CSX
TRANSPORTATION

Paul J. Kurzanski, REM
Manager Environmental Remediation
Direct: (904) 359-3101
FAX: (904) 245-2826
E-mail: paul_kurzanski@csx.com

Public Safety & Environment Department
500 Water Street, J-275
Jacksonville, FL 32202

July 7, 2006

Mr. David Pratt, P.E.
NYSDEC Region 8
6274 East Avon – Lima Road
Avon, New York 14414

Re: CSXT River St. Derailment
Rochester, New York
Site #V00524-8
Response to NYSDEC Comments on the Draft Remedial Action Work Plan

Dear Mr. Pratt:

CSX Transportation, Inc. (CSXT) has prepared this letter in response to your March 14, 2006 letter regarding AMEC's November 18, 2006 Remedial Action Work Plan for the River Street Derailment Project. This letter has been formatted so that the entire initiating comment is provided in italics and is followed by CSXT's response presented in standard font.

Comment 1. *Section 2.2.1 - The samples collected at the north and south ends of the track also have high levels of Acetone and Methylene Chloride. In fact the Northend SW sample has more methylene chloride than Track 5 Bottom. This indicates that the contamination may extend farther along the tracks than suggested in the work plan.*

Response 1. There are residual impacts under a portion of the tracks. The limits of excavation for this area during the IRM phase of the project were defined through various sampling events conducted, with considerable consideration given to the direct push sampling event conducted down the track centerline on May 21, 2002.

The northern sidewall sample (North-End SW) collected from the track excavation did have elevated levels of methylene chloride and those impacts could extend beyond the sample location. However, the sample taken approximately 15' north of this location, the GP-60 sample, had concentrations of the two contaminants of concern (COC) only slightly above the recommended soil cleanup objective levels of TAGM 4046. Further to the north sample GP-61 had COC concentrations below TAGM. So, the elevated levels indicated by the North-End SW do not appear to extend more than 15' to the north.

The injection points for the application of the amendment have an estimated 20' radius of influence (ROI). As illustrated on Figure 5 of the RAWP, during the amendment application, the area in question between North-End SW and GP-61will be effectively captured.

As for the residual COCs detected in the samples at the south end of the track excavation at Track 1 Bottom and GP-56, those residuals were going to be captured in any event by the 20' ROI of the application of the remedial amendment as illustrated on Figure 5 of the RAWP.

Nevertheless, in addressing this comment of the Department and comment 13 below, CSXT has determined that extending the limits of the application of the remedial amendment to the south beyond what is depicted in Figure 5 would satisfy the interest of all parties. The City data identifies residual impacts at its sample locations SS-67, SS-66 and SS-31. CSXT data GP-55 and K2.25 – 3.5' also indicate COC concentrations above TAGM. Additional amendment injection points have been incorporated at these locations into the RAWP.

Please replace Figures 3 and 5 of the RAWP with the revised Figures attached to this letter.

Comment 2. *Section 2.3.1 states: "It is highly unlikely that the property will be used as residential property in the foreseeable future." Although this may or may not be accurate for the CSXT parcel, it has come to our attention that there has been some interest in the Tapecon parcel for residential development. It is therefore possible that the Tapecon property could be used for residential development within the foreseeable future.*

Response 2. Commented noted. Because the statement that "it is highly unlikely that the property will be used as residential property in the foreseeable future" was in a paragraph addressing the CSXT property and not the Tapecon property, no change is necessary to that particular paragraph of the RAWP. CSXT believes that its property will remain as an active track corridor for the foreseeable future. CSXT, however, is aware of this reported potential change in the Tapecon property status. Therefore, the preceding paragraph of Section 2.3.1 will be amended to include as a new second sentence the following: "Although the Tapecon property is currently used for commercial/industrial purposes, and appears to have hazardous substance impacts associated with that use, it is possible that the Tapecon property could be used for residential development in the future." Please replace pages 13 and 14 from the November 2005 RAWP with the attached pages 13 and 14.

Comment 3. *Section 3.2.2 - The discussion and the appended literature address the ability of EHC™ to dechlorinate organic compounds. This is appropriate for the methylene chloride; however, its effectiveness in addressing acetone is not discussed. Has there been analysis of the effects of the EHC injection on the degradation of acetone? CSXT may have to consider the use of an oxygen release compound after the EHC has addressed the methylene chloride in order to create aerobic conditions that better promote acetone degradation.*

Response 3. The discussion and literature in the draft RAWP, which focused on the ability of EHC™ to dechlorinate organic compounds like methylene chloride, did not address acetone directly because Adventus, the EHC*™* manufacture, had no specific experience addressing acetone as a primary COC in the concentrations documented at the site. However, Adventus had observed acetone at many of its jobs and in a number of pilot tests, and had successfully remediated it.

In that regard, CSXT commissioned Adventus to conduct a bench scale test using site-specific soils to evaluate the effectiveness of EHC™ and its sister compound EHC-O™, which is an oxygen releasing compound, on both the methylene chloride and the acetone. Both the EHC™ and the EHC-O™ amendments have proven effective at remediating methylene chloride and acetone in saturated soils. Please see Response 4 for additional detailed information concerning the results of the bench test.

Comment 4. *Section 3.2.2 - Has there been any bench scale testing of this technology using the native site soils? Also, we understand that CSXT is planning a pilot test on a Tapecon area. The proposed pilot scale test is not discussed in the work plan except for a brief mention of a pilot test under the "Schedule" section of the plan. If such a pilot program is going to occur, what will be the time line for the test and what criteria will be used to deem it a success? Will the Tapecon area be used for the pilot test?*

Response 4. As mentioned in the response above, CSXT commissioned Adventus to conduct a bench scale test (BST) of the EHC™ and EHC-O™ amendment using site-specific soil and groundwater.

During field visits in January and February, AMEC collected soil and groundwater from the site to be evaluated in the BST. Groundwater was collected during the quarterly sampling event at multiple locations and composited to provide a representative sample from the site. Soils were collected from two areas based on residual COC locations and from both the saturated and unsaturated zone. Saturated soils were collected from the SB-11 area where the highest concentrations of residual COCs were observed (92,000 ppb methylene chloride).

Unsaturated soils were collected from the Track 3 SW 3' area because it exhibited the highest COC concentrations in the most representative conditions for this zone. Soils from the Tapecon property were not considered representative of the unsaturated zone, because the area impacted by residual COCs is isolated and small in size. Soil adjacent to the Track 4 SW 3.5' sample was not used because those particular soils were subsequently removed during a shallow soil excavation around the gas main. The unsaturated soils were collected approximately 8' west of the original Track 3 SW sampling location due to the City's new sidewalk.

The BST process included spiking of the collected samples to better mimic concentrations detected at the site. The amendments were added to both saturated and unsaturated soils, and degradation of the COCs was observed in four sampling events spread over 70 days.

Results from the test were mixed. Adventus reported a decrease in COC concentrations in both the saturated and unsaturated control samples which did not contain any amendment. The decrease in the control soils is most likely the result of the soils being handled during collection and spiking, and thereby, being altered from their natural state exposing additional surface area, introducing oxygen, and possibly activating slow or dormant microbes, all of which can contribute to the decrease in the controls.

Adventus observed the expected decrease in COCs in saturated soils, and that decrease was faster and more complete than the decrease observed in the control indicating that the EHC™/EHC-O™ compounds were working effectively in the saturated zone. However the unsaturated zone did not yield such results. But rather, the unsaturated soils had similar results to those observed in the controls. For your review, a copy of the BST Report has been included with this letter.

Although the BST had some positive results, the uncertainty as to the effectiveness of the amendments in the unsaturated soils make CSXT uncomfortable in proceeding directly with a full scale application. CSXT, therefore, believes that a field pilot study is necessary to further evaluate the effectiveness of the amendments at the site.

CSXT is currently evaluating the correct approach for conducting a field pilot test. In doing so, CSXT is reviewing the following factors:

1. Testing location (including, possibly Tapecon) for both the saturated and unsaturated zones.
2. Access to the testing location.
3. Amendment to be used (EHC™, EHC-O™, and/or ABC™).
4. Amendment application technique.
5. Size of the test area, and duration of test, including impact of colder weather.
6. Appropriate monitoring frequency and any necessary O&M.

With the Department's approval of the concept of CSXT conducting a pilot study, AMEC will prepare a pilot test work plan for the Department and affected parties to approve prior to mobilization. The goal of a pilot test would be to obtain additional information on how the amendment will address COCs in native conditions. This will further define the remedial path forward. A successful pilot test would reduce COCs in both the saturated and unsaturated soils. Because the remedial amendment can remain active in the environment for two years and pilot tests are significantly shorter, obtaining pilot test results that are at or below site cleanup criteria may not be feasible. However, evaluation of COCs and other environmental parameters along with application techniques will provide valuable information and experience prior to going full scale. AMEC on behalf of CSXT will provide this work plan under a separate cover within 30 days of the Department's approval of the concept of CSXT conducting a pilot study.

Comment 5. *Section 5.1.3.1 - Figure 5, referred to in the text for locations of the monitoring points, should be changed to Figure 6. Monitoring points should also be located to the north and south of the track area and some along the perimeter to verify the radius of influence.*

Response 5. The reference to Figure 5 in Section 5.1.3.1 will be changed to refer to Figure 6. In addition, Figure 6 has been revised to add monitoring points to the north and south of the track area and along the perimeter to better verify the radius of influence. Please replace page 31 and Figure 6 of the RAWP with the revised versions attached to this letter.

Comment 6. *Design documents will be necessary if the remedial approach is approved by NYSDEC. Details such as where the mixing unit and other necessary equipment will be set up, how many days the injection process will take, etc. will be necessary.*

Response 6.	CSXT is hopeful that the pilot study will demonstrate that the proposed Adventus amendment can successfully address the COCs in both the unsaturated and saturated soils on-site. If the pilot study is successful, then CSXT will prepare and submit design documents for NYSDEC approval of the remedial approach. The design submittal will also be circulated to the owners of the affected properties for review and comment.
Comment 7.	*Until it is shown that the land-side contamination has been remediated, institutional controls may still be required. What institutional controls are being proposed as part of the remedy for the various parcels? A soil management plan to address residuals will likely be necessary.*
Response 7.	CSXT acknowledges the Department's request for a soil management plan until such time as CSXT has implemented the RAWP and met applicable cleanup criteria. A soil management plan will be prepared and submitted under a separate cover.
Comment 8.	*Some of the proposed EHC treatment area is located in the vicinity of City-owned land at 490 River Street, and on or approaching the River Street Right-of-Way (ROW). The City has requested that AMEC provide them with more detailed mapping showing the location of the proposed EHC injection points and radius of influence in relation to the River Street ROW and public water main. The City can provide AMEC with River Street improvement as-built drawings if requested.*
Response 8.	AMEC has been provided by the City with River Street improvement as-built drawings and is incorporating them into the RAWP. Please replace Figures 3, 5 and 6 from the RAWP with the revised Figures which includes the River St. ROW limits and water main. AMEC is currently incorporating the new surface and subsurface features associated with the River St. improvement into its drawings and will provide the City and NYSDEC with more detailed mapping showing the location of the proposed injection points and radius of influence in relation to the River Street ROW and public water main with the work plan for the pilot study.
Comment 9.	*It has been requested that AMEC provide additional documentation and a final determination to the City's Bureau of Water regarding the compatibility of EHC with the existing underground utilities located within the River Street ROW, including the City installed public water main.*
Response 9.	The three Adventus amendments under consideration, EHC™, EHC-O™ and ABC™ are completely compatible with the existing underground utilities located within the River Street ROW, including the City installed public water main. They do not generate heat, materially change pH (EHC-O™ will raise the pH slightly to 9 immediately around the injection point), or utilize oxidants that in theory could accelerate corrosion of materials used in underground utilities. The amendments are composed of food-grade materials that have no adverse acute or chronic effects on human or environmental heath. The MSD sheets have been attached to this letter. AMEC will provide any additional documentation requested by the City's Bureau of Water, for a final determination regarding compatibility.
Comment 10.	*The LaBella IRM Summary Report dated February 2003 contains information and drawings showing confirmatory soil sampling locations that contained acetone and methylene chloride that exceed soil cleanup objectives. For example, the LaBella IRM Summary report identifies Area of Concern #4 on the City-owned 490 River*

Street parcel that contains elevated concentrations of acetone in soil. It does not appear that acetone in this area is targeted for active remediation by AMEC or CSXT. The LaBella IRM report also documented several other locations on City land or within the River Street ROW that contain residual concentrations of methylene chloride or acetone in soil, and it appears that these areas will not be actively remediated by CSXT. If these miscellaneous areas are not planned for active remediation, will CSXT propose monitoring? As stated in comment # 7 above, institutional controls/soil management plan to address residual contamination may be necessary.

