives and some heavy metals can be treated by EHC-L.

9. Has EHC-L been tested in the laboratory and in the field?

EHC-L® has been in testing since 2009 and has been applied so far at 22 field sites with over 100 solicited proposals currently under review. It is a re-formulation of EHC® and DRAMEND® ISCR products, for which long-term field applicability has been widely demonstrated and audited by EPA under their SITE program.

10. Is it easy to switch over to the EHC-L technology?

Yes. EHC-L has been accepted by many state and federal regulatory authorities in the USA and Europe. Technically, any remediation system designed for injecting emulsified vegetable oil, molasses or polylactic acid can be used to inject EHC-L.

11. How is the EHC-L packaged / delivered?

The product is packaged as 2 components

a. ***Part 1:*** Liquid emulsion delivered in 55-USG drums, filled with 50 USG / 420 lbs per drum.
b. ***Part 2:*** Water soluble powder with the organo-iron compound and other additives delivered in 24.5 lb bags.

12. What is the observed longevity?

Depending on the site-specific formulation, dosing and geochemistry, EHC-L® would typically last 1-2 years (as compared to 3 to 5 years for EHC).

13. Is EHC effective for treatment of NAPL?

Both chemical and biological degradation mechanisms only directly targets COIs present in the aqueous phase. ISCR mechanisms can only enhance the rate of NAPL dissolution by treating the aqueous phase and thus creating steeper concentration gradients.

EFFECT ON AQUIFER GEOCHEMISTRY AND PHYSICAL PROPERTIES

1. What are the EHC-L breakdown products?

EHC-L consists of lecithin (complex organic molecule) and soluble iron substrate, all food grade, and has the following break-down products: ferrous/ferric iron, hydrogen, dissolved organic carbon (VFAs) and methane.

2. What chemical or physical changes (pH, temp, etc.) are expected in groundwater following EHC-L application?

Redox Potential - The redox potential will decrease following the introduction of EHC-L and oxidized species such as sulfate, nitrate and iron (III) will be reduced. Redox potentials as low as -300 mV has been observed following EHC-L injection. The decrease in redox is established through both chemical and biological oxygen scavenging:

Oxygen and other oxidized species are reduced in contact with iron precipitates

pH – The pH of pure EHC-L product is 5.75. For example, at a typical site the concentrated product may be diluted by about 50 to 100 times after injection. Therefore, the pH effect is anticipated to be insignificant. Buffering of pH is recommended at sites with extreme pH values to facilitate the treatment.

Solubility of metals –A wide range of metals precipitates out under reducing conditions in contact with iron sulfides and other precipitates; an EHC-L formula with a slow release form of sulfide, EHC-LM, could be applied if metals mobilization is of particular/known concern or to reduce pre-existing elevated levels of metals in groundwater.

Temperature – EHC-L does not affect the temperature.

Permeability – EHC-L is 99% soluble in water and will not affect permeability

DESIGN

1. **How do you estimate dosing?**

In theory, the electron donor demand could be calculated from CVOCs concentrations using Stoichiometric relationships using appropriate safety factors accounting for H_2 release rate, speed of groundwater flow, timeline of treatment and levels of competing electron acceptors flowing into the zone over time. For sites with a low demand, we use a minimum dose to assure ISCR conditions are created.

2. **What is theoretical hydrogen produced from complete fermentation of organic substrate in EHC-L?**

The Lecithin based carbon component theoretically produces 122 moles of H_2 per mole of substrate (i.e.; 0.321 g H_2 per g of substrate) and is one of the most effective carbon substrates available for In-situ soil/groundwater remediation.

3. **Are specialty microorganisms or inoculants required?**

Indigenous dechlorinating bacteria are present at most sites and therefore biostimulation by the addition of an electron acceptor, such as EHC-L is expected to stimulate the required contaminant degradation. However, intermittent creation of chlorinated breakdown products (e.g.; cDCE or VC from TCE) may occur, especially at sites where the activity of dechlorinating microbes is depressed or absent. The use of commercial DHC (*Dehalococcoides* spp.) cultures has been proved to often accelerate that process, resulting in shorter remedial times and subsequent cost savings. Our cost analysis indicates that the cost of DHC bioaugmentation using a commercial inoculum (e.g., KB-1, SDC-9) may add 40% to 80% to the initial EHC-L amendment cost, depending on site conditions. Once the anaerobic population is established, repeated inoculation is not required if subsequent product re-injections are required.

MONITORING

What is the recommended baseline sampling and performance monitoring?

In general, we recommend quarterly monitoring of the performance monitoring well(s) over a 12-month period, with the first sampling event scheduled 3 months after the injection work. At a minimum, we recommend including the following parameters in the sampling schedule:

Field parameters: pH, DO, ORP, Temperature

Chlorinated Volatile Organic Carbons, CVOCs

Dissolved Gases (ethene, ethane, methane)

Total Iron

Total Organic Carbon, TOC

It would also be recommended to obtain a baseline for other potential competing electron acceptors:

Metals Scan (iron, manganese included)

Anion Scan (chloride, sulfate, nitrate included)

Additional information about the significance of these parameters are included here: http://www.adventusgroup.com/pdfs/EHC_sampling.pdf

[RS1]

INSTALLATION

1. How can EHC-L be emplaced in the subsurface?

EHC-L can be injected into the ground through a variety of methods due to its versatile properties, including:

- Injection into wells by gravity or under pressure;
- Direct Push Technology (DPT) through typical Geoprobe rods;
- Direct injection using hydraulic fracturing.

EHC-L distribution will depend on the product dose required (derived based on site conditions), the injection method chosen and the specific site hydrogeology. Depending upon the application method and site conditions, between 5% and 20% or higher of the effective porosity is normally targeted during EHC-L injection. Factors controlling pore volume displacement by the EHC-L injectate at a given site include: required product mass loading, aquifer lithology, placement method (*i.e.*; injection wells vs. direct injection) and injection point spacing. The recommended spacing between injection points will depend on these factors as well as on the treatment goals and objectives (source zone treatment [grid injections], permeable reactive barriers, etc.). For grid injections, typical spacing typically varies between 3 m and 6 m for DPT and between 4.5 m and 9 m for injection wells. Wider spacing may be considered for hydraulic fracturing injections. Closer spacing combined with a lower load per point should be considered in case of shallow injections (in order to avoid surfacing). EHC-L distribution through direct push injection will depend of the exact tools that will be used (injection tip, pump type, etc.). DPT may be slower than injections wells because one point would be injected at a time, while several injection wells could be manifolded and injected into simultaneously. However, field cost for DPT is typically lower than that for wells construction and subsequent application.

2. **Can EHC-L be injected though monitoring wells?**

In general, FMC Corporation (Adventus) does not recommend using monitoring well as injection wells for EHC-L delivery, unless those wells have been shown to provide adequate product distribution and have been abandoned as part of the monitoring program.

3. **Is the EHC-L emulsion easy to pump?**

EHC-L emulsion shipped to the site has 25% lecithin. It is a viscous (500 -1,000 cPs) but flowable liquid. The emulsion can be pumped or removed using a pail to make diluted solution for injection. Depending on site conditions, EHC-L dosing, and injection method, the product may be diluted by a factor of 5 to 20 which then has essentially the same properties as that of water.

4. **Is injection of chase water needed?**

Since EHC-L is injected as a dilute solution, no chase water is needed. Please refer to EHC-L mixing instructions.

5. **What kind of PPE is required to mix and inject EHC-L?**

All EHC-L components are food grade and non hazardous. The solid mix (iron-powder) but can be an irritant if inhaled. Polyethylene gloves and a dust mask should be used when mixing EHC-L solution. Please refer to our MSDS.

http://www. Adventusgroup.com/pdfs/MSDS/EHC-L_MSDS_JAN11.pdf and

http://www.Adventusgroup.com/pdfs/MSDS/EHC-L_Mix_MSDS_JAN11.pdf

Laboratory Evaluation of a Novel Liquid Amendment Containing Lecithin and Ferrous Iron for Reductive Treatment of Chlorinated Hydrocarbons

Alan Seech, Ph.D.
Eva Janzen, B.Sc.
Kerry Bolanos-Shaw, M.Sc.

SOIL & GROUNDWATER
REMEDIATION

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May 22, 2012

Presentation Outline

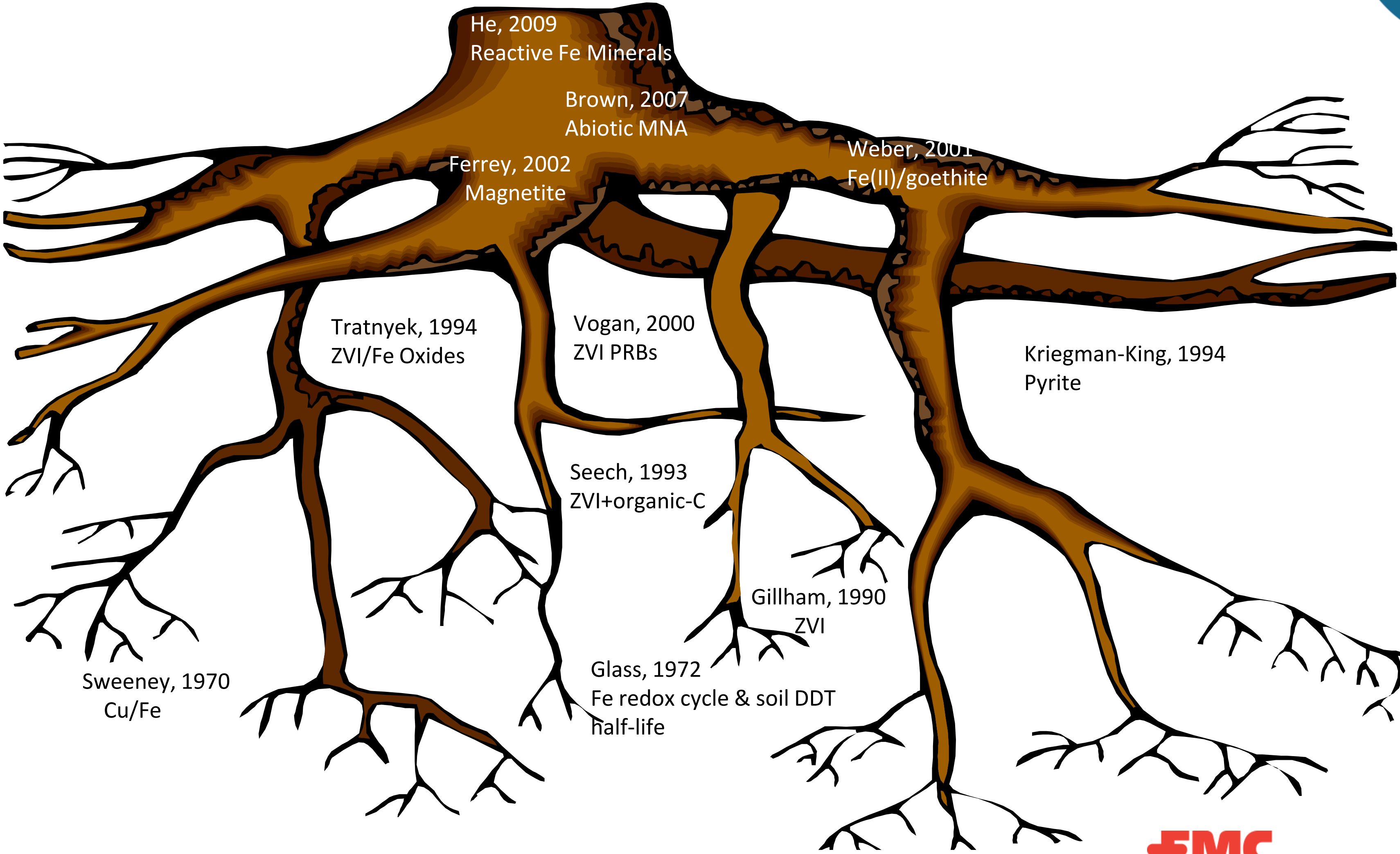
- Reasons for developing a new liquid ISCR reagent
- Product composition
  - Soluble Carbon
  - Soluble Iron
- Laboratory evaluations
- Field application
- Summary

Product Development

Objectives:

1) To create an ISCR product that is fully cold-water soluble and can be applied through well screens and tight formations.
2) To find a complex, relatively slow to ferment carbon source that also contains nutrients.
3) To find a source of soluble iron that will remain in the ferrous state (Fe^{2+}), not precipitate out during handling and injection
4) Promote formation of new/enhancement of existing reactive iron minerals

The Roots of ISCR (after Brown, 2008)



He, 2009
Reactive Fe Minerals

Brown, 2007
Abiotic MNA

Ferrey, 2002
Magnetite

Weber, 2001
Fe(II)/goethite

Tratnyek, 1994
ZVI/Fe Oxides

Vogan, 2000
ZVI PRBs

Kriegman-King, 1994
Pyrite

Seech, 1993
ZVI+organic-C

Gillham, 1990
ZVI

Sweeney, 1970
Cu/Fe

Glass, 1972
Fe redox cycle & soil DDT half-life

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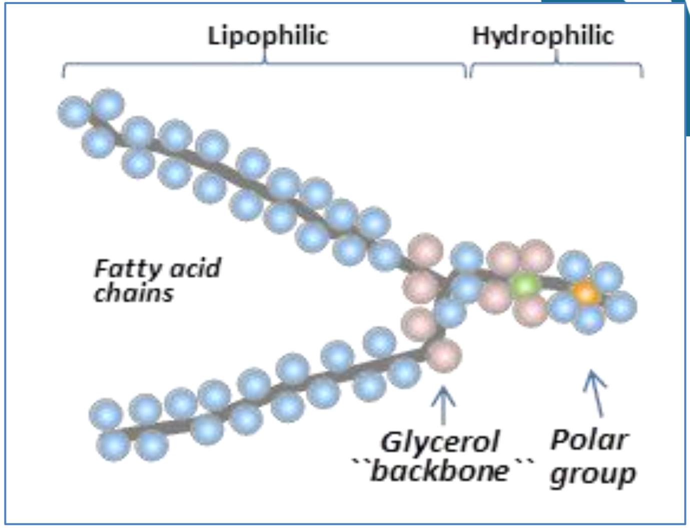
Product Composition

- After evaluation of a number of soluble carbon and iron sources, a new liquid amendment composed of lecithin and ferrous iron was selected.
- EHC-L = Liquid Emulsion + Powder Mix
- Liquid emulsion = 25% lecithin
- Powder Mix = Iron Salt + Amino Acids

EHC-L: The Carbon Component

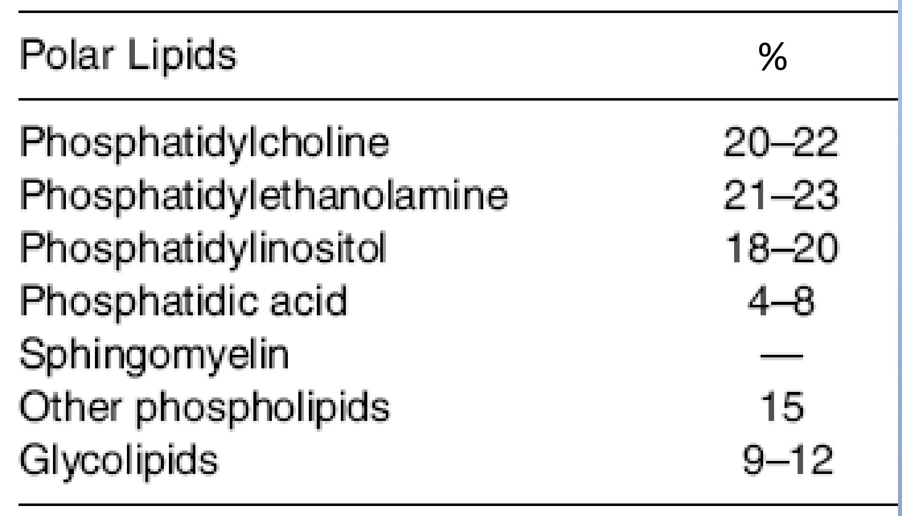


Benefits of Lecithin

- High molecular weight results in slower consumption and extended life.
- Slower rate of consumption may also reduce incidences of high methane production.
- Charged nature of the molecule may enable retention of EHC-L in the reactive zone as opposed to “wash out” with groundwater flow

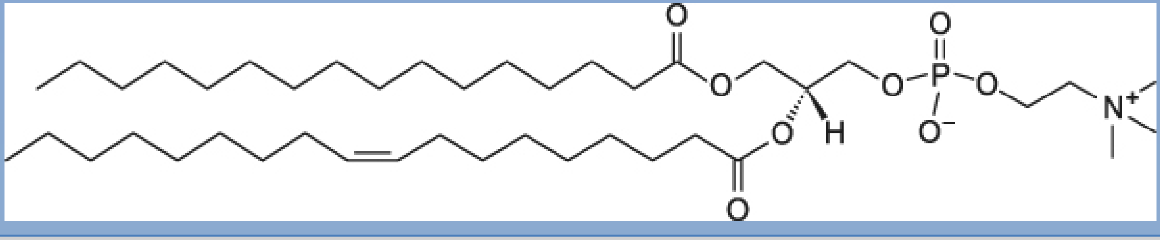
EHC-L: The Carbon Component

Composition of Soy Lecithin (from Bailey's Guide 2005)



Polar Lipids	%
Phosphatidylcholine	20–22
Phosphatidylethanolamine	21–23
Phosphatidylinositol	18–20
Phosphatidic acid	4–8
Sphingomyelin	—
Other phospholipids	15
Glycolipids	9–12

Major lipids above have a similar C:H:O ratio:
e.g., L-a –Phosphatidylcholine ($C_{42}H_{82}NO_8P$):



EHC-L: The Carbon Component

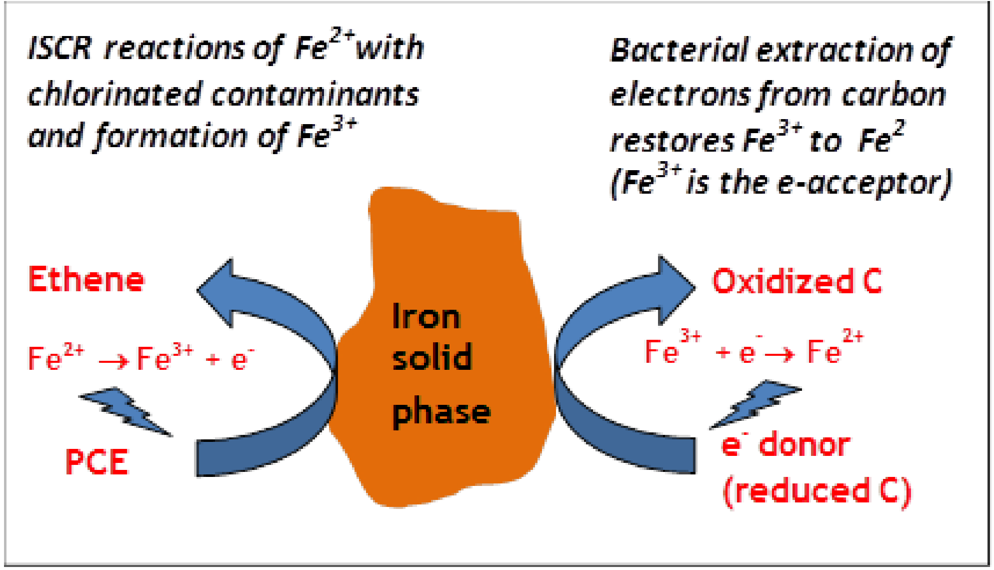
Benefits of Lecithin

- The two main components of lecithin (PE and PC) carry both positive and negative charges at the same time and can thus provide buffering of both acids and bases
- Dissolved phosphorus, nitrogen and major nutrients are slowly released as the lecithin undergoes fermentation.
- More stable emulsions.

EHC-L: The Iron Component

- The soluble ferrous iron (Fe^{+2}) in EHC-L can enable formation of a variety of iron minerals (e.g., mackinawite, magnetite, pyrite) that are capable of reducing contaminants as they oxidize further to the ferric (Fe^{+3}) state (one e^- transfer).

- Fe^{+3} can be “recycled back to Fe^{+2} to repeat the process.



ISCR reactions of Fe^{2+} with chlorinated contaminants and formation of Fe^{3+}

Bacterial extraction of electrons from carbon restores Fe^{3+} to Fe^{2} (Fe^{3+} is the e-acceptor)

EHC-L: The Iron Component

- As dissolved iron moves down gradient it will be adsorbed on iron oxide mineral surfaces such as goethite:
  - adsorbed Fe^{+2} is much more reactive than aqueous Fe^{+2} (theories for how and why: Shoonen and Strongen, 2005; Weber, 2001)
  - adsorbed Fe^{+2} mediates dehalogenation of CT while aqueous form does not
  - Fe^{+2} can convert (i.e., reduce) poorly reactive minerals to more highly reactive forms (e.g. ferrihydrite to green rust and magnetite; Usman et al., 2010) or hematite to magnetite (Matthews, 1976).
- These minerals can cycle between the ferrous and ferric forms, thereby serving as an iron redox cycle that works as long as other electrons from metabolizable carbon are available.
- A substantial reactive surface stimulating direct chemical abiotic dechlorination can be formed down gradient.

EHC-L: The Iron Component

Lecithin Protects Ferrous Iron:

- The anionic functional groups on PC and PE also enable binding of Fe^{+2} iron – thereby reducing its susceptibility to oxidation to Fe^{+3} form during mixing and injection (prevents loss during handling and injection).
- A second mechanism, vesicle formation, also helps to prevent oxidation of Fe^{+2} to Fe^{+3} (*Mehansho 2006*).
- Antioxidant nature of lecithin assists with maintenance of iron in the desired Fe^{+2} form.

EHC-L: A Water Soluble Form of EHC

- Like EHC, EHC-L supports degradation of organic constituents by enhancing:
  - anaerobic bioremediation processes
  - abiotic reduction reactions
- EHC-L can also control dissolved phase heavy metals by promoting their adsorption and/or conversion to insoluble forms.

EHC-L: Metals Reaction Chemistry

- The addition of ferrous iron may also control dissolved phase heavy metals by promoting formation of insoluble forms (e.g., arsenopyrite from arsenic, subject to aquifer chemistry).
- Reducible metals (Cr, Mo, U, Se) and metalloids (As, Sb) will also co-precipitate with oxidized iron minerals. Metals present as divalent cations (Pb, Zn, Cd, Cu, Ni) will precipitate as sulfides.

Laboratory Evaluation of EHC-L

- Plexiglas columns (50 cm long x 5 cm ID) loaded with 1% EHC-L by mass
- Two downgradient soil microcosms contained only site soil
- Control system contained only site soil
- Flow rate initially set at 45 ml/day; increased flow rate over time.
- Sampled influent and effluent routinely for VOCs and TOC

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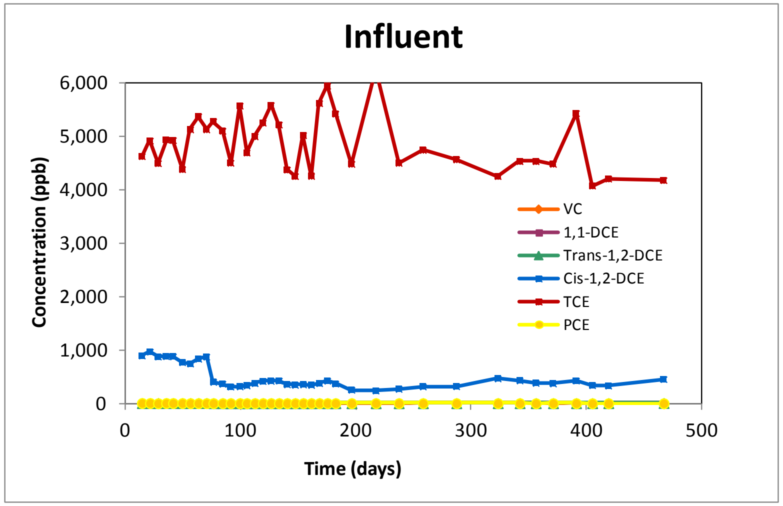
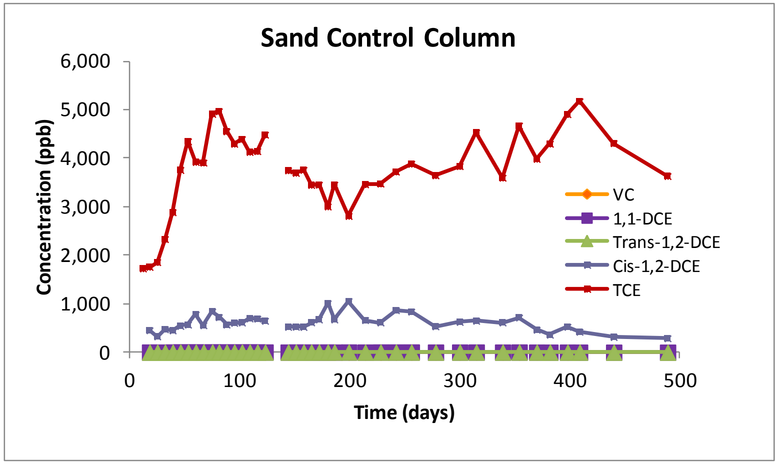
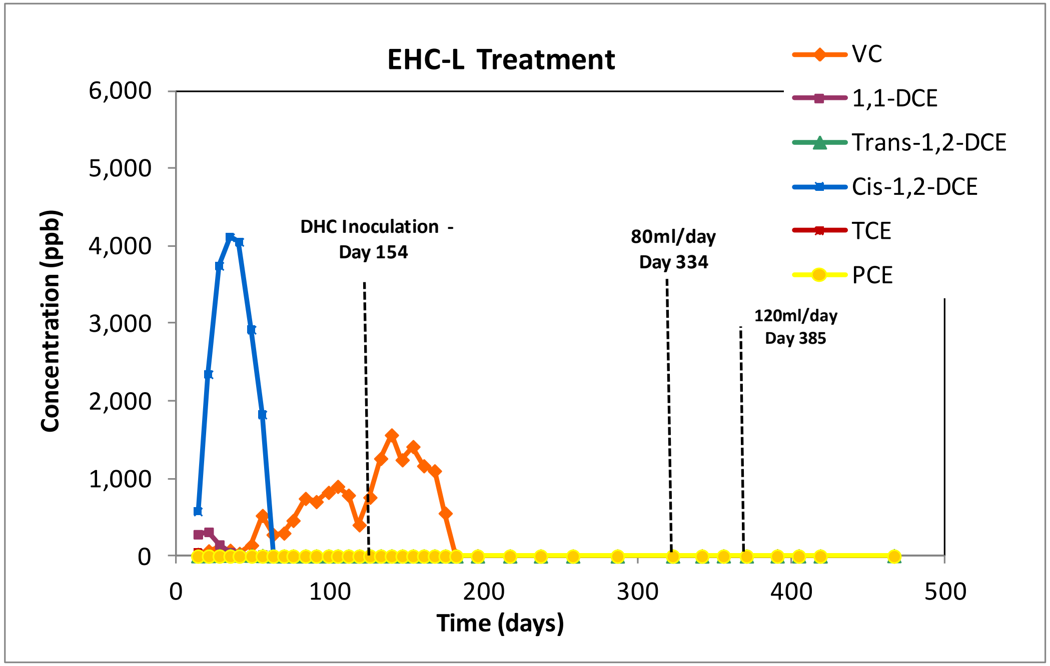
EHC-L Column Data