Response 10. Throughout the course of the project, CSXT has reviewed City generated data although it does not necessarily agree with all of the data collected, the way it was generated or the way that it has been presented. Even if the City data were to be accepted at face value, it must be viewed in context of the multitude of samples collected by CSXT pursuant to Department-approved sampling protocols. After this is done, the City data does appear to provide some useful information in a few limited locations. Again, taking this data at face value, CSXT has re-evaluated its proposed path forward in the interest of all parties involved, and adjusted the extent of the proposed injection of the Adventus amendment to cover these additional areas.

As detailed in the table below, CSXT will address 12 of the 20 residual COC locations identified by the City. Also as detailed in the table below, the voluminous CSXT data demonstrates that the soils at the other 8 locations do not indicate areas which contain statistically significant amounts of residual acetone and methylene chloride despite what the limited City data might otherwise indicate when viewed alone.

CSXT is confident that it is addressing all residual concerns associated with the Site. Please replace Figures 3 and 5 of the RAWP depicting the residual sample locations and amendment treatment zones.

City of Rochester Residual COC Sample Locations

City ID	Sample Date	Acetone Ug/kg	MC Ug/kg	Comment	To Be Addressed
SS-30	5/17/02	1,200	28.8 U	CSXT sample result L2 SW3.5' had residual acetone too. However, CSXT soil gas sample SG-30 was non-detect (ND) and the area is surrounded by sample results either ND or below TAGM; GP-54, L3/K3 SW 3.5', L/M2.5 SW 3.5'. Adjacent City samples SS-27, 28, 29, 34 are ND. Indicating residuals impacts are very limited if still present.	CSXT will place one additional injection point to capture any potential impacts
SS-31	5/17/02	1,690	143 U	CSXT data GP-55 and K2.25 – 3.5' also indicate COC concentrations above TAGM.	Amendment zone extended to capture.
SS-35	5/23/02	40.3 U	117	Minimally exceeds TAGM RSCO and has CSXT sample K3.5 SW3.5' immediately adjacent with ND (28.6).	N
SS-64	6/18/02	4,120 U	47,600	Already in "Track" area to be captured by amendment.	Already in plan to be captured by amendment.
SS-65	6/18/02	250	406	Already in "Track" area to be captured by amendment.	Already in plan to be captured by amendment.
SS-66	6/20/02	240	23.7 U	CSXT data GP-55 and K2.25 – 3.5' also indicate COC concentrations above TAGM.	Amendment zone extended to capture.
SS-67	6/20/02	212	22.3 U	CSXT data GP-55 and K2.25 – 3.5' also indicate COC concentrations above TAGM.	Amendment zone extended to capture.
SS-77	7/11/02	47,800	4,630 U	SB-5 9.5' was collected immediately adjacent to SS-77 and had ND (25) results. A duplicate sample was collected at this location with identical results.	CSXT will place additional injection points to capture any potential impacts
SS-78	7/11/02	202	33.4 U	Minimally above TAGM RSCO.	N
SS-80	7/11/02	64,400	4,060 U	Adjacent samples SB-5 9.5' and RB 0+10 7'SW are ND or acetone in addition to groundwater samples never exceeding 9J. However, because of the significant difference in results an injection point for the amendment will be added to this location.	CSXT will place additional injection points to capture any potential impacts
SS-81	7/16/02	207	38.1 U	Minimally above TAGM RSCO. CSXT surrounding samples (6'-20' away) D6/C6 SWE 5', D6/C6 B 10' and D6 SW W5' are all ND. Sample D6 B10' is 180 for acetone.	N
SS-87	7/22/02	53.5 U	228	SS-87 is surrounded by CSXT samples either ND or below TAGM, C6 B4', SB-1, D6/C6 SW West 5', D6/C6 B10', D6/C6 SW East 5', CD7 BB 3.5'.	N
SS-88	7/23/02	314	26.4 U	Isolated location above the water table exceeding TAGM RSCO by less than half. Also reference sample points in SB-3 description.	N
SS-90	7/24/02	6,320 U	26,400	Already in "Track" area to be captured by amendment.	Already in plan to be captured by amendment.
SS-96	7/26/02	172	1,420	Adjacent City sample SS-95 is ND. CSXT samples E6 B10', D5 12', CD4 B10', D6 B10', E5.5 12' are either ND or have significantly lower MC concentrations. SS-96 is 8' beyond the ROI for the East amendment area, shifting injection points can capture SS-96.	CSXT will shift existing injection points to capture any potential impacts
SS-100	8/12/02	611 U	3,020	Already in "Track" area to be captured by amendment.	Already in plan to be captured by amendment.
SS-101	8/12/02	5,620 U	20,300	Already in "Track" area to be captured by amendment.	Already in plan to be captured by amendment.
SB-3	2/28/03	149 U	3,000	City sample was collected after the initial derailment prior to any cleanup. More recent data collected by the City and CSXT show a distinct northern cutoff of impacts (not necessarily below TAGM but much lower than SB-3). City samples SS-82, 84, 85, 87, 88, 94, 95, 98, 99 ranging in depth from 3.8' to 11' BGS. CSXT samples C6 B4', D6/C6 B10', D6/C6 SW West 5', CD4 B10', D5 B12', SB1/MW-9, SB-9/MW-7, SB-6, sample depths range from 4'to 20'.	N Please see attached figure illustrating the referenced sample locations.
RB-1	10/22/02	318	18.6 U	CSXT sample RB 0+10 10' collected 10' from RB-1 had acetone at 110, below TAGM RSCO. Location is currently between two sheet pile walls and under the board walk.	N
RB-9	10/24/02	130 U	1,240	CSXT sample RB 1+30 10' collected 10' from RB-9 had methylene chloride at ND (14). Location is currently between two sheet pile walls and under the board walk.	N

Notes: -All concentrations are Ug/kg (ppb)

-NYSDEC TAGM RSCOs are 100 and 200 (above the water table) for methylene chloride and acetone respectively and 40 and 44 within the water table respectively.

Comment 11. *Sediment Management Plan - Section 3.0 - Figure 2 should better depict the area of residuals in the river with landmarks or coordinates that will assist in defining the area.*

Response 11. Please replace Figure 4 from the RAWP with the revised Figure 4 attached to this letter. The revised Figure 4 contains GPS coordinates to assist in defining the area of residual sediment impacts.

Comment 12. *Sediment Management Plan - Section 4.0 There is a new phone number for Joseph Albert, MCHD: 585-753-5904. Also, Mr. Albert's email address is jalbert@monroecounty.gov.*

Response 12. Please replace the original Sediment Management Plan (SMP) with the amended SMP, which incorporates the changes, attached to this letter.

Comment 13. *The AMEC report does not reference the City's confirmatory sediment sampling results documenting residual sediment contamination on City underwater land at 490 River Street. Several of the sediment samples contained methylene chloride in sediments at concentrations which exceed the cleanup objective for this project. These results are summarized in LaBella's Sediment Summary Report dated June 2005. The City has requested that AMEC's Sediment Management Plan reference the City's confirmatory sediment sampling results. Please include this information in the next revision.*

Response 13. The City's data has been included as a reference, please insert Table 6 into the RAWP. Also insert page 9 into the report which includes revised text directing readers to the table.

Comment 14. *The proposed remedy for sediments is for no further action with institutional controls in the form of the AMEC Sediment Management Plan. Does CSXT envision the use of signs, deed restrictions, or an environmental easement? What does CSXT envision will constitute an action or mechanism that triggers a referral? Does CSXT envision the initial referral be to CSXT or to the NYSDEC? It appears that the final institutional controls may require discussions and potentially agreements with impacted property owners. How does CSXT plan to address this?*

Response 14. The proposed remedy for sediments is no further action with the institutional controls embodied in the AMEC Sediment Management Plan. The attached Figure 4 illustrates the area within which residual impacts remain based upon the confirmatory data generated by CSXT and the City at the end of the sediment removal IRM. As illustrated in Figure 4, the City owns all of the upland adjacent to the sediments containing residual COCs in excess of the cleanup objective for this project. CSXT has obtained the City's agreement to provide an environmental easement for the benefit of the NYSDEC over the City's underwater land. CSXT is attempting to determine how far the City's underwater lands extend. They may extend to the centerline of the river in which case they would encompass the entire area delineated in Figure 4.

Nevertheless, CSXT had envisioned that the United States Army Corps of Engineers (USACE) would be the first point of contact since any dredging work within the limits of the Genesee River would require a Section 10 of the Rivers and Harbors Act permit and approval. The USACE will have a copy of Figure 4 demarcating the area within which residual impacts remain. AMEC contacted the USACE on behalf of CSXT to confirm its understanding and was assured that everybody within the USACE who is involved with permitting or river-based work is well aware of the impacts. The USACE will also automatically contact the NYSDEC via the Section 401 water quality certification requirement because any such dredging might result in a discharge to navigable water.

Very truly yours,

Paul Kurzanski

Paul J. Kurzanski
Manager Environmental Remediation

cc: Matthew Forcucci, NYSDOH
Joseph Albert, MCDOH
Joseph Biondolillo, City of Rochester
Paul Sylvestri, Harter Secrest & Emery, LLP
Allan Knauf, Knauf Shaw, LLP
William Danis
Thomas Walsh, Hiscock & Barclay, LLP
Mike Sykes, AMEC