Influent


Sand Control Column


EHC-L Treatment

DHC Inoculation - Day 154

80ml/day Day 334

120ml/day Day 385

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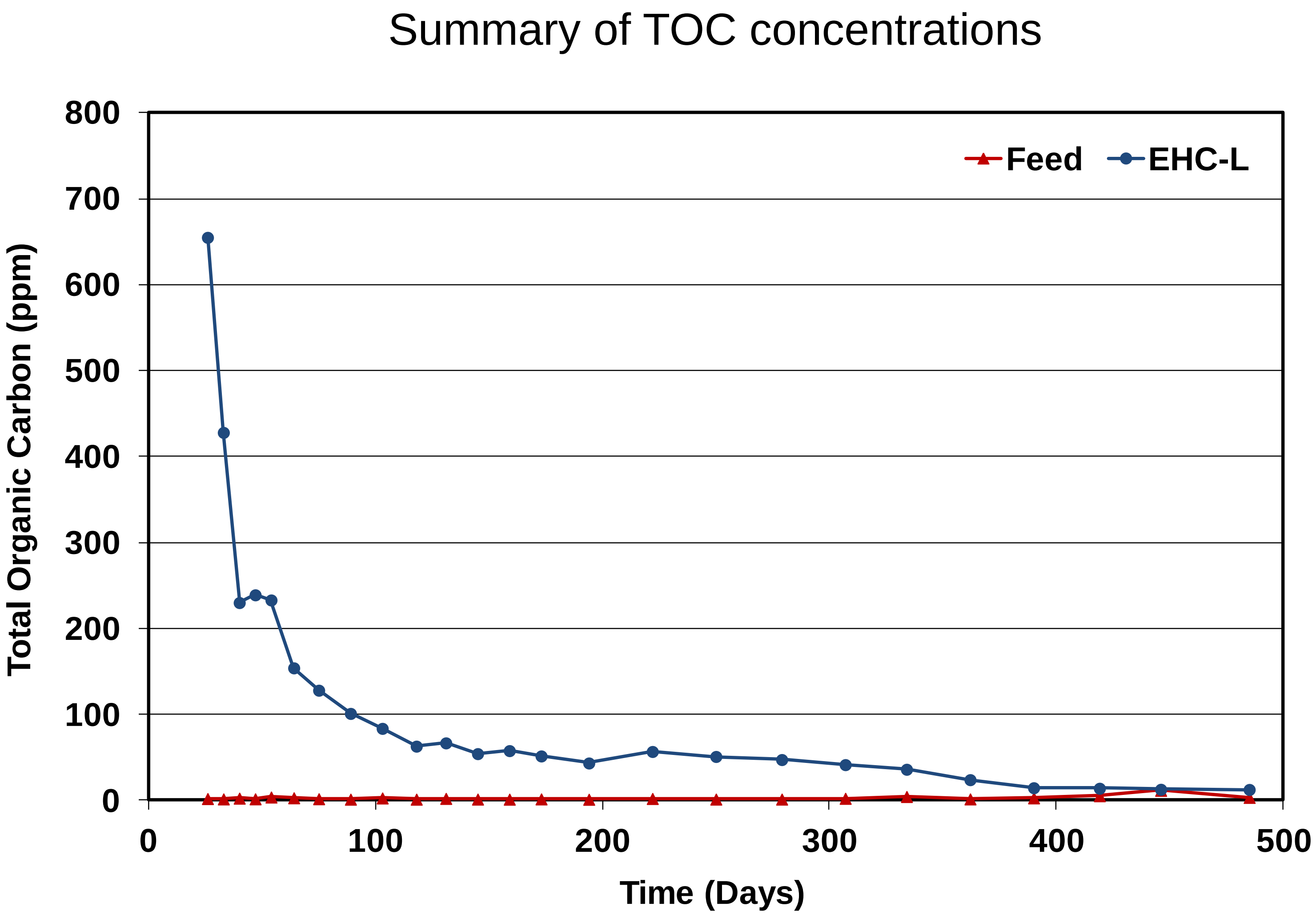
EHC-L Longevity

- The primary lifetime of EHC-L in the subsurface is estimated at 2-3 years, based on long-term column tests (with data from field applications pending), depending on site-specific geochemistry.
- As noted, more permanent benefits (function of TOC) are realized from formation of reactive minerals both in and down gradient of the reactive zone.

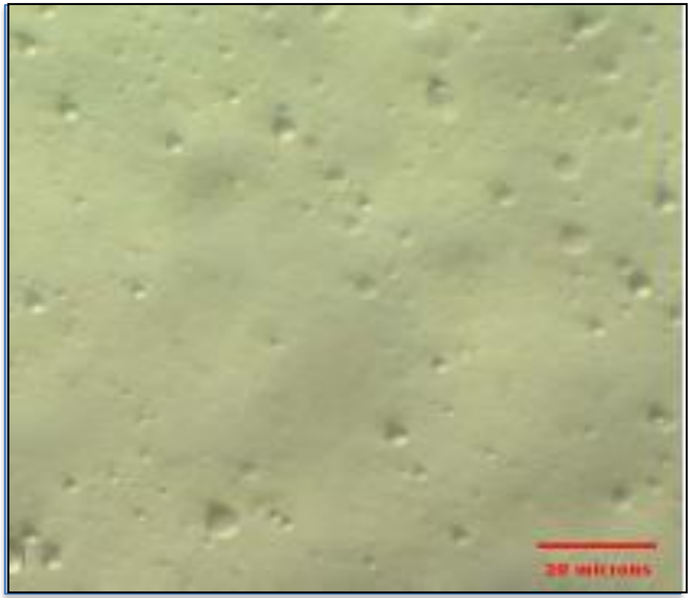
EHC-L Column Data

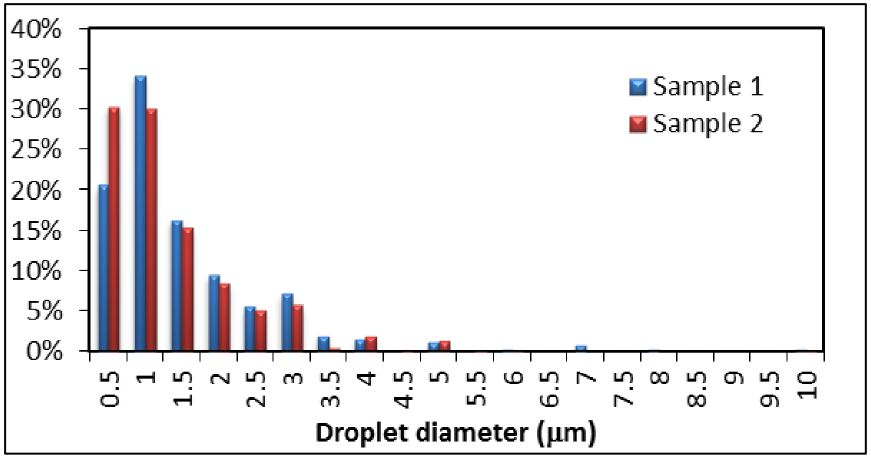


Field Application: EHC®-L Microemulsion

- Majority (90%) of droplets are <3 µm, therefore are expected to easily pass through typical unconsolidated formations (e.g., critical pore size for fine to coarse sand ranges from 12 to 120 µm)

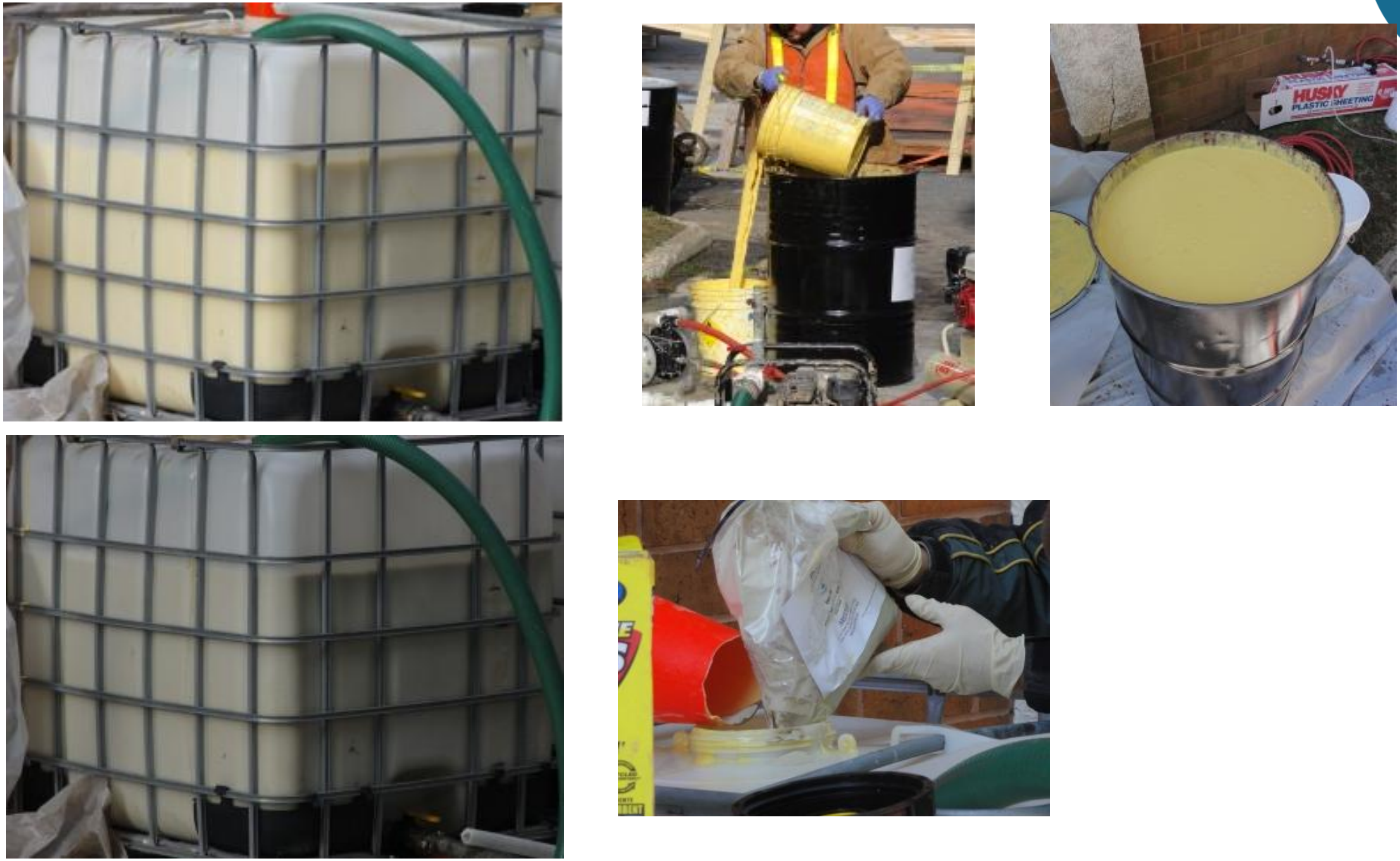
- Silt and clay aquifers may require high pressure injections and/or closer IP spacing, due to smaller pores and a higher content of charged particles





FMC Environmental Solutions

EHC®-L: Applications



EHC®-L Field Results

- To date, over 25 applications of EHC-L have been completed in Canada, the US and Europe.
- Reports from the field confirm the emulsion is easy to work with, completely cold water soluble with no precipitates forming, and negative redox is recorded in the mixing tank.
- Initial results look positive and we continue to collect data (see poster sessions).