FIGURE

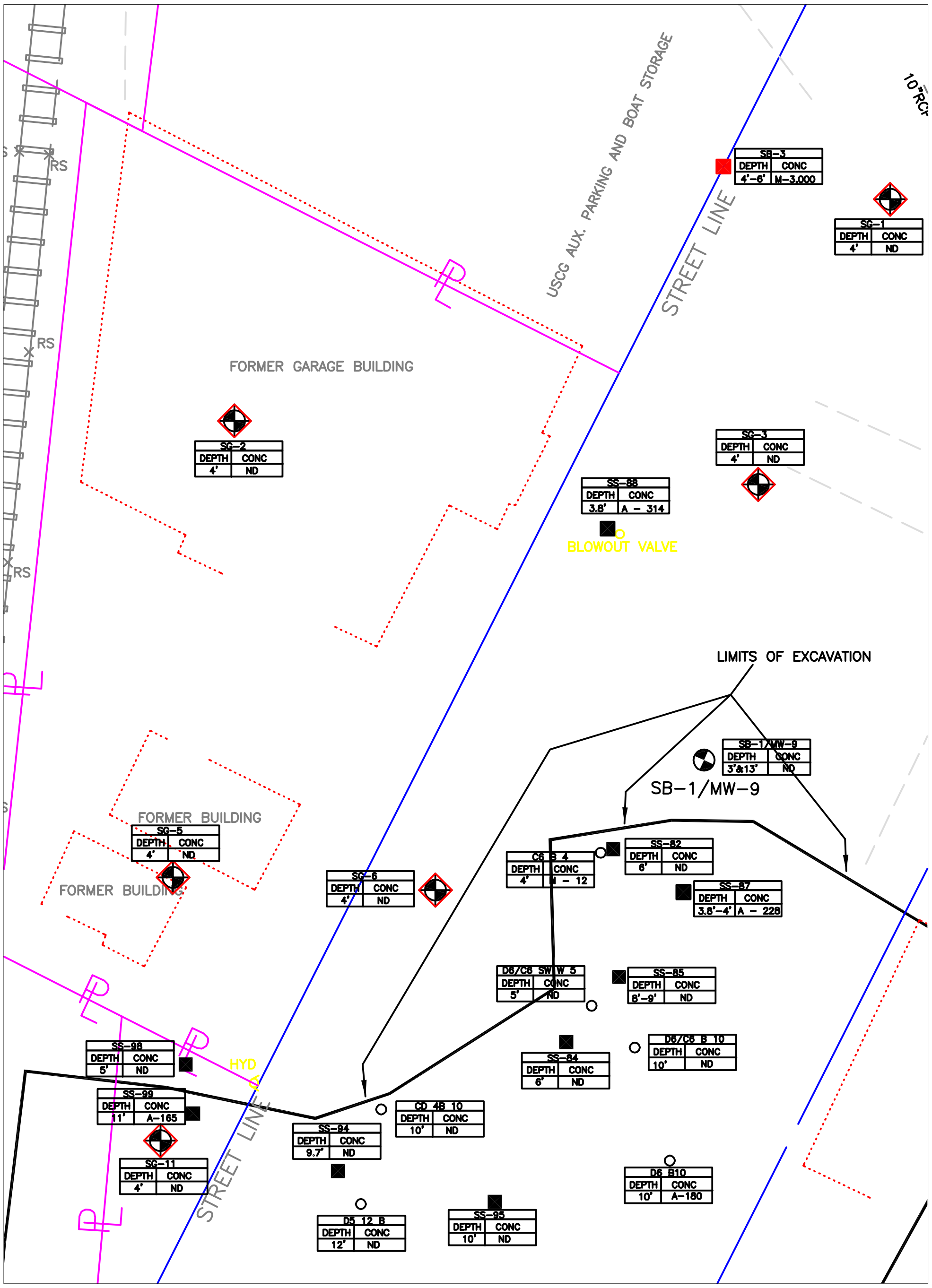
SB-3 NORTHERN CUT-OFF SAMPLE LOCATIONS

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

◆	CSXT SOIL GAS SAMPLE
●	MONITORING WELL
○ GB5	CSXT SOIL SAMPLE
🟥 SB-3 ■ SB-82	CITY SAMPLE LOCATION
A	ACETONE
M	METHYLENE CHLORIDE
ND	NON DETECT

----ALL UNITS PPB----

NOTE:
SB-3 IS CLEARLY SEPERATED FROM THE SPILL SITE TO SOUTH BY A SERIES OF MORE RECENT CITY AND CSXT DATA DEMOSTRATING A CUT-OFF OF IMPACTS AT THE LIMIT OF EXCAVATION.



amec

CSX TRANSPORTATION, INC.
JACKSONVILLE, FL

NORTHERN CUTOFF SAMPLES FOR SB-3
RESPONSE TO NYSDEC RAWP COMMENTS

EDISON PLAZA
155 ERIE BOULEVARD
SCHENECTADY, NY 12305

SIZE	FSCM NO.	DWG NO.	REV
SCALE	1 = 30	SHEET	

BENCH SCALE TEST REPORT

ABC, EHC-O, AND EHC TREATABILITY STUDY FOR THE TREATMENT OF VOLATILE ORGANIC COMPOUNDS IN SOIL AND GROUNDWATER FROM THE CSX TRANSPORTATION - RIVER STREET SITE IN ROCHESTER, NY (THE SITE)

FINAL REPORT

Prepared for:

AMEC Earth & Environmental, Inc.
Edison Plaza
155 Erie Boulevard
Schenectady, New York 12305

***Submitted by*:**
ADVENTUS AMERICAS INC.
ADVENTUS Project No.: AAI5-151b

June 27, 2006

EXECUTIVE SUMMARY

A bench-scale treatability study was completed at the Adventus laboratory in Mississauga, Ontario for the treatment of soil and groundwater impacted with volatile organic compounds (VOCs) from the River Street Site in Rochester, NY (the Site). The primary constituents of interest (COI) were acetone and methylene chloride (DCM). The overall objective was to determine the ability of ABC®, EHC-O and EHC™ to treat VOCs in the soil and groundwater collected from the Site.

A set of 12 batch jars was set up with the unsaturated Site soil to monitor the treatment of acetone and DCM, with ABC and EHC-O. A set of three column systems were set up with the saturated Site soil to evaluate the treatment of acetone and DCM with EHC and EHC-O. For both tests, controls were run parallel to the treatments. The effectiveness of these treatment systems was assessed using data collected in four sampling events over a period of 70 days.

In the unsaturated soil batch test, the results from the 70 day test revealed that the removal of acetone and DCM in the treatments and the controls was equivalent. The removal of COIs from the experimental controls presents an unrealistic and optimistic scenario. However, these data indicate that the COIs are readily biodegradable and that they can be easily removed from soil given the proper physicochemical conditions (*i.e.*, aerobic environment).

In the saturated soil column test, the COI removal was more rapid in the treatments (EHC and EHC-O) than in the control. The most effective treatment was EHC-O, based on the observation that none of the COIs were detected in the final effluent (detection limit ranged from <100 ug/L to <4 ug/L) by day 42.

Based on the laboratory data reported herein, it appears that EHC-O will facilitate the rapid and complete removal of all COIs from both the saturated and unsaturated soils. Pilot-scale field studies can be conducted to confirm these observations under actual site conditions, and to assess the constructability and cost-effectiveness of the EHC-O technology as compared to other remedial options.

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TABLES

FIGURES

1. INTRODUCTION

1.1. Project Background

Adventus was contracted by AMEC Earth & Environmental, Inc. (AMEC) to conduct a bench-scale treatability study to assess the ability of ABC, EHC-O and EHC™ to remove volatile organic compounds in soil and groundwater present at the River Street Site in Rochester, NY (the Site). ABC and EHC-O were evaluated for the treatment of the unsaturated soils and EHC and EHC-O were evaluated for the treatment of the saturated soils. This report was prepared for AMEC and presents the results and data interpretation of the bench-scale treatability study completed between March 2006 and June 2006.

1.2. Technology Background

1.2.1 ABC

Redox Tech, LLC has developed a proprietary formulation to promote anaerobic biodegradation of halogenated solvents in groundwater. The product, Anaerobic Biochem ABC®, is a patented mixture of lactates, fatty acids, and a phosphate buffer. ABC® contains soluble lactic acid as well as slow- and long-term releasing components. The phosphate buffer provides phosphates, which are a micronutrient for bioremediation. In addition, the buffer helps to maintain the pH in a range that is best suited for microbial growth. Through a license agreement provided by Envirometals and Adventus, Redox Tech is now the only licensed and approved company able to add zero valent iron to our formulation of Anaerobic BioChem. Using a GeoProbe® and proprietary injection equipment, Redox Tech is able to inject ABC® in most geologic environments, including low-permeability silt and clay. For low permeability environments, Redox Tech utilizes hydraulic fracturing.

1.2.2 EHC-O

EHC-O™ is an integrated source of slow release oxygen, major-, minor-, and micro-nutrients, and a pH buffering agent. This unique combination of materials facilitates the aerobic bioremediation of soils, sediment or groundwater environments impacted by various organic and inorganic compounds. For organic constituents amenable to aerobic biodegradation processes (e.g., petroleum hydrocarbons, certain pesticides/herbicides), EHC-O significantly stimulates the catabolic activity of the indigenous microflora, thereby accelerating the rate of contaminant removal. Native microorganisms utilize the dissolved oxygen as an electron acceptor, and the targeted contaminant serves as the electron donor resulting in its destruction.

1.2.3 EHC

Adventus has adapted its patented combination of controlled-release solid carbon and zero-valent iron (ZVI) particles to yield a material for stimulating reductive dechlorination of persistent organic solvents in groundwater and source zones. Variations of these materials have been used for the treatment of more than 800,000 tons of soils and sediments contaminated with recalcitrant; hazardous organic COIs as part of the company's DARAMEND® bioremediation technology. For groundwater applications, the materials are known as EHC™ and can be injected into the saturated zones in a variety of ways yielding *in situ* chemical reduction and accelerated anaerobic biodegradation of targeted organics.

Following placement of EHC into the saturated zone, a number of physical, chemical and microbiological processes combine to create strong reducing conditions that stimulate dechlorination of organic solvents and other recalcitrant organics (*e.g.*, perchlorate). The organic component of EHC (fibrous organic material) is nutrient rich, hydrophilic, and has high surface area; thus, it is an ideal support for growth of bacteria in the groundwater environment. As they grow on EHC particle surfaces, indigenous heterotrophic bacteria consume dissolved oxygen and thereby reduce the redox potential in groundwater.

In addition, as the bacteria grow on the organic particles they ferment carbon and release a variety of volatile fatty acids (acetic, propionic, butyric), which diffuse into the groundwater plume and serve as electron donors for other bacteria including dehalogenators and halorespiring species. The ability of the substrate to release electron donor is determined by measuring the TOC in groundwater. Finally, the small ZVI particles (*i.e.*, <50 μm diameter) provide substantial reactive surface area that stimulates direct chemical dechlorination and an additional drop in the redox potential (Eh; measured in mV) of the groundwater. Typically, ORP in the range of -500 to -600 mV can be reached, and under these extreme environments thermodynamic decomposition of constituents of interest (COI) is possible. These physical, chemical and biological processes combine to create an environment that stimulates chemical and microbiological dechlorination of solvents, defined herein as *in situ* chemical reduction, or ISCR.

The solid-phase EHC can be placed in the subsurface using a variety of techniques, each suited for the type of geology encountered, the depth of treatment zone and treatment goal among others. The granular EHC can be placed using the conventional trench approach and is applicable for treatment of shallow plumes. The powder form of EHC can be injected as a slurry (20 to 40% by wt. solids) using direct push technology in medium to fine sands and even silty sands. EHC slurry can also be injected using hydraulic and pneumatic fracturing in tighter formations. EHC-A (the aqueous form) can be injected via direct push technology as well as through standard monitoring and injection wells. Other liquid ISCR reagents are also available. The choice of injection methodology depends primarily on the formation and then on the type of EHC being recommended *(i.e.* granular, powder or liquid).

2. PROJECT OBJECTIVES AND METHODS

2.1 Project Objectives

The aim of this bench-scale feasibility study was to determine the ability of ABC, EHC-O and EHC^{TM} to treat VOCs in the soil and groundwater collected from the Site. Specific objectives included:

- to determine the ability of ABC, EHC-O, and EHC^{TM} to treat the COI to their respective treatment goals;
- to determine which of the products is the most cost efficient and effective, and determine their optimal application rates for full-scale treatment.
- to identify any adverse effects brought about by the treatment in soil or groundwater based on visual observations and laboratory analyses.

2.2 Initial Groundwater and Soil Characterization

On February 10th, 2006 Adventus received six pails (5 gallon) of groundwater and two pails of soil from the Site. All samples were placed into cold room storage upon receipt.

On February 15th, 2006 a composite sample of groundwater was submitted for volatile organic compounds (VOCs), total organic carbon (TOC), chloride (Cl), alkalinity (Alk), pH, nitrate (NO_3-N), sulfate (SO_4), total iron and dissolved iron analyses. A composite soil sample from each of the two pails (BT-2/SB-11 – Saturated; BT-3/SW Track 3 – Unsaturated) was submitted for VOC, TOC, Cl, Alk, pH, NO_3-N, SO_4, and total iron. All samples were shipped via overnight courier to Severn Trent Laboratories (STL) – Buffalo for analysis. The TOC, Cl, Alk, pH, NO_3-N, SO_4, and iron analysis were conducted to determine the baseline conditions in the soil and identify any conditions that would not be favorable to bioremediation. For example, high TOC concentration in the soil would affect the sorption and desorption of VOCs in the soil. Also, NO_3-N and SO_4 are electron acceptors and depending on their concentration they may interfere with the dechlorination process (*i.e.* compete with the COI for electrons).

The initial groundwater and soil analytical results are presented in **Tables 1** and **2**. The results from the AMEC baseline sampling are also presented for comparison. The main VOCs detected in both the saturated (BT-2/SB11) and unsaturated (BT-3/SW Track 3) soil samples were methylene chloride (DCM) and acetone. The DCM and acetone concentrations in the saturated soil sample that Adventus received were 130,000 ug/kg and 150 ug/kg, respectively. The DCM concentration in the unsaturated soil that Adventus received was 29 ug/kg and acetone was not detected (DL=28 ug/kg). No VOCs were detected in the composite groundwater sample. The acetone concentration in the saturated soil and both the DCM and acetone concentrations in the unsaturated soil were lower than expected and thus these COI were spiked in the soil as outlined in **Table 3**. The acetone and DCM concentrations in the site groundwater were also lower then expected and thus the groundwater was also spiked as outlined in **Table 3**.

The total iron concentrations in the soil samples were 13,400 ug/kg and 12,800 ug/kg in the saturated and unsaturated soils, respectively. The total and dissolved iron concentrations in the groundwater were 3.1 and 3.3 mg/L. The pH values of the saturated soil and groundwater were neutral (6.9; 7.0) and the pH of the unsaturated soil was slightly alkaline (7.96). The leachable chloride concentrations in both soil samples were lower than that in the baseline samples collected by AMEC. The chloride concentration in the groundwater was 219 mg/L. Leachable TOC and nitrate were not detected in either soil sample while the groundwater had a TOC concentration of 8.9 mg/L and nitrate was not detected (detection limit - DL = 0.050 mg/L). The groundwater had sulfate concentration of 85.2 mg/L and an alkalinity of 577 mg/L. Sulfate was not detected in the saturated (DL=134,000 ug/kg) and unsaturated (110,000 ug/kg) soil samples.

2.3 Unsaturated Soil Test Set Up

A total of four jars (500 mL, glass, with Teflon lined lid) were set up for each of the three treatments (ABC, EHC-O, control) tested, yielding a total of twelve microcosms (**Table 4, Photograph 1**). Approximately 300 g of spiked unsaturated Site soil was weighed out into each of the twelve jars. The amendments for jars 1 and 2 were added to the appropriate treatment jars to yield a loading rate of 1% for both the ABC and EHC-O substrate (the loading rate of 1% was determined to be sufficient based upon a review of baseline data and a comparison to previous experiences with other site samples). Approximately 70 mL of Site water was then added to each jar to “wet” the soil. The jars were incubated in the dark to avoid photodegradation of COIs. On April 12th (day 28), duplicate soil samples were collected from the jars labeled "A" for VOCs. On April 26th (day 42) duplicate soil samples were collected from the jars labeled "B" for VOCs. On May 10th (day 56) duplicate soil samples were collected from the jars labeled "C" for VOCs. On May 24th (day 70) duplicate soil samples were collected from the jars labeled "D" for VOCs. All samples were shipped via overnight courier to STL-Buffalo.

Photograph 1: Laboratory set up of the batch jar. 500 mL jar with 300 g of unsaturated soil.

2.4 Saturated Soil Test Set Up

On March 13th, 2006 three column systems were set up with the spiked saturated Site soil and groundwater samples. Each column was connected to three soil microcosms in series (**Photograph 2**). EHC and EHC-O treatments were evaluated for the treatment of DCM and acetone under reductive and aerobic conditions, respectively. For the EHC and EHC-O systems, the column and first two soil microcosms were amended with EHC or EHC-O at the selected application rate (**Table 5**). The amendments loading rates of 1% for EHC and 0.5% for EHC-O were determined to be sufficient based upon a review of baseline data and a comparison to previous experiences with other site samples). The third soil microcosm was filled with only spiked saturated Site soil to assess contaminant removal downstream of the EHC or EHC-O zones. The column and all three soil microcosms were filled with the spiked saturated Site soil.

Photograph 2. Laboratory set up of the columns. Each system consists of a column followed by three soil microcosms. Systems 1-3 (left to right).

The feed was prepared by transferring Site groundwater into a Tedlar bag and spiking the water with DCM and acetone. To prepare the feed for the control column, a portion of the spiked feed was transferred into a second Tedlar bag labeled as "sterile feed" and sodium azide was added to minimize microbial activity within the control system. The goal was to inhibit microbial activity, however, it is not possible to completely sterlize the soil without using an expensive and rigorous process.

The VOC-amended Site water was continuously pumped into the bottom of the column. The effluent line from the column was connected to the influent line of the first soil microcosm and the effluent from the first soil microcosm was connected to the influent line of the second soil microcosm and so forth. The final effluent was collected in an effluent reservoir. The flow rate was set to 150 mL/day.

On April 12th, 26th and May 10th, 2006 influent and effluent samples were collected from each system for VOC analyses. Effluent samples were collected from the second and third soil microcosms. The influent and final effluents were also sampled for chloride. On May 24th, effluent samples were collected from the column and each soil microcosm for VOC analysis. The influents were sampled for VOCs and chloride. The final effluent of each system was also sampled for chloride. The soil in each column was sampled in duplicate for VOCs.

After the fourth sampling event, the feed pump was turned back on and the final effluent from each system was collected for SVOCs and metals analyses. On June 5th 2006 the SVOC and metal samples were submitted and the soil in each column was sampled for SVOCs and metals.

3. RESULTS

3.1 Unsaturated Soil Test Results

The VOCs concentrations in the batch treatment jars are summarized in **Table 6**. All reported results are the average of duplicate samples collected from the same treatment jar. The complete data set is presented in **Appendices C** to **G**. The total VOC concentrations in both the treatment jars and the control were significantly lower that that of the spiked soil. The ABC treatment showed a slight decrease in total VOC from 1,243 ug/kg on day 28 to 928 ug/kg on day 42. On days 56 and 70, the total VOC concentration in the ABC jars increased to 1,164 ug/kg and 1,597 ug/kg, respectively. The EHC-O and control treatments showed an increase in total VOCs when comparing the day 28 and 42 data. On days 56, the EHC-O and control jars showed a decrease in total VOCs and then a subsequent increase on day 70. The variability in the methylene chloride and acetone concentrations in the batch jars over time are summarized in **Figures 1** and **2**.

A comparison of the metal (**Table 7**) concentrations in the unsaturated soil pre and post treatment showed that treatments had no effect on the metals present in the soil. A comparison of the SVOC concentrations on day 70 with the baseline data revealed that a decrease in the SVOC concentration was observed in both the treatments and control (**Table 8**). The EHC-O treatment supported the greatest reduction in SVOCs, followed by the ABC treatment and the control. These data might indicate the SVOCs were preferentially degraded by the soil microbes and that given a longer treatment time; the VOCs would have further degraded.

3.2 Saturated Soil Test Results

Tables 9 to **18** present the data from the flow through column systems set up with the saturated soil. The VOC concentrations for the non-sterile feed, EHC, and EHC-O treatments are summarized in **Table 9** and the data for the sterile feed and control are presented in **Table 10**. The DCM and acetone concentrations in the non-sterile feed were below their targeted concentration of 100 ug/L. In the sterile feed, the acetone was also below its targeted value; however, the DCM concentration was maintained at approximately 100 ug/L throughout the study. On day 28, higher concentrations of acetone were detected in the column system effluents, than in the feed, which indicated that acetone was partitioning into the aqueous phase from the impacted soil. During the 28 day sampling event, acetone was detected in the EHC and control systems while complete removal (DL = 50 ug/L) of acetone was observed in the EHC-O system. Lower concentrations of DCM were detected in the EHC-O and control systems on day 28, however, DCM was not detected in any system on day 42. On day 42, the EHC and EHC-O systems showed 77% and >99% reductions in total VOCs, respectively, when compared to the control. On day 56, acetone was detected in the control (150 ug/L) and was non-detect (<25 ug/L) in the EHC and EHC-O systems. During the final sampling event, acetone was not detected (<20 ug/L) in the treatment and control systems (**Figure 3**). DCM was not detected in the treatment and control systems on day 56 and trace concentrations were detected in the control (2.1 ug/L) and EHC-O (2.8 ug/L) systems on day 70 (**Figure 4**).

Toluene was detected in the EHC column during the first three sampling events. A reduction in toluene was observed on day 56 and it was not detected (<4 ug/L) on day 70 (**Figure 5**). The toluene may have been present in the soils used to set up this column (toluene was not detected in the baseline analyses of these soils, but it has been observed in other site samples). Another less likely but possible explanation is that it may have been produced from the anaerobic degradation of other constituents in the soil. In any event, it is important to note that the toluene was rapidly biodegraded during the study.

Since the dechlorination of DCM results in an increase in chloride, the chloride concentrations were also monitored in the feed and the final effluents (**Tables 9** and **10**). The chloride concentrations in the feeds on days 28 and 70 were similar to that of the initial sampling; however, on days 42 and 56 the chloride concentrations were more than double the baseline values. This large increase in chloride on days 42 and 56 can not be attributed to the dechlorination of DCM and was likely due to the soil fines that were present in those batches of Site groundwater. The chloride concentrations in the EHC, EHC-O and control systems effluents were similar to each other and may be the result of chloride leaching from the saturated soil in the columns and microcosms.

A comparison of the VOC concentrations after the second and third soil microcosms is provided in **Tables 11** to **13**. During the first sampling event, an increase in acetone was observed between the second and third soil microcosms of the EHC and control systems. During the remaining study, acetone and DCM were not detected in the effluent of the EHC system. On day 42, the control system continued to show an increase in the acetone concentration between soil microcosms two and three. This confirmed that the control was not treating acetone and that as the contact time with the soil increased, additional acetone partitioned into the water from the soil. The EHC-O system showed a decrease in both acetone and DCM between the second and third soil microcosms which indicated that further treatment of the COIs was supported downgradient of the EHC-O enriched zone.

A comparison of the VOC concentrations in the saturated soil pre and post treatment showed significant reductions in total VOCs in the treatments and control (**Table 14**). The reduction in VOCs in the soil confirmed that the COI partitioned into the aqueous phase.

The metal concentrations in the saturated soil pre and post treatment showed slight variations due to the treatments (**Table 15**). As expected, an increase in the iron concentration was observed in the EHC (16,300 mg/kg) when compared to the baseline (12,900 mg/kg) and the EHC-O (12,200 mg/kg) and control (12,000 mg/kg) treatments.

The SVOC concentrations in the saturated soil pre and post treatment are presented in **Table 16**. SVOCs were not detected in the EHC and EHC-O treatments while trace concentrations were detected in the control.

The metal concentrations in the Site groundwater pre and post treatment are presented in **Table 17**. As with the soil, an increase in the aqueous iron concentration was observed in the EHC treatment.

SVOC were not detected in the Site groundwater pre and post treatment (**Table 18**).

4. DISCUSSION

4.1 Unsaturated Soil Batch Tests

The VOC concentration data presented in **Table 6** indicate that removal in the control was equivalent to that in the treatments. This observation is likely a result of the soil preparation process, which renders the control to be a form of treatment. It should be recognized that during collection of samples at the site, homogenization of samples for baseline analyses, and spiking of the samples in preparation for the study, the soil samples are, of necessity, subjected to a fairly vigorous physical treatment. Such handling will break down stable soil structure, open fresh surface area, and release significant nutrients to the microbial population. As a result, in comparison to native undisturbed soil, the control soil will experience a sharp increase in microbial activity. In some cases (i.e., when the target compounds are recalcitrant compounds such as pesticides), such stimulation of native microbial activity will have little impact on removal. In other cases (i.e., when the target compounds are simple compounds that are readily biodegradable), soil handling can stimulate removal of target compounds in the control.