EHC-L: Project Data #1

Aug 2011 Injection

WELL	DEPTH / SCREEN	12/1/2010	4/1/2011	11/1/2011	12/1/2010	4/1/2011	11/1/2011	12/1/2010	4/1/2011	11/1/2011
		TCE			CIS-1,2-DCE			VC		
EW-5	80-250	950	1500	440	120	180	1450	1.5	2.7	2.5
EW-6	90-250	240	1600	600	27	210	130	1	1.4	0.93
PWA-A	145-160	NS	80	57	NS	15	10	NS	ND	ND
PWA-B	115-140	NS	260	50	NS	260	92	NS	38	11
PWA-C	50-110	NS	550	200	NS	550	38	NS	ND	ND
PWA-D	32-45	NS	73	35	NS	120	60	NS	NS	6.6
PWB-A	135-152	NS	110	44	NS	11	56	NS	ND	ND
PWB-B	105-130	NS	74	14	NS	63	21	NS	140	35
PWB-C	30-100	NS	340	190	NS	300	39	NS	ND	0.89
PWC-A	160-185	340	1500	660	58	190	210	0.71	ND	1.9
PWC-B	95-155	220	210	50	25	29	9.2	0.35	ND	ND
R2-A	110-130	1200	4000	810	140	430	220	0.97	ND	ND
R2-B	95-105	380	225	25	74.5	62	16	0.9	ND	0.52
R2-C	15-95	5.3	NS	NS	10	NS	NS	0.42	NS	NS
MW-60D	175-185	210	1100	10.4	45	180	1450	ND	ND	14
MW-60I2	80-90	280	3800	1000	60	330	250	1.2	ND	0.68
MW-60I1	120-130	400	1100	11	45	210	350	1.1	ND	1.2

Injections took place at EW-5 early August 2011.

Only have 90 day data available at this time, further reductions excepted in following sampling events.

Client pleased with results thus far; indicated that they are significantly better than results of previous EVO injection in 2008.

EHC®-L: Project Data

Summary of changes in TCE, cDCE and VC molar concentrations

Location	**TCE**				**c-DCE**				**VC**			
	Apr-11	**Nov-11**	**Change**		**Apr-11**	**Nov-11**	**Change**		**Apr-11**	**Nov-11**	**Change**	
	ug/L	**ug/L**	**ug/L**	**umoles/L**	**ug/L**	**ug/L**	**ug/L**	**umoles/L**	**ug/L**	**ug/L**	**ug/L**	**umoles/L**
EW-5	1,500	440	-1,060	***-8.07***	180	1,450	1,270	***13.10***	2.7	2.5	-0.2	***0.00***
EW-6	1,600	600	-1,000	***-7.61***	210	130	-80	***-0.83***	1.4	0.93	-0.47	***-0.01***
PWA-A	80	57	-23	***-0.18***	15	10	-5	***-0.05***	0	0	0	***0.00***
PWA-B	260	50	-210	***-1.60***	260	92	-168	***-1.73***	38	11	-27	***-0.43***
PWA-C	550	200	-350	***-2.66***	550	38	-512	***-5.28***	0	0	0	***0.00***
PWA-D	73	35	-38	***-0.29***	120	60	-60	***-0.62***	0	6.6	6.6	***0.11***
PWB-A	110	44	-66	***-0.50***	11	56	45	***0.46***	0	0	0	***0.00***
PWB-B	74	14	-60	***-0.46***	63	21	-42	***-0.43***	140	35	-105	***-1.68***
PWB-C	340	190	-150	***-1.14***	300	39	-261	***-2.69***	0	0.89	0.89	***0.01***
PWC-A	1,500	660	-840	***-6.39***	190	210	20	***0.21***	0	1.9	1.9	***0.03***
PWC-B	210	50	-160	***-1.22***	29	9	-20	***-0.20***	0	0	0	***0.00***
R2-A	4,000	810	-3,190	***-24.28***	430	220	-210	***-2.17***	0	0	0	***0.00***
R2-B	225	25	-200	***-1.52***	62	16	-46	***-0.47***	0	0.52	0.52	***0.01***
MW-60D	1,100	10	-1,090	***-8.29***	180	1,450	1,270	***13.10***	0	14	14	***0.22***
MW-60I2	3,800	1,000	-2,800	***-21.31***	330	250	-80	***-0.83***	0	0.68	0.68	***0.01***
MW-60I1	1,100	11	-1,089	***-8.29***	210	350	140	***1.44***	0	1.2	1.2	***0.02***
			TCE removed =	***-94***			**cDCE produced =**	***13***			**VC removed =**	**-2**

EHC®-L Summary

- EHC®-L is a liquid ISCR reagent composed of a slow-release carbon source (lecithin), a ferrous iron salt, and amino acids – all components are food-grade.
- The formulation is designed to enhance both microbially-mediated reductive dechlorination *and* abiotic dechlorination by formation of reactive reduced iron minerals.
- EHC®-L is easy to prepare for injection using equipment that is readily available and widely-used in the groundwater remediation industry.
- Initial results from field applications are positive.

Questions are Welcome!

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CASE STUDY

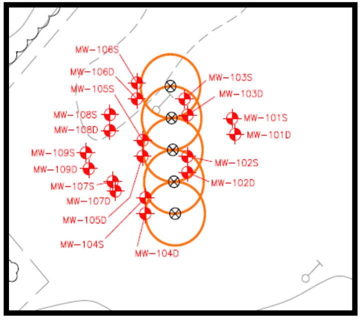
EHC® Liquid PRB Application, Farmingdale, NJ

Summary

Groundwater at a former industrial site in Farmingdale, NJ is impacted with chlorinated solvents (TCE, PCE, 1,1 DCA and 1,1 DCE). A pilot test was conducted in Nov 2011 to evaluate the efficacy of EHC® Liquid Permeable Reactive Barrier (PRB) to reductively treat the CVOCs, and reduce the flux of CVOCs immediately downgradient of the source area. EHC® Liquid amendment is an *in situ* chemical reduction amendment consisting of lecithin (electron donor) and an organo-iron salt (to promote formation of reactive iron minerals). Performance monitoring conducted for six months showed 63% reduction in the flux of TCE at monitoring points 30 ft downgradient of the EHC® Liquid PRB.

Remedial Strategy

The highest concentrations are found behind the former manufacturing building where TCE concentrations range from 10 to 100 mg/L (ppm). Groundwater is encountered at a depth of between 5 to 10 ft bgs. The site geology consists of 160 ft of unconsolidated sediments of the Kirkwood Formation (clayey to silty mud rock, massive sand and thin pebbly lenses), followed by the Manasquan Formation (clay) which acts as an Aquitard. The Lower Member of the Kirkwood Formation is where most of the contaminants reside and is comprised of 10 to 30 ft of coarse sand with components of silt and gravel. Groundwater velocity is estimated at 35 ft/yr in the central portion of the main plume.



Solution

Due to the size of the plume, the overall remedial strategy will have multiple components which will provide mass reduction in source area and a PRB in the diffused part of the plume. The EHC® Liquid PRB was 50 ft long, and constructed by injecting the amendment through five injection points spaced 10 ft apart. The targeted vertical zone was from 5 ft to 30 ft bgs. Approximately 425 lbs of EHC® Liquid solution was injected in each of the five points of the PRB. Performance monitoring was conducted by monitoring and collecting groundwater samples from 18 monitoring wells (9 shallow and deep nested wells). Real time data (pH, DO, ORP, conductivity) was collected from some of the wells using sensors. **Figure 1** (left) shows layout of injection and monitoring wells.

Results

Figures 2 and 3 below show trends in concentrations of TCE in shallow and deep monitoring wells. TCE concentrations decreased in all monitoring wells within the PRB and downgradient of the PRB except well MW-104D which was located at the downgradient edge of the PRB. **Figure 4** shows the trends in CVOCs concentration in monitoring well MW-108D (20 ft downgradient from the PRB).

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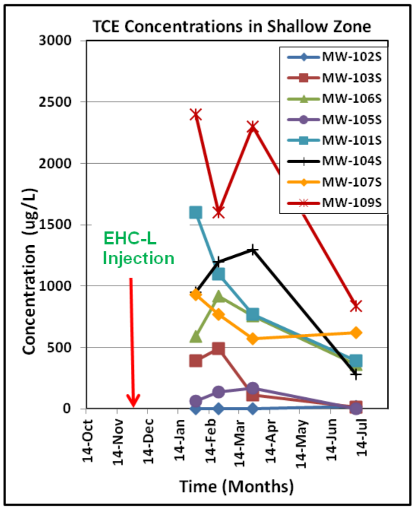

Figure 2: TCE Trends in Shallow Wells

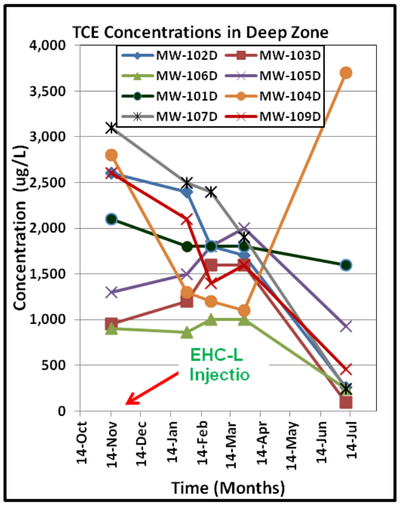

Figure 3: TCE Trends in Deep Wells

Figure 5 shows trends in CVOCs concentrations in monitoring well MW-109D (25 ft downgradient of the PRB). Both wells show significant reduction in concentrations of TCE with some generation of cis-1,2 DCE after six months. Vinyl chloride (VC) generation was none to minimal in these wells. Some wells showed close to 100% conversion of TCE to cis-1,2 DCE. Concentrations of cis-1,2 DCE ranged from ND to 3,800 ppb. Nine out of sixteen wells had cis-1,2 DCE concentrations above the regulatory limit of 70 ppb after six months. Concentrations of VC ranged from ND to 39 ppb. Seven out of sixteen wells had VC concentrations above the regulatory limit of 1 ppb after six months.

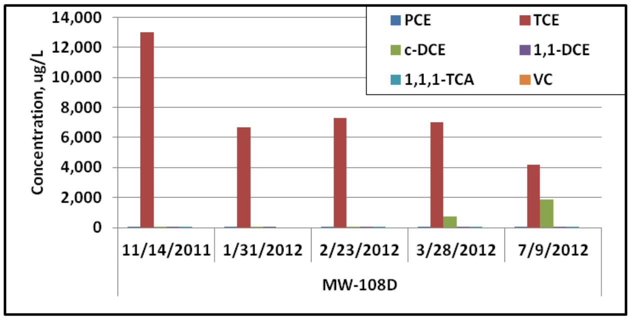

Figure 4. CVOCs in MW-108D

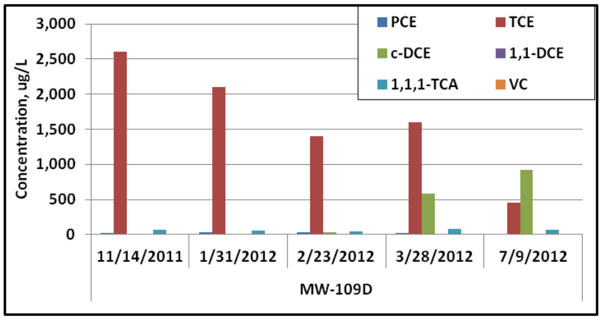

Figure 5. CVOCs in MW-109D

Post-injection anlysis showed the presence of *Dhc* hydogenase genes. Due to the short evaluation time for the pilot test (6-months) and the high concentrations of CVOCs, the increase in concentration of cis-1,2 DCE could be transitory. Microbial analysis and geochemical conditions monitored suggest that with time, cis-1,2 DCE concentrations would decrease.

The primary objective of the pilot test was to show flux reduction of TCE downgradient of the EHC® Liquid PRB. **Figures 6 and 7** below show pre and post-injection distribution of TCE in the pilot test area. The figures show a slice taken downgradient where the flux of TCE is calculated. The flux calculations showed that there was a 73% reduction (from 18.56 g/day to 5.08 g/day) in discharge of TCE between Nov 2011 and July 2012

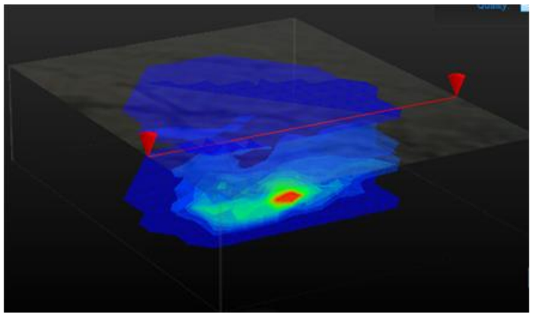

Figure 6. TCE Before Injection

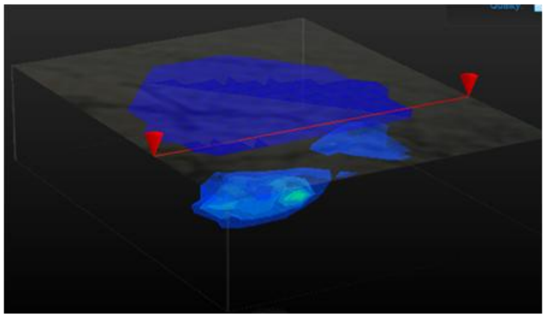

Figure 7. TCE after Injection

Lessons Learned

- Real-time geochemical data collected using sensors assisted in quick understanding of how EHC® Liquid amendment was distributed during injection.
- Advanced diagnostic tools such as CSIA and MBT confirmed the involvement of contaminant degrading microorganisms in the process.
- The assessment of TCE concentrations over time, using traditional analytical evaluation methods, coupled with the calculation of mass flux and mass discharge confirmed that contaminant concentrations were attenuating post EHC® Liquid PRB injection.
- The mass flux and mass discharge metrics in particular are very expressive at a “whole systems” level and enhances the value of evaluating discrete changes in individual wells.
- Bioaugmentation with Dhc culture would have helped with continued degradation of cis-1,2 DCE and VC.