Our interpretation of the VOC data for the Batch Tests conducted on unsaturated soil is that, up to day 70, there has been equivalent removal of contaminants in the control and the treatments. If the study were to be allowed a longer run, the influence of the treatments may become apparent as the stimulation of microbial activity in the control, resulting from soil handling and preparation, would probably subside. In contrast, the influence of treatments upon contaminant removal would probably increase as microbial populations adapt to the new environment created by the treatments. It should also be noted that a 70 day study conducted at room temperature will not, in most cases, provide a full picture of the extent of contaminant removal that would be attained over a longer time period and at warmer temperatures. In general, compound removal rates will double with a 10°C increase in soil temperature between 20°C and 30°C.

It is important to recognize that the degree of compound removal observed in the Batch Test control is not likely to be predictive of natural biodegradation rates in undisturbed soil at the site, where the limitations imposed by nutrient stress would not be addressed by soil mixing, as they were in our control soil.

The SVOC contaminant concentration data presented in **Table 7** indicate that compound removal in the treatments, particularly the EHC treatment, was greater than that in the control. This observation is likely related to the fact that these compounds are less volatile and less subject to leaching than VOCs. The pattern of compound removal is also consistent with enhanced biodegradation. For example, the removal of two and three ring PAHs in the treatments is substantially greater than that in the control. This is consistent with the normal observation that concentrations of lower molecular weight PAHs will be substantially reduced before significant biodegradation of their high molecular weight counterparts is observed.

4.2 Saturated Soil Column Tests

The VOC contaminant concentration data presented in **Table 9** and **Table 10** indicate that removal was more rapid in the treatments than in the control. The most effective treatment was EHC-O, based on the observation that a non-detect level for all VOCs was achieved in the final effluent by day 42. In contrast, the control system had measurable VOC concentrations in the final effluent even at day 70.

An examination of the VOC data from sampling of effluents between the soil microcosms (jars) in each treatment system (**Tables 11, 12**, and **13**) suggests that much of the reduction observed in the control system was likely due to wash-out of contaminants with the effluent. This assumption is based on the observation that VOC concentrations in effluents of Jar 3 were consistently higher than those in the effluents from Jar 2 (i.e., the up gradient jar). In contrast, in the EHC-O system effluents from Jar 3 (the down gradient jar) consistently had lower VOC concentrations than those found in the effluents from Jar 2. Thus, it may be inferred that much of the removal of VOCs in the EHC-O system was a result of biodegradation, and not wash-out.

It should be recognized that the results of the control column study probably provide an unrealistically optimistic picture of the treatment that would be achieved at the site in the event that no treatment was applied. This assumption is based on the fact that the freshly added (spiked) VOCs that were uniformly mixed into the homogenized soil were probably more prone to migration with water moving through the columns than historic contaminants that may be trapped inside stable soil in situ at the site. This could also be true of the compound removal observed in the EHC-O column system, for the same reasons. Offsetting this, however, is the fact that the column system provides a much shorter "reactive zone" than that which would be created at the site upon injection of EHC-O. For example the total length of the oxygenated reactive zone in the column system would have been limited to less than 5 feet; while the corresponding reactive zone in situ at the site would likely be several times larger. Thus, compounds would have more time to undergo biodegradation at the site than they did in the EHC-O column system.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The primary objective of this bench-scale treatability study was to assess the ability of the ABC, EHC-O and EHC^{TM} amendments to remove volatile organic compounds in soil and groundwater present at the River Street Site in Rochester, NY (the Site). ABC and EHC-O were evaluated for the treatment of the unsaturated soils and EHC and EHC-O were evaluated for the treatment of the saturated soils. The following summary is provided based on the results presented herein:

- The initial characterization of the Site groundwater revealed that the acetone concentration in the saturated soil and both the DCM and acetone concentrations in the unsaturated soil were lower than expected, thus the Site soil was spiked with these COI to better represent the Site conditions.
- VOCs were not detected in the composite Site groundwater sample and thus DCM and acetone were spiked into the Site groundwater prior to conducting the saturated soil test.
- In the unsaturated soil test, the VOC removal in the treatments and the controls were equivalent. While not desirable, these data indicate that the COIs are readily biodegradable and that they can be easily removed from the unsaturated soil under the proper physicochemical conditions (*i.e.*, aerobic environment)
- In the saturated soil test, the VOC removal was more rapid in the treatments than in the control. The most effective treatment was EHC-O, based on the observation that a non-detect level for all VOCs was achieved in the final effluent by day 42.
- The VOC reductions observed in the controls would not be expected in the undisturbed soil present at the Site.
- The variability in the VOC data of the unsaturated soil test was likely due to the handling of the soil in preparation for the study. To eliminate the effect of the soil handling, a pilot scale test could be done to demonstrate COI removal *in situ*.
- Despite some VOC reductions in the control column of the saturated test, the EHC-O treatment provided the most effective treatment of acetone and DCM. EHC-O also provided the quickest treatment and thus represents a viable remedial option for the saturated soil.

RECOMMENDATIONS

The laboratory data reported herein are representative of those generated with samples from other sites with similar COI impacts. These data suggest that EHC-O will facilitate the rapid and complete biodegradation of all COIs from both the saturated and unsaturated soils. Pilot-scale field studies can be conducted to confirm these observations under actual site conditions, and to assess the constructability and cost-effectiveness of the EHC-O technology as compared to other remedial options.

TABLES

FINAL REPORT: ABC, EHC-O AND EHC™ TREATABILITY STUDY FOR THE TREATMENT OF VOLATILE ORGANIC COMPOUNDS IN SOIL AND GROUNDWATER FROM THE CSX TRANSPORTATION - RIVER STREET SITE IN ROCHESTER, NY (THE SITE)

Table 1: Initial VOC results in the Site soil samples

Parameter	AMEC		Adventus	AMEC		Adventus	Units
	Saturated Soil			Unsaturated Soil			
	BT-2/ SB11	**BT-2/ SB11[A]**	**BT-2/ SB11**	**BT-3/SW Track 3**	**BT-3/SW Track 3[A]**	**BT-3/SW Track 3**	
Acetone	50	61	150	40	40	ND (28)	ug/kg
Benzene	ND (6)	ND (6)	ND (7)	4[1]	4[1]	ND (6)	ug/kg
2-Butanone	11[1]	12[1]	19[1]	ND (28)	ND (27)	ND (28)	ug/kg
Carbon Disulfide	3[1]	ND (6)	6[1]	ND (6)	ND (5)	ND (6)	ug/kg
Chloromethane	1[1]	2[1]	6[1]	ND (6)	ND (5)	ND (6)	ug/kg
Cyclohexane	ND (6)	ND (6)	ND (7)	8	7	ND (6)	ug/kg
1,1-Dichloroethene	ND (6)	ND (6)	1[1]	ND (6)	ND (5)	ND (6)	ug/kg
trans-1,2-Dichloroethene	ND (6)	ND (6)	2[1]	ND (6)	ND (5)	ND (6)	ug/kg
ethylbenzene	ND (6)	ND (6)	ND (7)	2[1]	3[1]	ND (6)	ug/kg
isopropylbenzene	ND (6)	ND (6)	ND (7)	2[1]	2[1]	ND (6)	ug/kg
methylcyclohexane	ND (6)	ND (6)	ND (7)	16	14	ND (6)	ug/kg
methylene chloride	24,000[2]	22,000[2]	130,000	26	52	29	ug/kg
Toluene	ND (6)	ND (6)	ND (7)	10	9	2[1]	ug/kg
Total Xylenes	ND (18)	ND (19)	ND (20)	ND (17)	ND (16)	4[1]	ug/kg
Total VOCs	**24,065**	**22,075**	**130,184**	**108**	**131**	**35**	**ug/kg**
Total Iron	12,800	13,000	13,400	9,750	12,300	12,800	mg/kg
Leachable Chloride	799	831	90.5	45.1	84.3	ND (22.1)	ug/g
Leachable Nitrate	ND (1.3)	ND (1.3)	ND (1.3)	ND (1.1)	ND (1.1)	ND (1.1)	ug/g
Leachable Alkalinity	822	877	NS	955	772	NS	ug/g
Leachable Total Organic Carbon	28.4	28.7	ND (26.9)	43.6	36.7	ND (22.1)	ug/g
Leachable pH	7.19	7.17	6.9	8.06	8.02	7.96	pH units
Sulfate	ND (126,000)	ND (127,000)	ND (134,000)	206,000	165,000	ND (110,000)	ug//kg

[A] Duplicate sample
[1] J = estimated value; TIC; or result is less than quantitation limit but greater than zero
[2] E = concentration exceeds calibration range of the instrument
ND = non detect (detection limit); NS = not sampled

Table 2: Initial VOC results in the Site groundwater samples

Parameter	AMEC		Adventus	Units
	BT-1	BT-1[A]	Composite	
Acetone	4.5[1]	3.2[1]	ND (5)	ug/L
Benzene	ND (1)	ND (1)	ND (1)	ug/L
2-Butanone	ND (5)	ND (5)	ND (5)	ug/L
Carbon Disulfide	ND (1)	ND (1)	ND (1)	ug/L
Chloromethane	ND (1)	ND (1)	ND (1)	ug/L
Cyclohexane	ND (1)	ND (1)	ND (1)	ug/L
1,1-Dichloroethene	ND (1)	ND (1)	ND (1)	ug/L
trans-1,2-Dichloroethene	ND (1)	ND (1)	ND (1)	ug/L
ethylbenzene	ND (1)	ND (1)	ND (1)	ug/L
isopropylbenzene	ND (1)	ND (1)	ND (1)	ug/L
methylcyclohexane	ND (1)	ND (1)	ND (1)	ug/L
methylene chloride	ND (1)	ND (1)	ND (1)	ug/L
Toluene	ND (1)	ND (1)	ND (1)	ug/L
Total Xylenes	ND (3)	ND (3)	ND (3)	ug/L
Total VOCs	**4.5**	**3.2**	**ND (5)**	**ug/L**
Total Iron	30.8	27.60	3.1	mg/L
Dissolved Iron	34.5	25.8	3.3	mg/L
Chloride	294	294	219	mg/L
Nitrate	ND (0.05)	ND (0.05)	ND (0.050)	mg/L
Redox Potential	244	254	NS	mV
Sulfate	91.3	92.7	85.2	mg/L
Total Alkalinity	526	531	577	mg/L
TOC	6.2	6.3	8.9	mg/L
pH	7.07	7.06	7.0	pH units

[A] Duplicate sample

[1] J=estimated value; TIC; or result is less than quantitation limit but greater than zero

ND = non detect (detection limit)

NS = not sampled

Table 3: Table 3 – Target VOC concentrations in the Site soil and groundwater samples

Parameter	Methylene Chloride			Acetone			Units
	Initial	Target	After Spiking	Initial	Target	After Spiking	
Saturated Soil (BT-2/ SB11)	130,000	19,000	18,000	150	78,000	190,000	ug/kg
Unsaturated Soil (BT-3/SW Track 3)	29	8,000	1,000	ND (28)	9,000	4,700	ug/kg
Groundwater	ND (1)	100	NS	ND (5)	100	NS	ug/L

ND = Non detect (detection limit)
NS = not sampled

Table 4: Summary of batch jars set up

Jar ID	Treatment	Application Rate[1] (%)
1A, 1B, 1C, 1D	ABC	1
2A, 2B, 2C, 2D	EHC-O	1
3A, 3B, 3C, 3D	None - Control	0

[1] Based on soil weight

Table 5: Summary of column systems

System #	Treatment Material	Application Rate[1] (%)
1	EHC	1
2	EHC-O	0.5
3	None - Control	0

[1] Based on a standard dry bulk density of 1.77 g/mL

Table 6: Influence of ABC and EHC-O on VOCs concentrations in the unsaturated soil

Parameter	Units	Initial Spiked Soil	ABC[1]				EHC-O[1]				Control[1]			
			Day 28	Day 42	Day 56	Day 70	Day 28	Day 42	Day 56	Day 70	Day 28	Day 42	Day 56	Day 70
Acetone	ug/kg	4,700	1,010[3]	745	875	1,300	655[3]	960	530	830	670[3]	1,050	470	695
Benzene	ug/kg	ND (6)	3[2]	3[2]	4.5[2]	4.5[2]	ND (7)	2[2]	ND (7)	1.5[2]	ND (6)	ND (6)	ND (7)	2[2]
2-Butanone	ug/kg	ND (28)	24[2]	28[2]	33[2]	39.5	4[2]	9[2]	ND (36)	ND (35)	ND (32)	ND (32)	ND (33)	ND (34)
Carbon Disulfide	ug/kg	ND (6)	ND (8)	ND(6)	ND (7)	ND (7)	2[2]	3.5[2]	2.5[2]	2.5[2]	ND (6)	ND (6)	ND (7)	ND (7)
Chloromethane	ug/kg	ND (6)	ND (8)	1.5[2]	8	25.5	ND (7)	ND (7)	ND (7)	ND (7)	ND (6)	ND (6)	ND (7)	ND (7)
Cyclohexane	ug/kg	2	15	11	20.5	18	4[2]	9	5.5[2]	5[2]	4[2]	14	5[2]	8
Ethylbenzene	ug/kg	ND (6)	3[2]	2[2]	4.5[2]	3	ND (7)	ND (7)	ND (7)	ND (7)	ND (6)	ND (6)	ND (7)	ND (7)
Isopropylbenzene	ug/kg	ND (6)	2.5[2]	1.5[2]	3.5[2]	2.5	ND (7)	ND (7)	ND (7)	ND (7)	ND (6)	ND (6)	ND (7)	ND (7)
Methylcyclohexane	ug/kg	4	24	21	36	31.5	5[2]	20	9.5	8	5.5	29.5	7	12
Methylene Chloride	ug/kg	1,000	130[3]	97	135[3]	140	115[3]	135	125[3]	125[3]	120[3]	140	120[3]	160
Toluene	ug/kg	2	9	6	13.5[3]	11	2[2]	3.5[2]	3.5[3]	3.0[2]	2[2]	ND (6)	3[3]	4
Total Xylenes	ug/kg	5	22[2]	13[2]	30.5	21	4[2]	8.5[2]	9.5[2]	5.0[2]	4[2]	ND (19)	8[2]	7
TOTAL VOC	**ug/kg**	**5,713**	**1,243**	**929**	**1,164**	**1,597**	**791**	**1,151**	**686**	**980**	**806**	**1,234**	**613**	**887**

[1] Average of duplicate samples

[2] J = estimated value; TIC; or result is less than quantitation limit but greater than zero

[3] B = analyte found in associated blank as well as sample

ND = non detect (detection limit)

Table 7: Comparison of metal concentrations in the unsaturated soil pre and post treatment

Parameter	**Units**	**BT-3/SWTrack3 (unsaturated soil)**			
		Baseline	**Post Treatment[1]**		
			ABC	**EHC-O**	**CONTROL**
Aluminum	mg/kg	3,650	3,840	4,220	4,370
Antimony	mg/kg	ND (16.7)	ND (18.6)	ND (20.0)	ND (19.2)
Arsenic	mg/kg	10	9.5	9.7	12.0
Barium	mg/kg	55	54.2	52.4	91.5
Beryllium	mg/kg	0.61	0.58	0.60	0.73
Cadmium	mg/kg	ND (0.23)	0.24	0.32	0.85
Calcium	mg/kg	57,600	73,550	79,350	84,150
Chromium	mg/kg	9	7.9	8.6	8.1
Cobalt	mg/kg	3	2.3	2.7	2.7
Copper	mg/kg	34	30.5	37.4	35.6
Iron	mg/kg	11,025	10,600	12,100	12,100
Lead	mg/kg	46	41.2	47.1	45.6
Magnesium	mg/kg	16,250	39,100	24,000	16,700
Manganese	mg/kg	226	266	277	338
Mercury	mg/kg	0.069	0.056	0.060	0.048
Nickel	mg/kg	8	6.7	7.9	8.2
Potassium	mg/kg	608	860	744	917
Selenium	mg/kg	ND (4.6)	ND (4.9)	ND (5.3)	ND (5.1)
Silver	mg/kg	ND (0.57)	ND (0.62)	ND (0.66)	ND (0.64)
Sodium	mg/kg	349	778	356	402
Thallium	mg/kg	ND (6.9)	ND (7.4)	ND (8.0)	ND (7.7)
Vanadium	mg/kg	8	7.7	7.6	8.9
Zinc	mg/kg	69	52.2	60.2	81.9

[1] Average of duplicate samples

Table 8: Comparison of SVOC concentrations in the unsaturated soil pre and post treatment

Parameter	Units	BT-3/SWTrack3 (unsaturated soil)			
		Baseline	Post Treatment[1]		
			ABC	EHC-O	CONTROL
Acenaphthene	ug/kg	22,000	9,200	8,800	13,500
Acenaphthylene	ug/kg	5,850	2,400[2]	2,400[2]	4,150[2]
Acetophenone	ug/kg	290	ND (2,200)	ND (4,200)	ND (4,100)
Anthracene	ug/kg	20,500	7,000	7,100	11,750
Benzo(a)anthracene	ug/kg	14,000	5,500	5,750	9,100
Benzo(b)fluoranthene	ug/kg	17,000	7,200	8,600	11,500
Benzo(k)fluoranthene	ug/kg	17,000	5,300[2]	8,700	2,950[2]
Benzo(ghi)perylene	ug/kg	3,600	2,100[2]	1,950[2]	3,100[2]
Benzo(a)pyrene	ug/kg	9,600	4,450	4,550	7,500
Benzoic Acid	ug/kg	4,850	28,500	ND (61,000)	ND (60,000)
Biphenyl	ug/kg	3,350	2,050[1]	2,100[2]	2,850[2]
Bis(2-ethylhexyl)phthalate	ug/kg	1,045	570[2]	710[2]	800[2]
Caprolactam	ug/kg	490	ND (2,200)	ND (4,200)	ND (4,100)
Chrysene	ug/kg	13,000	5,100	5,300	8,900
Dibenzo(a,h)anthracene	ug/kg	1,350	760[2]	735[2]	1,150[2]
Dibenzofuran	ug/kg	22,500	9,900	10,200	14,000
2,4-Dimethylphenol	ug/kg	230	ND (2,200)	ND (4,200)	ND (4,100)
Fluoranthene	ug/kg	48,500	17,000	18,500	29,500
Fluorene	ug/kg	30,500	12,000	11,100	18,000
Indeno(1,2,3-cd)pyrene	ug/kg	3,450	2,000	1,900[2]	3,100[2]
2-Methylnaphthalene	ug/kg	27,500	11,000	11,500	15,000
2-Methylphenol	ug/kg	ND (360)	ND (2,200)	ND (4,200)	ND (4,100)
4-Methylphenol	ug/kg	150	ND (1,700)	ND (4,200)	ND (4,100)
Naphthalene	ug/kg	66,500	22,500[3]	23,000[3]	28,500[3]
Phenanthrene	ug/kg	88,000	28,000	29,000	43,500
Pyrene	ug/kg	32,500	10,500	11,000	17,500
TOTAL SVOC	**ug/kg**	**453,799**	**193,030**	**172,895**	**246,350**

[1] Average of duplicate samples; [2]J = estimated value; TIC; or result is less than quantitation limit but greater than zero
[3]B = analyte found in associated blank as well as sample; ND = non detect (detection limit)

Table 9: Influence of EHC and EHC-O on VOCs and chloride concentrations in the final effluent

Parameter	**Units**	**Feed**				**EHC**				**EHC-O**			
		Day 28	**Day 42**	**Day 56**	**Day 70**	**Day 28**	**Day 42**	**Day 56**	**Day 70**	**Day 28**	**Day 42**	**Day 56**	**Day 70**
Chloride	mg/L	186	536	586	151	601	424	480	373	771	416	433	446
Acetone	ug/L	30	ND (5)	ND (5)	ND (5)	39,000	ND (100)	ND (25)	ND (20)	ND (50)	ND (50)	ND (25)	ND (20)
2-Butanone	ug/L	ND (5)	ND (5)	ND (5)	ND (5)	260	ND (100)	ND (25)	ND (20)	ND (50)	ND (50)	ND (25)	ND (20)
1,2-Dichloroethane	ug/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (10)	ND (20)	ND (5)	ND (4)	ND (10)	ND (10)	ND (5)	ND (4)
Ethylbenzene	ug/L	ND (1)	ND (1)	ND (1)	ND (1)	11	16[1]	3.4[1]	ND (4)	ND (10)	ND (10)	ND (5)	ND (4)
Methylene Chloride	ug/L	54	80	ND (1)	ND (1)	ND (10)	ND (20)	ND (5)	ND (4)	20	ND (10)	ND (5)	2.8
Toluene	ug/L	ND (1)	ND (1)	ND (1)	ND (1)	1,300	1,500	260	ND (4)	ND (10)	ND (10)	ND (5)	ND (4)
TOTAL VOC	**ug/L**	**84**	**80**	**ND (5)**	**ND (5)**	**40,571**	**1,516**	**263**	**ND (20)**	**20**	**ND (10)**	**ND (25)**	**2.8**

[1] J = estimated value; TIC; or result is less than quantitation limit but greater than zero
ND = non detect (detection limit)

Table 10: VOCs and chloride concentrations in the sterile feed and final effluent of the control

Parameter	Units	Sterile Feed				Control			
		Day 28	Day 42	Day 56	Day 70	Day 28	Day 42	Day 56	Day 70
Chloride	mg/L	184	548	583	168	614	416	463	392
Acetone	ug/L	26	3.2[1]	ND (5)	ND (10)	25,000	6,500	150	ND (20)
2-Butanone	ug/L	ND (5)	ND (5)	ND (5)	ND (10)	ND (50)	ND (100)	ND (25)	ND (20)
1,2-Dichloroethane	ug/L	ND (1)	ND (20)	ND (1)	ND (2)	ND (10)	ND (20)	3.9[1]	3.5
Ethylbenzene	ug/L	ND (1)	ND (1)	ND (1)	ND (2)	ND (10)	ND (20)	ND (5)	ND (4)
Methylene Chloride	ug/L	97	120	110	120	110	ND (20)	ND (5)	2.1
Toluene	ug/L	ND (1)	ND (1)	ND (1)	ND (2)	ND (10)	ND (20)	ND (50)	ND (4)
TOTAL VOC	**ug/L**	**123**	**123**	**110**	**120**	**25,110**	**6,500**	**154**	**5.6**

[1] J = estimated value; TIC; or result is less than quantitation limit but greater than zero
ND = non detect (detection limit)

Table 11: Influence of EHC on VOC concentrations in the effluents of soil microcosms 2 and 3

Parameter	Units	Day 28		Day 42		Day 56		Day 70	
		EHC Soil Jar 2	EHC Soil Jar 3	EHC Soil Jar 2	EHC Soil Jar 3	EHC Soil Jar 2	EHC Soil Jar 3	EHC Soil Jar 2	EHC Soil Jar 3
Acetone	ug/L	21,000	39,000	ND (100)	ND (100)	ND (50)	ND (25)	ND (20)	ND (20)
2-Butanone	ug/L	160	260	ND (100)	ND (100)	ND (50)	ND (25)	ND (20)	ND (20)
1,2-Dichloroethane	ug/L	ND (10)	ND (10)	ND (20)	ND (20)	ND (10)	ND (5)	ND (4)	ND (4)
Ethylbenzene	ug/L	ND (10)	11	ND (20)	16[1]	ND (10)	3.4	ND (4)	ND (4)
Methylene Chloride	ug/L	ND (10)	ND (10)	ND (20)	ND (20)	5.2[1]	ND (5)	ND (4)	ND (4)
Toluene	ug/L	740	1,300	1,100	1,500	620	260	ND (4)	ND (4)
TOTAL VOC	**ug/L**	**21,900**	**40,571**	**1,100**	**1,516**	**625**	**263**	**ND (20)**	**ND (20)**