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EHC ® Liquid Amendment Pilot Application to Treat CVOCs at a Former Industrial Site, Holmdel, NJ

Summary

Groundwater at a site in Holmdel, NJ is impacted with chlorinated solvents (primarily PCE, TCE and 1,2-DCE). A pilot test was first conducted in Nov 2011 by injecting EHC® Liquid amendment into the shallow aquifer. The injected amendments were successful at establishing long-lasting, highly-reducing conditions conducive to chemical and biological reduction of cVOCs. Full-scale remedy will be designed to address shortcomings identified during the pilot test.

Remedial Strategy

The geology is primarily silty sand in the top 30 ft of the aquifer, vertical impacts span from 7 ft to 21 ft bgs. The upgradient source area was formerly excavated where EHC® ISCR reagent was applied at the bottom of the excavation to treat residual contamination in saturated soil. The downgradient portion of the area of interest was to be addressed by a liquid In-situ chemical substrate to promote biotic and abiotic reduction of CVOCs with a possible addition of a buffer to raise the pH of the acidic aquifer.

Solution

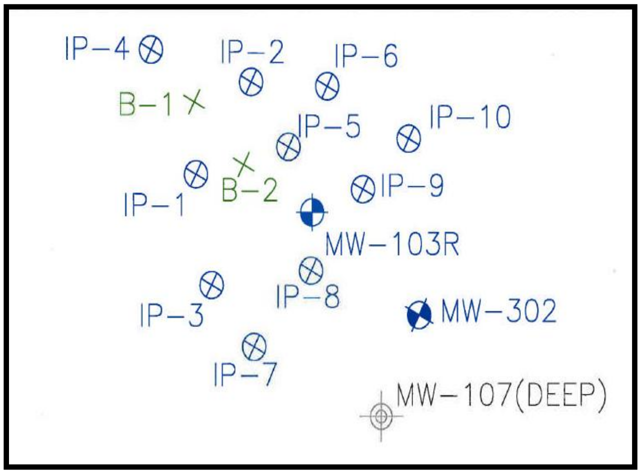
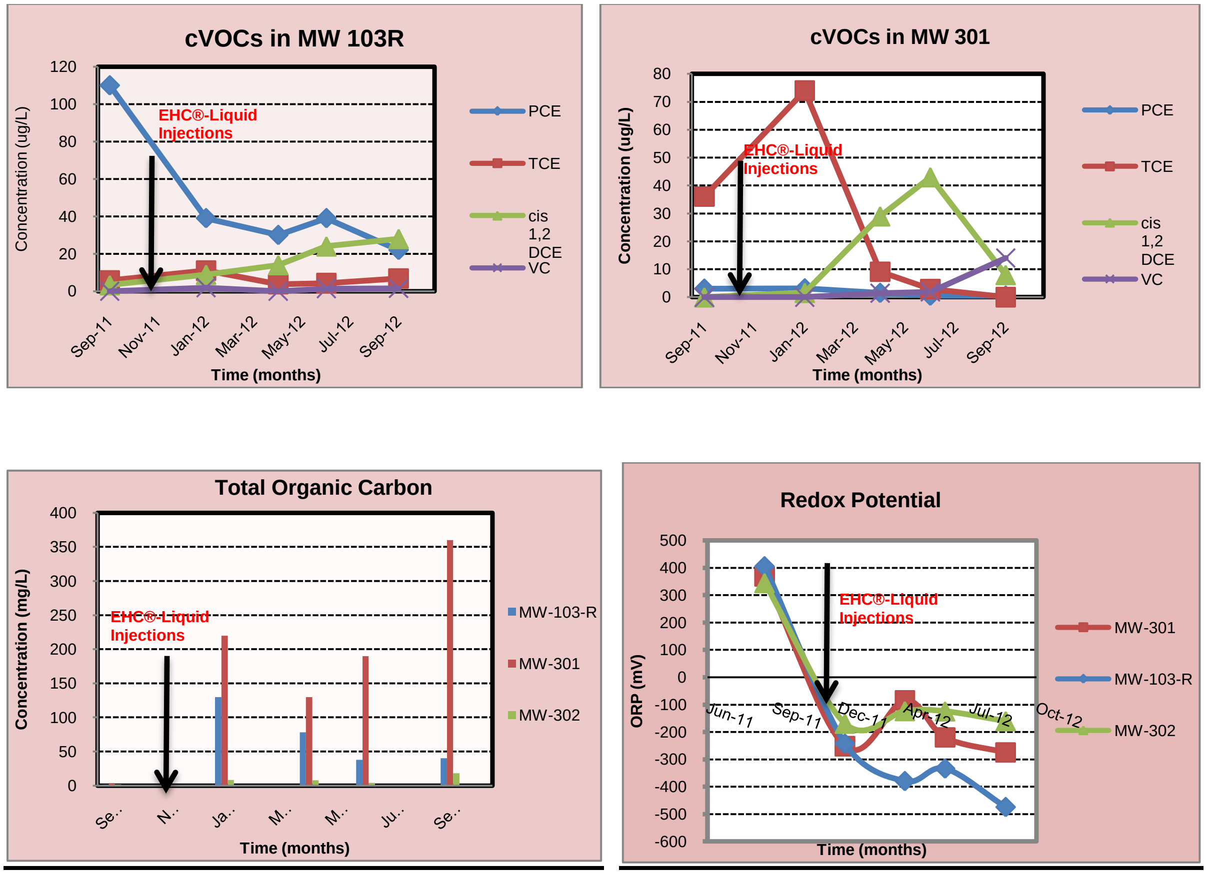


Figure 1 shows the site map with the layout of pilot test injection and monitoring wells. A total of 5,110 gallons of solution was injected containing 10,920 pounds of EHC® Liquid amendment (emulsified lecithin), 639 lbs of EHC® Liquid amendment dry mix (organo-iron compound), 3,670 lbs of magnesium hydroxide buffering agent and 24 L of dehalococcoides (DHC) containing solution. Nineteen injection points targeted a vertical zone from 7-21 ft bgs.

Results

Figure 2 shows the concentrations of CVOCs, Total Organic Carbon and ORP in performance monitoring wells within the treatment area. PCE and TCE concentrations were reduced to concentrations below the GWQS within 9 months following the pilot-scale treatment.

Figure 2:



Future Scope of Work

- The quantity of magnesium hydroxide (alkaline buffer) injected during the pilot test was excessive, resulting in high pH conditions restricting the proliferation of microbial community.
- Full-scale remedy will be designed to address shortcomings identified during the pilot test including proper pH dosing and introduction of a sufficient population of bacteria capable of dechlorinating VC and 1,2-DCE.

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CASE STUDY

EHC ® Liquid Application to Treat CVOCs at a Dry Cleaning Facility, Millbrae, CA

Background

Jiffy Cleaners is a dry cleaning facility located in Millbrae, California that is underlain by groundwater impacted with tetrachloroethene (PCE). Several small spills occurred in the vicinity of the dry cleaning machine during of the early years of operation, which date back to the 1960s. Although PCE impacts to underlying soil have attenuated over time, a relatively stagnant groundwater plume of PCE presents a vapor intrusion risk to the existing dry cleaning facility and adjacent businesses.

Remedial Strategy

After detailed site characterization, TRC (consultant) developed a strategy for remediating on-site groundwater via enhanced in-situ bioremediation (EISB). TRC evaluated the naturally existing microbial community at the site to determine if the appropriate bacteria were present in groundwater to facilitate degradation of PCE, and if so, whether or not the addition of a carbon food source for the bacteria would promote higher rates of degradation. Based on the analytical results from the Bio-Traps® with various amendments, EHC® Liquid amendment was selected as the remedial approach for the pilot study injection test. This amendment provides a controlled-release of carbon used to support the growth of fermenting bacteria, and allows for less frequent injections.

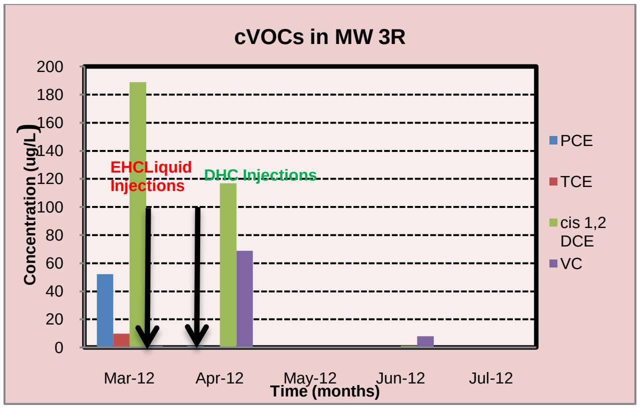
Solution

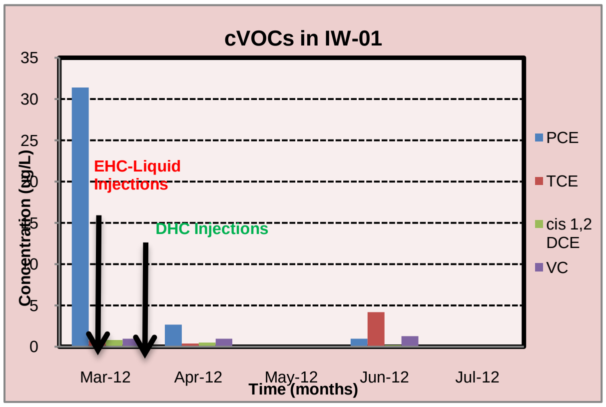
On March 13, 2012, TRC conducted an injection test at IW-1. A mixture consisting of 550 gallons of water, 50 gallons of liquid organic EHC® Liquid amendment, 25 lbs of a water soluble EHC® Liquid mix and 2.5 kg of potassium bromide was injected at 10 to 12 psi. TRC injected 3 liters of DHC, followed by 94 gallons of semi-anoxic, distilled (DI) chase water as recommended by the manufacture of EHC® Liquid amendment. The intent of the inoculation was to introduce DHC under anaerobic, non-toxic conditions with excess electron donor and carbon source present to encourage the population of DHC in the treatment zone and formulate a thriving, sustainable microbial community. Three post-injection monitoring events were conducted for wells IW-1, MW-3R and MW-5. The first post-injection monitoring event took place on March 27, 2012, the second on April 23, 2012 and the third on June 4, 2012.

Figure 1 indicates the pilot test injection area and performance monitoring wells.

Results

Figure 2 shows the concentrations of CVOCs in wells MW 3R and IW-01 pre and post injection indicating significant reduction in contaminant concentrate post substrate and Inoculum injections in a short time frame.





Discussion and Future Scope of Work

- A substantial decrease in CVOC concentrations and an increase in ethene concentrations was observed in IW-1 during the three rounds of post monitoring event.
- Geochemical data from MW-3R suggests acceptable reducing conditions for PCE biodegradation. Nitrate levels have consistently been below reporting limits, and sulfate concentrations have generally been low (less than 10 mg/L to 67.0 mg/L) and likely do not pose a substantial competitive threat to PCE degradation. ORP levels are also relatively low (-38.8 mV to -170.7 mV), suggesting reduced conditions. Increases in ferrous iron concentrations from 4.9 mg/L to 30.7 mg/L imply that naturally-occurring ferric iron concentrations are being depleted and/or DVI is being utilized for abiotic PCE degradation.
- Pilot study results suggest EISB using EHC® Liquid amendment is a valid remediation technology at the site. Evidence of complete reductive dechlorination of PCE was observed over a relatively short time period and DHC inoculation appears to have been successful in IW-1.
- With regard to potential future EISB injections at the site, TRC recommends continued use of controlled-release carbon amendments with DVI, such as EHC® Liquid amendment, due to its demonstrated effectiveness and less frequent injections needed. Additionally, TRC recommends adding a buffer to the EHC® Liquid amendment injection solutions to maintain ideal pH levels for DHC bacteria and performing DHC inoculation approximately one month after the amendment injection.

Interactions Between Biological and Abiotic Pathways in the Reduction of Chlorinated Solvents

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While biologically mediated reductive dechlorination continues to be a significant focus of chlorinated solvent remediation, there has been an increased interest in abiotic reductive processes for the remediation of chlorinated solvents. In situ *chemical reduction (ISCR) uses zero-valent iron (ZVI)–based technologies, such as nanoscale iron and bimetallic ZVI, as well as naturally occurring reduced minerals incorporating dual-valent iron (DVI), such as magnetite, green rust, and iron sulfides that are capable of dechlorinating solvents. A more recent area of development in ISCR has been in combining biological and abiotic processes.*

There are several ways in which biological and abiotic processes can be combined. First, the interaction between the two may be "causative." For example, the Air Force Center for Engineering and the Environment's biogeochemical reductive dechlorination (BiRD) technology combines a mulch barrier with hematite and gypsum to create an iron-sulfide-based reducing zone. Biodegradation under sulfate-reducing conditions produces sulfide that combines with the hematite to form iron sulfides. As such, the BiRD technology is "causative"; the biological processes create reducing minerals. The biological generation of other reducing minerals such as magnetite, siderite, and green rust is feasible and is, with magnetite, observed in nature at some petroleum sites. A second type of interaction between abiotic and biotic processes is "synergistic." For example, biological processes can enhance the activity of reduced metals/minerals. This is the basis of the EHC® ISCR technologies, which combine ZVI with a (slowly) degradable carbon substrate. This combination rapidly creates buffered, strongly reducing conditions, which result in more complete solvent degradation (i.e., direct mineralization). The extent and level of reducing activity commonly observed are much greater when both the carbon substrate and the ZVI are present. When the carbon substrate is expended, the reducing activity due to ZVI alone is much less.

The understanding of biogeochemical processes and their impact on abiotic processes is still developing. As that understanding develops, new and improved methods will be created to enhance volatile organic compound destruction. *© 2009 Wiley Periodicals, Inc.*

INTRODUCTION

The investigation of natural attenuation processes at contaminated sites has commonly focused on biological degradation of compounds of concern. Recently, it has become increasingly apparent that abiotic mechanisms also play an important role in contaminant degradation. Historically, where evidence of biological degradation was lacking, it would

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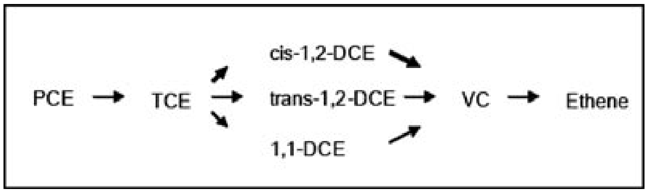

Exhibit 1. Sequential reductive dechlorination of PCE

commonly have been assumed that nondestructive processes, such as adsorption, dispersion, and volatilization, were responsible for declining concentration trends. Recent research, however, has shown that abiotic reductive processes often represent an important remedial pathway at these sites and account for significant declines in contaminant levels. There are *two* reductive processes used to treat chlorinated solvents (CVOCs): biologically mediated reductive dechlorination (reductive dechlorination), and in situ chemical reduction (ISCR). While both ultimately involve the transfer of electrons to the chlorinated solvent, resulting in dechlorination, the pathways and the mechanisms are quite different.

Reductive Dechlorination

Reductive dechlorination is a distinct metabolic pathway wherein halo-respiring bacteria use the CVOC as an electron acceptor. The electron donor is typically a carbon substrate or molecular hydrogen (produced by the fermentation of a carbon substrate). The dechlorination is a sequential hydrogenolysis wherein chlorines are replaced by a hydrogen ion (H^+). Both the hydrogen-ion addition and the chlorine removal require an electron. The reduction, therefore, involves two sequential electron transfers that are mediated by halo-respiring bacteria.

Exhibit 1 depicts the complete reductive pathway for tetrachloroethene (PCE). The degradation sequence is tetrachloroethene → trichloroethene → dichloroethene → vinyl chloride → ethene. Trichloroethene (TCE) can degrade into three different isomers of dichloroethene (DCE)—*cis*, trans, and 1,1-; however, *cis*-1,2-DCE is the dominant product.

ISCR

ISCR also involves two electron transfers. The electrons are supplied by a reduced metal, such as zero-valent iron (ZVI) or ferrous iron (dual-valent iron, or DVI). Iron-mediated reductive pathways are, in general, different from those that occur with strictly biologically mediated reduction. In particular, the primary reaction products from the reduction of chlorinated ethenes are acetylenes, not ethenes. The primary abiotic reaction pathway is a β-elimination in which chlorines on adjacent carbon atoms are removed, forming a third C-C bond. PCE is reduced to dichloroacetylene through this pathway. Abiotic reduction of the CVOCs can also go through the hydrogenolysis pathway. Hydrogenolysis typically accounts for only 10 percent of the reduction of the parent compound (Arnold, 2000). However, hydrogenolysis reactions may be used to further reduce the chloroacetylenes that are formed. Overall, abiotic reaction pathways are more complex than biologically mediated pathways.

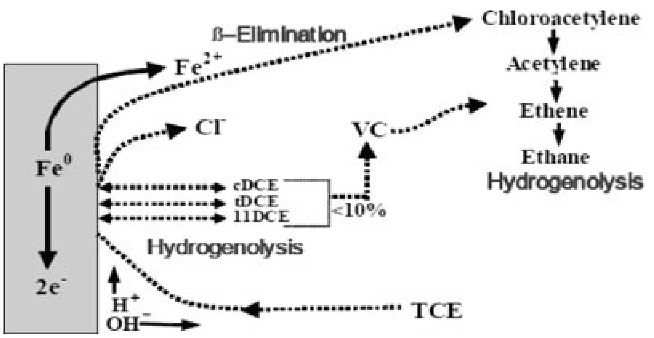

Exhibit 2. Abiotic reduction of TCE by ZVI

Exhibit 2 depicts the abiotic reduction of TCE by ZVI. It involves both β-elimination and hydrogenolysis. Approximately 90 percent of the TCE goes to chloroacetylene; 10 percent to DCE (primarily *cis*). The DCE and chloroacetylene are further reduced through hydrogenolysis ending in ethene and ethane. Chloroacetylenes can also hydrolyze to acetic acid:

$$\mathrm{Cl\text{-}C \equiv C\text{-}H + 2H_2O \rightarrow CH_3CO_2H + HCl} \tag{1}$$

Whether hydrolyzed or further reduced, chloroacetylenes are short-lived in groundwater.

Combined Abiotic and Biotic Processes

Biotic and abiotic reductive pathways are commonly viewed as unrelated. As a result, the development of these two reductive technologies has commonly been separate. Reductive dechlorination has focused on enhancing the microbiology through the use of improved carbon substrates or through bioaugmentation. ISCR has focused on understanding and enhancing the rate and or density of electron transfer through the use of nanoscale ZVI, bimetallic ZVI, or the use of chemical reductants to enhance DVI formation. More recently, however, there has been a growing awareness of and interest in the interaction between biological and abiotic processes.

Current research and development implies that there are two types of biotic-abiotic interactions. One is a causative relationship; the other is a synergistic relationship. In a causative interaction, biological reactions are used to create reducing minerals, such as iron sulfides or reduced-iron oxides like magnetite. In synergistic interactions, one process is used to enhance the reactivity or efficacy of the other. Both types of interactions will be discussed.

CAUSATIVE INTERACTIONS

The reductive capacity of reduced minerals has been a central theme in ISCR technology. It has focused on the *geochemistry* of iron minerals. Reduced iron minerals, including iron sulfides, iron oxides, iron carbonates, and mixed oxides (green rust), have been found to be active dechlorinating minerals. Reducing minerals have also been artificially created by the addition of ferrous iron to steel slag and clays.

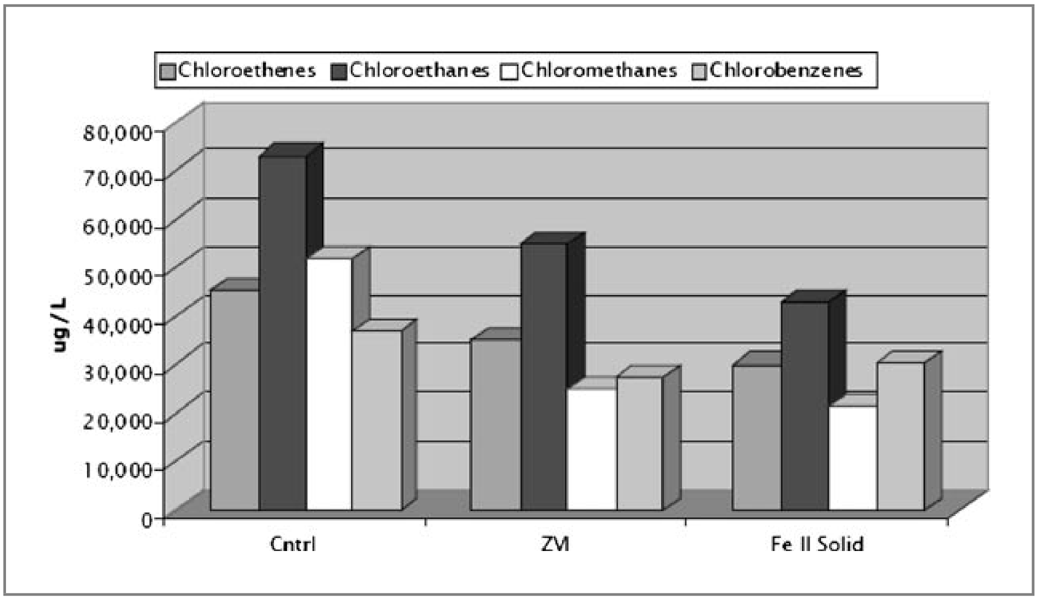

Exhibit 3. Reduction of chlorinated solvents with precipitated ferrous oxide

The abiotic reduction of chlorinated solvents by naturally occurring reduced iron minerals is a major attenuation pathway (Brown et al., 2006; Wilson, 2003). Significant degradation of parent compounds, such as 1,1,1-TCA, PCE, and TCE, is often observed without the accumulation of daughter products, indicating abiotic pathways.

Active reduced minerals have been emplaced through matrix modification, which chemically increases the amount of reduced iron minerals present. There are two methods. First is the injection of chemical reductants to convert existing oxidized-iron minerals to reduced-iron minerals. The injection of sodium dithionite into an iron-rich, oxidized matrix creates a reduced zone, which abiotically reduces TCE (Szecsody et al., 2004). A second method of matrix modification is the direct emplacement of reduced iron. Exhibit 3 shows laboratory data on the relative reactivity of ferrous iron with a mixture of chlorinated compounds including ethenes, ethanes, methanes, and benzenes. Over a 14-day reaction period, precipitated ferrous iron oxide solids (DVI) showed a level of activity equivalent to ZVI (200 mesh). The DVI and ZVI were added in chemically equivalent amounts.

While commonly thought to be unrelated technologies, there is increasing evidence that biotic and abiotic reactions may be interrelated. One area of interaction is the biogenic production of reduced-iron minerals. The biological process “causes” the formation of the reducing mineral. ISCR research and development is broadening from *geochemistry* to *biogeochemistry*.

Biogenic Minerals

Bacteria use carbon to grow and produce energy. The metabolism of carbon requires an electron acceptor. While there are a number of reductive metabolic pathways, two pathways, iron reduction and sulfate reduction, can have a substantial effect on abiotic processes.

Iron reduction uses ferric iron to metabolize carbon, producing soluble ferrous iron:

$$2H_2O + -CH_2- + 6Fe^{+3} \rightarrow CO_2 + 6Fe^{+2} + 6H^+ \quad (2)$$

The reduced iron can combine with solid-phase ferric iron to produce reducing minerals such as magnetite or green rust (Chaudhuri, 2001; Moore, 2003):

$$Fe^{+2} + Fe_2O_3 \text{ (hematite)} + H_2O \rightarrow Fe_3O_4 \text{ (magnetite)} + 2H^+ \quad (3)$$

Reduced-iron-bearing minerals that form from the precipitation of dissolved iron are capable of mediating abiotic dechlorination reactions. Ferrey et al. (2004) studied a groundwater plume in a magnetite-rich geology that contained both 1,2-*cis*-DCE and 1,1-DCE. Using aquifer sediment from three different intervals within the impacted plume, they evaluated the degradation rates of the constituents of interest. The first-order rate constant determined in the laboratory for *cis*-DCE varied from 0.31 to 2.29 per year and, for 1,1-DCE, was 1.37 per year. Autoclaved soil had the same degradation rates as did the ambient soil, indicating that the dechlorinating activity was abiotic.

Sulfate reduction converts sulfate to sulfide. The sulfide then reacts with dissolved- or solid-phase iron (Fe II of Fe III) to produce iron sulfides:

$$4(-CH_2-) + 3SO_4^{-2} \rightarrow 4CO_2 + 3S^{-2} + 4H_2O \quad (4)$$

$$2Fe^{+3} + 3S^{-2} \rightarrow FeS + FeS_2 \quad (5)$$

$$Fe^{+2} + S^{-2} \rightarrow FeS \quad (6)$$

The Air Force Center for Engineering and the Environment (AFCEE) has developed a barrier technology that uses sulfate-reducing technology to create a reduced-iron mineral zone. The technology is termed Biogeochemical Reductive Dechlorination (BiRD; Kennedy et al., 2006). To apply this technology, a trench is filled with a mixture of wood mulch, gypsum, and an iron oxide. Iron-reducing and sulfate-reducing conditions are created, resulting in the precipitation of iron sulfides. The iron sulfides create a reduced mineral zone, resulting in the dechlorination of the CVOCs. Iron sulfides formed by biological processes have been found to be more reactive than naturally occurring species, potentially due to greater surface area (AFCEE, 2008).

> Iron sulfides formed by biological processes have been found to be more reactive than naturally occurring species, potentially due to greater surface area.

Exhibit 4 depicts the performance of a BiRD trench. Sulfate levels dropped as the groundwater flowed through the trench and the sulfate was reduced to sulfide, which reacted with the hematite. Exhibit 4 has a photo inset showing the mulch particles coated with black iron sulfide. TCE was subsequently reduced in the trench without the creation of daughter products. Mulch trenches (wood chips only) typically produce significant quantities of daughter products. The lack of daughter products produced in the BiRD trench is a strong indication of an abiotic reductive pathway.