[1] J = estimated value; TIC; or result is less than quantitation limit but greater than zero
ND = non detect (detection limit)

Table 12: Influence of EHC-O on VOC concentrations in the effluents of soil microcosms 2 and 3

Parameter	Units	Day 28		Day 42		Day 56		Day 70	
		EHC-O Soil Jar 2	EHC-O Soil Jar 3	EHC-O Soil Jar 2	EHC-O Soil Jar 3	EHC-O Soil Jar 2	EHC-O Soil Jar 3	EHC-O Soil Jar 2	EHC-O Soil Jar 3
Acetone	ug/L	11,000	ND (50)	1,600	ND (50)	56	ND (25)	ND (20)	ND (20)
2-Butanone	ug/L	ND (50)	ND (50)	ND (100)	ND (50)	ND (25)	ND (25)	ND (20)	ND (20)
1,2-Dichloroethane	ug/L	ND (10)	ND (10)	ND (20)	ND (10)	ND (5)	ND (5)	ND (4)	ND (4)
Ethylbenzene	ug/L	ND (10)	ND (10)	ND (20)	ND (10)	ND (5)	ND (5)	ND (4)	ND (4)
Methylene Chloride	ug/L	1,800	20	1,400	ND (10)	170	ND (5)	120	2.8
Toluene	ug/L	ND (10)	ND (10)	ND (20)	ND (10)	ND (5)	ND (5)	ND (4)	ND (4)
TOTAL VOC	**ug/L**	**12,800**	**20**	**3,000**	**ND (50)**	**226**	**ND (25)**	**120**	**2.8**

[1] J = estimated value; TIC; or result is less than quantitation limit but greater than zero
ND = non detect (detection limit)

Table 13: VOCs concentrations in the control effluent of soil microcosms 2 and 3

Parameter	Units	Day 28		Day 42		Day 56		Day 70	
		Control Soil Jar 2	Control Soil Jar 3	Control Soil Jar 2	Control Soil Jar 3	Control Soil Jar 2	Control Soil Jar 3	Control Soil Jar 2	Control Soil Jar 3
Acetone	ug/L	310	25,000	1,200	6,500	ND (25)	150	ND (20)	ND (20)
2-Butanone	ug/L	ND (50)	ND (50)	ND (50)	ND (100)	ND (25)	ND (25)	ND (20)	ND (20)
1,2-Dichloroethane	ug/L	ND (10)	ND (10)	ND (10)	ND (20)	3.2	3.9	2.9[1]	3.5[1]
Ethylbenzene	ug/L	ND (10)	ND (10)	ND (10)	ND (20)	ND (5)	ND (5)	ND (4)	ND (4)
Methylene Chloride	ug/L	14	110	ND (10)	ND (20)	2.8[1]	ND (5)	ND (4)	2.1
Toluene	ug/L	ND (10)	ND (10)	ND (10)	ND (20)	ND (5)	ND (50)	ND (4)	ND (4)
TOTAL VOC	**ug/L**	**324**	**25,110**	**1,200**	**6,500**	**6.0**	**154**	**2.9**	**5.6**

[1] J = estimated value; TIC; or result is less than quantitation limit but greater than zero
ND = non detect (detection limit)

Table 14: Comparison of VOC concentrations in the saturated soil pre and post treatment

Parameter	Units	BT-2/SB-11 (saturated soil)			
		Baseline	Post Treatment		
			EHC	EHC-O	CONTROL
Acetone	mg/kg	190,000	34.5	45.5	38
Benzene	mg/kg	ND (6)	1[2]	1[2]	1[2]
2-Butanone	mg/kg	5	7[2]	7[2]	8[2]
Carbon Disulfide	mg/kg	2	1.45[2]	1.4[2]	2[2]
Chloromethane	mg/kg	ND (6)	ND (3)	ND (5)	ND (4)
Cyclohexane	mg/kg	ND (6)	4.5	6	6
Ethylbenzene	mg/kg	ND (6)	ND (3)	ND (5)	ND (4)
Isopropylbenzene	mg/kg	ND (6)	ND (3)	ND (5)	ND (4)
Methylcyclohexane	mg/kg	ND (6)	5.5	7.5	7
Methylene Chloride	mg/kg	18,000	20[3]	23[3]	25[3]
Toluene	mg/kg	ND (6)	3[2]	3[2]	2[2]
Total Xylenes	mg/kg	ND (19)	ND (8)	ND (14)	ND (6)
TOTAL VOC	**mg/kg**	**208,007**	**77.0**	**94.4**	**88.7**

[1] Average of duplicate jars;

[2] J = estimated value; TIC; or result is less than quantitation limit but greater than zero

[3] B = analyte found in associated blank as well as sample; ND = non detect (detection limit)

Table 15: Comparison of metal concentrations in the saturated soil pre and post treatment

Parameter	Units	BT-2/SB-11 (saturated soil)			
		Baseline	Post Treatment		
			EHC	EHC-O	CONTROL
Aluminum	mg/kg	6,215	5,920	5,810	6,120
Antimony	mg/kg	ND (19)	ND (18)	ND (18.1)	ND (17.3)
Arsenic	mg/kg	4	3.1	2.7	3.3
Barium	mg/kg	34	32.7	33.7	31.8
Beryllium	mg/kg	0.335	0.28	0.29	0.28
Cadmium	mg/kg	ND (0.25)	ND (0.24)	ND (0.24)	ND (0.23)
Calcium	mg/kg	19,700	25,900	26,700	23,700
Chromium	mg/kg	9	13.7	8.6	8.5
Cobalt	mg/kg	6	6.8	5.6	5.7
Copper	mg/kg	14	16.8	14.5	14.3
Iron	mg/kg	12,900	16,300	12,200	12,000
Lead	mg/kg	14	8.6	8.9	9.7
Magnesium	mg/kg	6,560	8,340	8,280	8,060
Manganese	mg/kg	338	336	363	389
Mercury	mg/kg	0.059	ND (0.023)	ND (0.027)	ND (0.027)
Nickel	mg/kg	14	15.7	12.7	13.1
Potassium	mg/kg	859	1,050	1,000	1,060
Selenium	mg/kg	ND (5.1)	ND (4.8)	ND (4.8)	ND (4.6)
Silver	mg/kg	ND (0.63)	ND (0.60)	ND (0.60)	ND (0.58)
Sodium	mg/kg	ND (178)	ND (168)	ND (169)	ND (161)
Thallium	mg/kg	ND (7.6)	ND (7.2)	ND (7.2)	ND (6.9)
Vanadium	mg/kg	10	16.9	10.8	11.2
Zinc	mg/kg	37	36.1	34.1	34.7

Table 16: Comparison of SVOC concentrations in the saturated soil pre and post treatment

Parameter	**Units**	**BT-2/SB-11 (saturated soil)**			
		Baseline	**Post Treatment**		
			EHC	**EHC-O**	**CONTROL**
Acenaphthene	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Acenaphthylene	ug/kg	81	ND (400)	ND (410)	ND (420)
Acetophenone	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Anthracene	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Benzo(a)anthracene	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Benzo(b)fluoranthene	ug/kg	ND (420)	ND (400)	ND (410)	45
Benzo(k)fluoranthene	ug/kg	ND (420)	ND (400)	ND (410)	47
Benzo(ghi)perylene	ug/kg	ND (420)	ND (400)	ND (410)	32
Benzo(a)pyrene	ug/kg	ND (420)	ND (400)	ND (410)	24
Benzoic Acid	ug/kg	ND (6,100)	ND (5,800)	ND (6,000)	ND (6,000)
Biphenyl	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Bis(2-ethylhexyl)phthalate	ug/kg	49	ND (400)	ND (410)	ND (420)
Caprolactam	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Chrysene	ug/kg	ND (420)	ND (400)	ND (410)	22
Dibenzo(a,h)anthracene	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Dibenzofuran	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
2,4-Dimethylphenol	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Fluoranthene	ug/kg	ND (420)	ND (400)	ND (410)	33
Fluorene	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Indeno(1,2,3-cd)pyrene	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
2-Methylnaphthalene	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
2-Methylphenol	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
4-Methylphenol	ug/kg	33	ND (400)	ND (410)	ND (420)
Naphthalene	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Phenanthrene	ug/kg	ND (420)	ND (400)	ND (410)	ND (420)
Pyrene	ug/kg	ND (420)	ND (400)	ND (410)	32
TOTAL SVOC	**ug/kg**	**162**	**ND (5,800)**	**ND (6,000)**	**235**

[1] J = estimated value; TIC; or result is less than quantitation limit but greater than zero
ND = non detect (detection limit)

Table 17: Comparison of metal concentrations in the groundwater pre and post treatment

Parameter	**Units**	**BT-1 Groundwater**			
		Baseline	**Post Treatment**		
			EHC	**EHC-O**	**CONTROL**
Aluminum	mg/L	0.67	0.77	ND (0.20)	ND (0.20)
Antimony	mg/L	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
Arsenic	mg/L	0.029	ND (0.010)	ND (0.010)	ND (0.010)
Barium	mg/L	0.4	0.28	0.092	0.23
Beryllium	mg/L	ND (0.0020)	ND (0.0020)	ND (0.0020)	ND (0.0020)
Cadmium	mg/L	0.0068	ND (0.0010)	ND (0.0010)	ND (0.0010)
Calcium	mg/L	213.5	193	190	227
Chromium	mg/L	ND (0.0040)	ND (0.0040)	ND (0.0040)	ND (0.0040)
Cobalt	mg/L	ND (0.0040)	ND (0.0040)	ND (0.0040)	ND (0.0040)
Copper	mg/L	ND (0.0100)	ND (0.010)	ND (0.010)	ND (0.010)
Iron	mg/L	29.2	43.8	1.0	2.4
Lead	mg/L	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Magnesium	mg/L	58.85	43.5	22.7	47.4
Manganese	mg/L	2.1	0.9	0.4	2.4
Mercury	mg/L	ND (0.00020)	ND (0.00020)	ND (0.00020)	ND (0.00020)
Nickel	mg/L	ND (0.010)	ND (0.010)	ND (0.010)	ND (0.010)
Potassium	mg/L	7.9	15.1	7.1	10.1
Selenium	mg/L	ND (0.015)	ND (0.015)	ND (0.015)	ND (0.015)
Silver	mg/L	ND (0.0030)	ND (0.0030)	ND (0.0030)	ND (0.0030)
Sodium	mg/L	106.5	93.8	111	107
Thallium	mg/L	ND (0.020)	ND (0.020)	ND (0.020)	ND (0.020)
Vanadium	mg/L	ND (0.0050)	ND (0.0050)	ND (0.0050)	ND (0.0050)
Zinc	mg/L	ND (0.020)	ND (0.010)	ND (0.010)	ND (0.010)

ND = non detect (detection limit)

Table 18: Comparison of SVOC concentrations in the groundwater pre and post treatment

Parameter	**Units**	**BT-1 Groundwater**			
		Baseline	**Post Treatment**		
			EHC	**EHC-O**	**CONTROL**
Acenaphtene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Acenaphthylene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Acetophenone	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Anthracene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Benzo(a)anthracene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Benzo(b)fluoranthene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Benzo(k)fluoranthene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Benzo(ghi)perylene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Benzo(a)pyrene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Benzoic Acid	ug/L	ND (150)	ND (140)	ND (150)	ND (150)
Biphenyl	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Bis(2-ethylhexyl)phthalate	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Caprolactam	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Chrysene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Dibenzo(a,h)anthracene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Dibenzofuran	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
2,4-Dimethylphenol	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Fluoranthene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Fluorene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Indeno(1,2,3-cd)pyrene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
2-Methylnaphthalene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
2-Methylphenol	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
3 & 4-Methylphenol	ug/L	ND (20)	ND (19)	ND (20)	ND (20)
Naphthalene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Phenanthrene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Pyrene	ug/L	ND (10)	ND (10)	ND (10)	ND (10)
Total SVOCs	**ug/L**	**ND (150)**	**ND (140)**	**ND (150)**	**ND (150)**