In investigating the behavior of the BiRD technology, Shen and Wilson (2007) evaluated the removal of TCE in a laboratory column that simulated the passive reactive barrier constructed with plant mulch (a BiRD biowall). Groundwater containing 1,000 to 2,000 mg/L of sulfate flowed through a reactive bed composed of shredded plant mulch and river sand containing iron(III) coatings. Sulfate reduction driven by anaerobic biodegradation of the plant mulch produced as much as 100 mg/L of sulfide. The sulfide reacted with the iron in the river sand to produce 500 to 2,500 mg/L of acid volatile sulfide (He et al., 2008). Shen and Wilson (2007) attributed as much as one-half of the

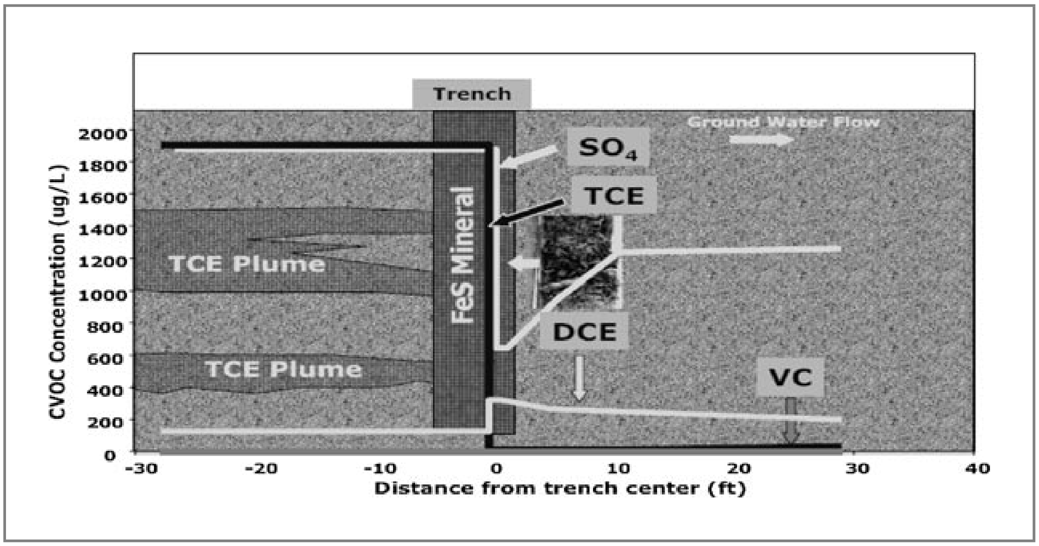

Exhibit 4. Performance of a BiRD trench using biogenic iron sulfides

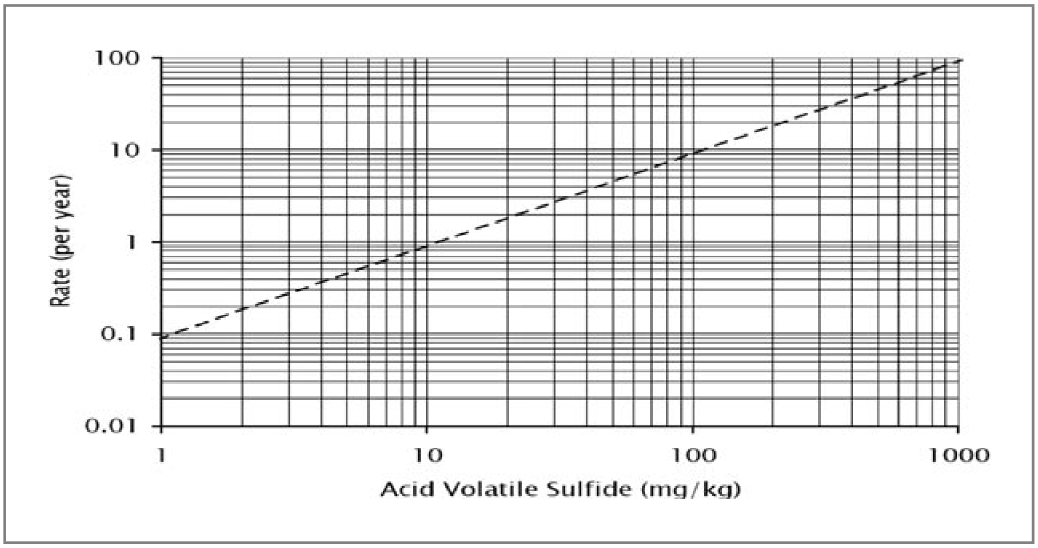

Exhibit 5. Rate TCE removal on biogenic FeS

TCE removal to abiotic reactions with iron monosulfides, and the remainder to biological degradation. The content of iron monosulfides in geological material can be estimated from a determination of acid volatile sulfide (AVS). Analyses of AVS are simple, affordable, and commercially available.

Exhibit 5 compares the pseudo first-order rate constant for removal of TCE that can be expected for reaction of TCE in typical aquifer sediment containing iron monosulfides. The rate constants predicted from Exhibit 5 represent an upper boundary on rates that might be expected in field-scale systems. The exhibit can be used to estimate the potential for TCE removal through abiotic reaction with iron monosulfides.

Groundwater chemistry can sharply influence the formation of minerals and the extent of contaminant transformation that will be mediated by ISCR. Groundwater under relatively neutral pH with little dissolved O_2 and NO_3^{-1} and adequate supplies of biodegradable organic carbon, ferrous iron, and reduced/reducible sulfur compounds is likely to support formation of iron monosulfides, which are among the most reactive minerals from an ISCR perspective. In contrast, groundwater, which has the same pH, O_2, NO_3^{-1}, and supply of biodegradable organic carbon but lacks reduced/reducible sulfur compounds, is more likely to support formation of magnetite, a somewhat less reactive iron mineral (Lee & Batchelor, 2002). Thus, the type of reactive minerals formed can influence the rate and extent of CVOC degradation, while the groundwater chemistry influences the type of mineral formed.

SYNERGISTIC INTERACTIONS

The second type of biotic-abiotic interaction is synergistic reactions in which biological processes are used to improve the performance of abiotic reactions. In synergistic interactions, the biological reactions are coupled to the abiotic reactions.

Synergistic Combinations

One example of such synergy is EHC®, a commercially available ISCR reagent that combines controlled-release carbon plus ZVI particles (www.adventusgroup.com). With EHC®, a number of physical, chemical, and microbiological processes combine to create a very strong reducing environment (e.g., Eh < -550 mV) that stimulates rapid and complete dechlorination of organic solvents and other recalcitrant compounds (Seech et al., 1995). At this low of an Eh, many chlorinated solvents are thermodynamically unstable (Dolfing et al., 2008). Chlorinated solvents readily degrade via pathways more typical of physical destruction processes, which yield minimum production and no accumulation of typical biodegradation intermediates, such as DCE for TCE.

Groundwater chemistry can sharply influence the formation of minerals and the extent of contaminant transformation that will be mediated by ISCR.

The carbon component of EHC® has several functions. First is biological reduction/consumption of oxygen and nitrate, which can interfere with or inhibit abiotic reactions. Next is buffering capacity. Fermentation of the organic component liberates organic acids, which counter the production of hydroxyl ions resulting from the ZVI corrosion process, leading to more reactive ZVI surfaces. Third is metal precipitation. In the presence of sulfate, EHC® can cause sulfate reduction, which leads to precipitation of heavy metals. The primary mechanism of removal is hypothesized to consist of the precipitation and coprecipitation of metals with iron/sulfur compounds. For example, arsenic precipitation is associated with the reduction of sulfate to sulfide and formation of stable arsenopyrite (FeAsS; Craw et al., 2003), thereby transferring it from the aqueous phase to the solid phase.

An example of these synergistic effects is also seen in the degradation of 1,2-dichloroethane (1,2-DCA). Typically, treatment of 1,2-DCA with ZVI only, or sources of carbon only, yields limited and, at best, incomplete degradation. As discussed later, EHC® achieved rapid and complete mineralization of 1,2-DCA without accumulating catabolites.

A bench-scale column study was conducted on groundwater from a site impacted with 1,2-DCA. The total volatile organic compound (VOC) concentration of the site groundwater was 337 mg/L, and the 1,2-DCA concentration was 329 mg/L. The study setup used a column followed by two soil microcosms. In the reactive setup, the column and first downstream soil microcosm were filled with site soil supplemented with 1 percent EHC® (by mass). The second soil microcosm was filled with site soil alone. This experimental setup was designed to mimic an injection of EHC® into the subsurface at the site. The second soil microcosm, containing only site soil, was added to monitor any further degradation of VOCs that may occur downgradient of the reactive zone. A control system was also set up as described earlier, except no EHC® was added to the column and soil microcosms. VOC and chloride concentrations were monitored in the influent and effluents over time.

VOC sampling on day 98 revealed a 99+ percent reduction in 1,2-DCA from 329 mg/L in the feed to 83 mg/L and 0.041 mg/L in the column and first soil microcosm effluents, respectively. The 1,2-DCA concentration was further reduced to 0.019 mg/L in the second soil microcosm. Chloroethane, a potential breakdown product of 1,2-DCA, was not detected in the effluents. The 1,2-DCA concentration in the final effluent of the control (no EHC® present) was 221 mg/L, which corresponded to a 33 percent removal of 1,2-DCA, most likely due to native dechlorinators present in the site soil and groundwater. The chloride mass balance confirmed dechlorination of the VOCs in the EHC® columns (99 percent chloride recovery, based on the percent removal of 1,2-DCA), while the control system showed little production of chloride (less than 15 percent chloride).

Results show that the EHC®-amended soil columns reduced 1,2-DCA from an initial concentration of 24 mg/L by 95 percent with a 100 percent molar conversion to chloroethane (CA) in 35 days.

A second bench-scale study compared the treatment of 1,2-DCA in ZVI or EHC®-amended soil columns over a period of 223 days. Results show that the EHC®-amended soil columns reduced 1,2-DCA from an initial concentration of 24 mg/L by 95 percent with a 100 percent molar conversion to chloroethane (CA) in 35 days (Exhibit 6). The molar ratio of CA was reduced to 42 percent after 64 days, and after 223 days there were no detections of 1,2-DCA or CA in the column effluent. In comparison, the soil column amended with ZVI only showed 26 percent, 20 percent, and 4 percent reductions in 1,2-DCA on days 35, 65, and 223, respectively. This study showed that 1,2-DCA is more effectively treated under the synergistic ISCR conditions created with EHC® than with ZVI alone.

A second type of synergy between biotic and abiotic reactions is the role of reduced iron. Bacteria readily reduce iron in the presence of degradable carbon substrates releasing soluble ferrous iron. Ferrous iron can then bind to the surface of iron minerals creating reactive sites.

Lee and Batchelor (2002) evaluated the ability of pure magnetite to dechlorinate PCE, TCE, *cis*-DCE, and VC in a laboratory study. The first-order rate constant at reactive mineral sites varied from 0.185 to 1.71 per day. They found that the addition of Fe^{+2} to a magnetite suspension increased the rate of dechlorination by a factor of nearly ten. Other iron minerals capable of dechlorination include green rust (Fe(II)Fe(III)–hydroxide), iron sulfides, and others. The chemisorption of ferrous iron onto the surfaces of such minerals was generally found to increase the reactivity of the mineral (AFCEE, 2008).

Scherer and Larese-Casanova (2007) studied the effect of adding Fe^{+2} on the reactivity of magnetite in the reduction of RDX (Exhibit 7). Neither Fe^{+2} nor magnetite alone showed significant reduction of RDX over 200 hours. The addition of soluble Fe^{+2} to magnetite, however, increased the rate of RDX reduction by greater than 20-fold.

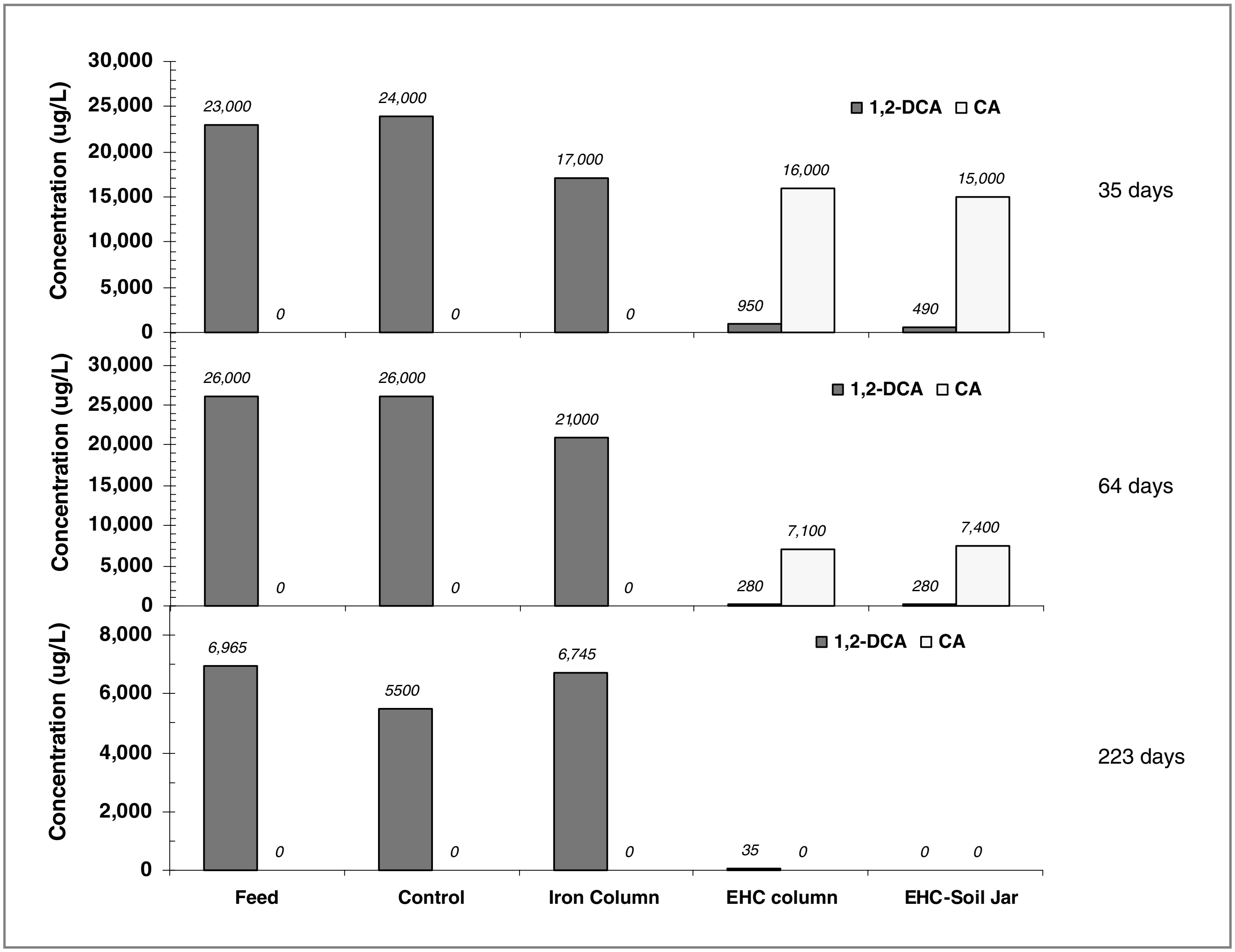

Exhibit 6. Influence of EHC and ZVI on treatment of 1,2-DCA

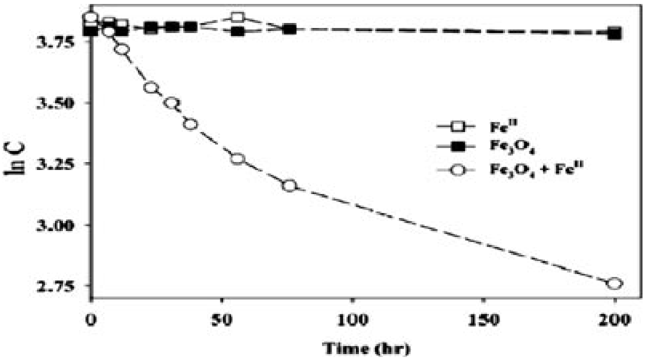

Exhibit 7. First-order plot of 47 μM of RDX reduction in the presence of 1.5 mM of Fe^{+2} and a magnetite suspension (44 m^2/L) at pH of 7.0

In the presence of reduced minerals or minerals with mixed iron valences, the biological production of soluble ferrous iron can improve the reducing capacity and kinetics of the minerals.

An implication of this type of synergy is the coupling of biodegradation to abiotic reduction. Naturally occurring biological processes could result in abiotic attenuation. If soluble iron is produced biologically and if there is an iron-rich mineralogy present, a reducing mineral could be created as a result of the biological activity creating an under-layer of abiotic activity. This mineral could be collocated with the biologically active zone or it could be created downgradient.

CONCLUSION

Biological and abiotic dechlorination processes have previously been viewed as separate pathways and not interrelated. This is in part because abiotic processes are surface-catalyzed processes relying on minerals or on metals like ZVI while biological processes were viewed as aqueous-phase reactions relying on microorganisms.

This viewpoint is changing. Biological processes and abiotic processes have a strong interrelationship. The interaction can be causative. Biological processes can produce reduced-iron minerals, such as pyrite, magnetite, or green rust. Sulfate reduction and iron reduction are two of the key metabolic pathways. The biological production of iron sulfides is the basis of AFCEE's BiRD technology.

The interaction also can be synergistic. Biological processes can enhance the reactivity of abiotic materials. EHC® intentionally uses this synergy by combining ZVI with a degradable carbon substrate. The production of dissolved iron II can create highly reactive sites on iron minerals through chemisorption.

Further understanding of the interaction between biotic and abiotic reactions can lead to the development of improved remedial methods. It has implications for both aggressive remediation as well as natural attenuation.

Effective site management requires a holistic understanding of contaminant attenuation, regardless of the form it takes. Abiotic mechanisms are effective at degrading contaminants, and some abiotic remedial technologies have been shown to be viable at contaminated sites; others will likely emerge that combine biotic and abiotic processes. Increasing our understanding of these processes will improve management of contaminated sites and, in doing so, help ensure contaminated sites are managed to be protective of human health and the environment.

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FMC
ENVIRONMENTAL SOLUTIONS

ELS® Mixing Instructions

Introduction

Emulsified Lecithin Substrate (ELS®) is a cold-water soluble carbon substrate that is specially designed to be emplaced via existing wells and/or hydraulic injection networks for the treatment of a wide range of groundwater contaminants. The base composition is a slow release carbon source (lecithin), an organo-iron compound and amino acids (all food-grade). The lecithin component, a 25% liquid emulsion of lecithin, is provided in 55-USG drums containing 50 USG of emulsion. This document provides standard operating procedures for preparation of diluted ELS for injection.

Packaging

Liquid emulsion delivered in 55-USG drums, filled with 50 USG/ 420 lbs per drum.

ELS Injection Volumes and Dilutions

Depending on the application method, between 10% and 100% of the effective porosity is normally targeted during ELS injection, with a higher percent pore fill normally targeted during low-flow injections into wells and injection networks. This is in contrast to applications via direct push technology (DPT) where normally around 10 to 15% is targeted. To facilitate the desired injection volume, the ELS components will be diluted in the field. Table 1 shows examples of mixing recipes for a 55-USG drum of ELS.

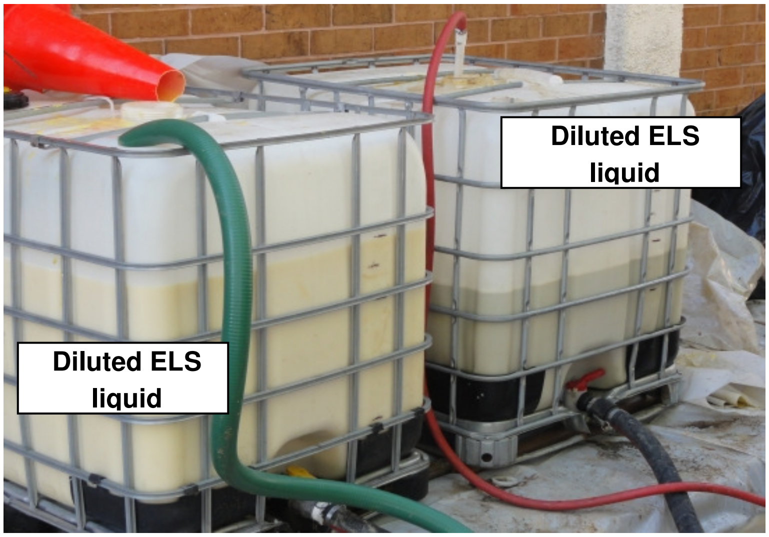
Table 1: ELS dilutions and corresponding concentration.

Dilution:	**5-fold**	**10-fold**	**25-fold**	**50-fold**
Volume ELS emulsion per drum (USG)	50	50	50	50
% active components in ELS as delivered	25%	25%	25%	25%
Dilution factor for ELS slurry to inject	5	10	25	50
Volume water (USG)	200	450	1200	2450
Resulting total volume (USG)	250	500	1250	2500
Resulting ELS concentration	5.8%	2.9%	1.2%	0.6%

General Mixing Procedures

Proportioning can be varied to accommodate mixing tank size. The general mixing procedure is:

1. Fill mixing tank with required amount of dilution water per the treatment design.
2. Transfer ELS liquid to mixing tank. Note that this material is pre-emulsified, has a viscosity of about 13 cPs and will require an appropriate pump for transfer from the drum. Alternatively, the concentrated emulsion may be transferred in pails by hand. A paddle mixer and/or recirculation pump is sufficient for mixing.
3. If other additives are used (e.g., pH buffers), they may be added at this time.
4. Mixing time depends on equipment used (typically 10-15 min). Material is to be mixed until uniform.



Health and Safety

ELS is completely non-hazardous and safe when handled properly in accordance with instructions for use, the advisory below and the MSDS. The ELS MSDS is posted on our web site at:

: http://msdsviewer.fmc.com/private/document.aspx?prd=EHCL-C~~PDF~~MTR~~CPNA~~EN~~1/1/0001%2012%3A00%3A00%20AM~~EHC%7CTS-L~~&language=d__EN&reviseddate_condition=d__lt&publisheddate_condition=d__lt&productName=EHC&productName_option=d__value~&hidRequiredLis

When working with ELS, the use of standard personal protective equipment, including safety glasses, steel toe boots, nitrile gloves, hearing protection (when Geoprobe is operated) and hard hat is recommended.

APPENDIX 5

OPERATING LOGS

Operating Log T.F. Green Interlink
In-Situ Oxidation

Date:

Ambient Temperature: ______________________________

Weather Conditions: ______________________________

Personnel On-Site: ______________________________

1. Contingency Plan Implementation:

Was it triggered on this day? Yes ________ No ________

If yes, please explain: ______________________________

____

____

____

____

2. Analytical Records:

Was any analytical data attached into the operating log book?

Yes ________ No ________

3. Progression of Remedial Action:

Were any CVOC reduction graphs attached into the operating log book?

Yes ________ No ________

4. Inspection Plan:

Was an inspection completed by the State of Rhode Island registered P.E.?

*Inspections should occur weekly during injection events

Yes ________ No ________

5. Inspection problems and repairs: ______________________________

____

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Operating Log T.F. Green Interlink
In-Situ Oxidation

6. Record Site Activities:

North Plume

Well Designation	Persulfate (gal)	Hydroxide (gal)	Pressure	Injection Rate
E1				
E2				
E31				
E32				
E33				
E34				
E35				
E36				
E37				
E38				
E39				
E40				
E41				
E42				
E43				
E44				
E45				
E46				

Comments:

Operating Log T.F. Green Interlink
In-Situ Oxidation

6. Record Site Activities:

South Plume

Well Designation	Persulfate (gal)	Hydroxide (gal)	Pressure	Injection Rate
E4				
E5				
E6				
E7				
E8				
E9				
E10				
E11				
E12				
E13				
E14				
E18				
E19				
E20				
E21				
E22				
E23				
E24				
E25				
E26				
E27				
E28				
E29				
E30				

Comments:

Operating Log T.F. Green Interlink
Anaerobic Reductive Dechlorination

Date:

Ambient Temperature: ____

Weather Conditions: ____

Personnel On-Site: ____

1. Contingency Plan Implementation:

Was it triggered on this day? Yes ________ No ________

If yes, please explain: ____

____

____

____

____

2. Analytical Records:

Was any analytical data attached into the operating log book?

Yes ________ No ________

3. Progression of Remedial Action:

Were any CVOC reduction graphs attached into the operating log book?

Yes ________ No ________

4. Inspection Plan:

Was an inspection completed by the State of Rhode Island registered P.E.?

*Inspections should occur weekly during injection events

Yes ________ No ________

5. Inspection problems and repairs: ________________________________

____

____

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____

____

Operating Log T.F. Green Interlink
Anaerobic Reductive Dechlorination

6. Record Site Activities:

Jefferson Blvd.

Well Designation	Persulfate (gal)	Hydroxide (gal)	Pressure	Injection Rate
W8				
W9				
W10				
W11				
W12				
W13				
W14				
W15				
W16				
W17				
W18				
W19				
W20				
W20A				
W20B				
W21				
W22				
W23				
W24				
W25				
W26				

Comments:

Operating Log T.F. Green Interlink
Anaerobic Reductive Dechlorination

6. Record Site Activities:

Jefferson Blvd.

Well Designation	Persulfate (gal)	Hydroxide (gal)	Pressure	Injection Rate
W27				
W28				
W29				
W30				
W31				

Comments:

APPENDIX 6

CERTIFICATES OF ACCURACE

Certification of Accuracy

SIGNED STATEMENT, PREPARERS OF RAWP

I attest that I have personally prepared, examined and am familiar with this Remedial Action Work Plan, including any and all documents accompanying this submittal. I certify to the accuracy of the information contained in this report to the best of my knowledge.

Clayton Carlisle

Clayton Carlisle, P.E.
Senior Environmental Engineer
Louis Berger Group

Thomas Sylvia
Principal Chemical Engineer
Environmental Strategies and Management

Certification of Accuracy

SIGNED STATEMENT, AUTHORIZED REPRESENTATIVE

I attest that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this report submittal and based on my inquiry of those individuals immediately responsible for obtaining the information, the material information contained in this submittal is, to the best of my knowledge and belief, true, accurate and complete, and that I am fully authorized to make this attestation on behalf of the entity legally responsible for this submittal.

____

Kazem Farhoumand, P.E.
Chief Engineer
RIDOT