ND = non detect (detection limit)

FIGURES

FINAL REPORT: ABC, EHC-O AND EHC™
TREATABILITY STUDY FOR THE TREATMENT OF
VOLATILE ORGANIC COMPOUNDS IN SOIL AND
GROUNDWATER FROM THE CSX
TRANSPORTATION - RIVER STREET SITE IN
ROCHESTER, NY (THE SITE)

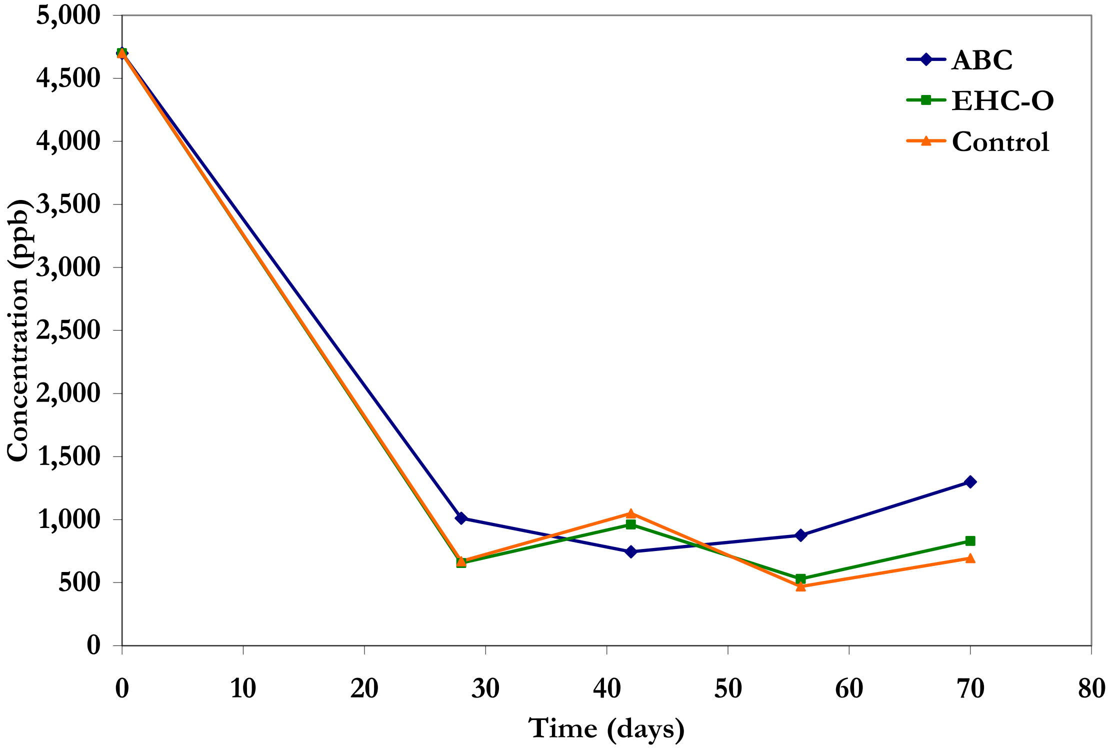

Figure 1: Influence of ABC and EHC-O on acetone concentrations in the unsaturated soil

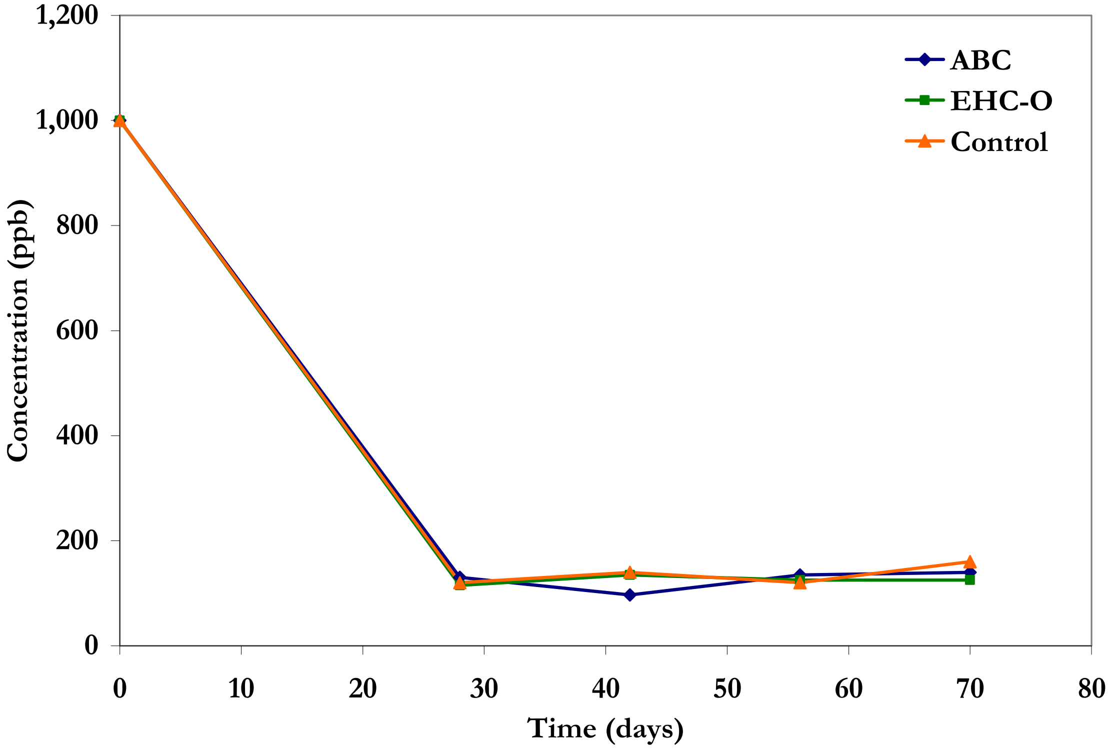

Figure 2: Influence of ABC and EHC-O on DCM concentrations in the unsaturated soil

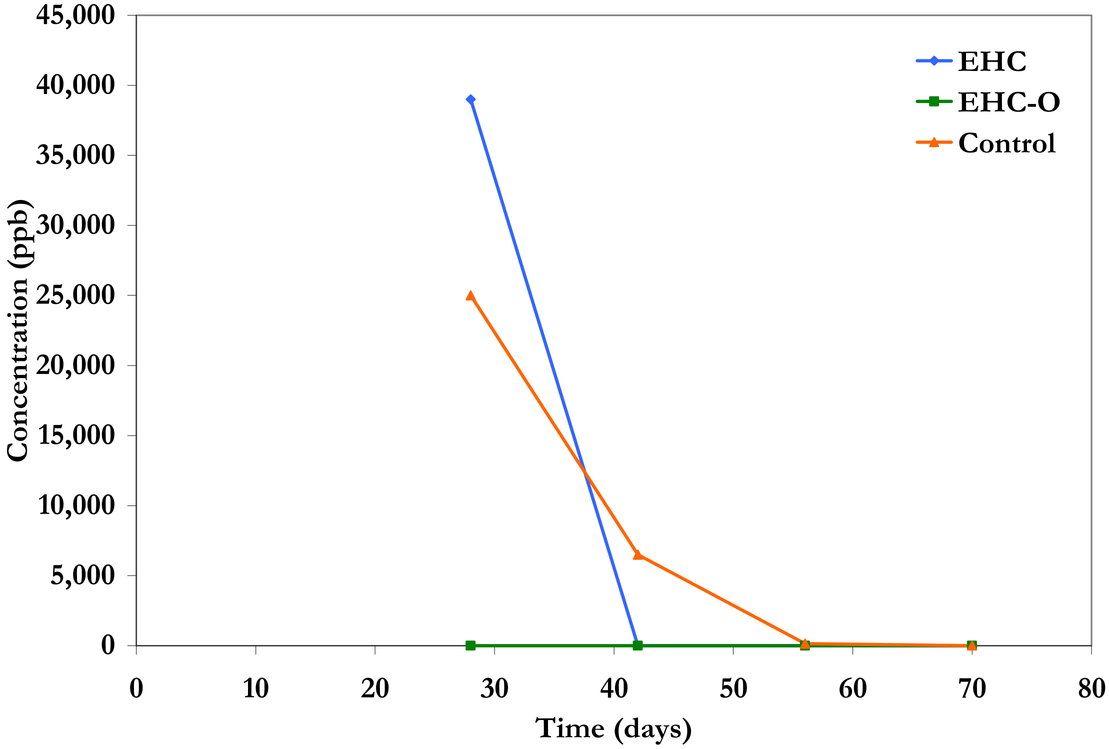

Figure 3: Influence of EHC and EHC-O on acetone concentrations in the saturated soil

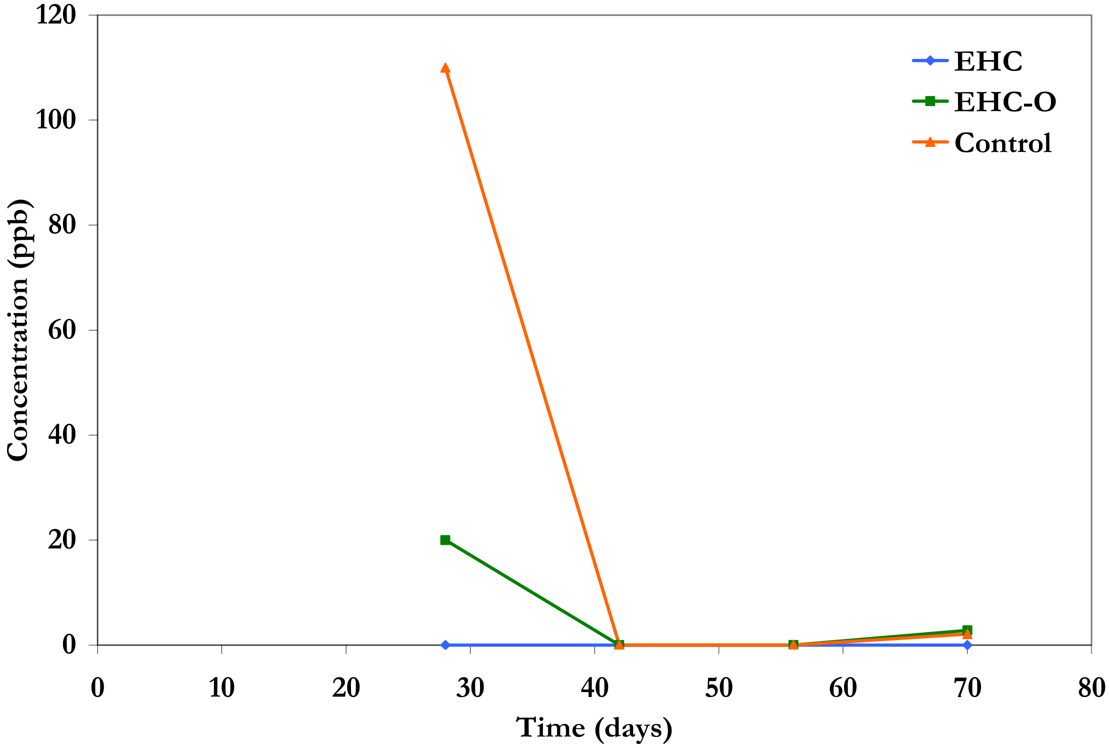

Figure 4: Influence of EHC and EHC-O on DCM concentrations in the saturated soil

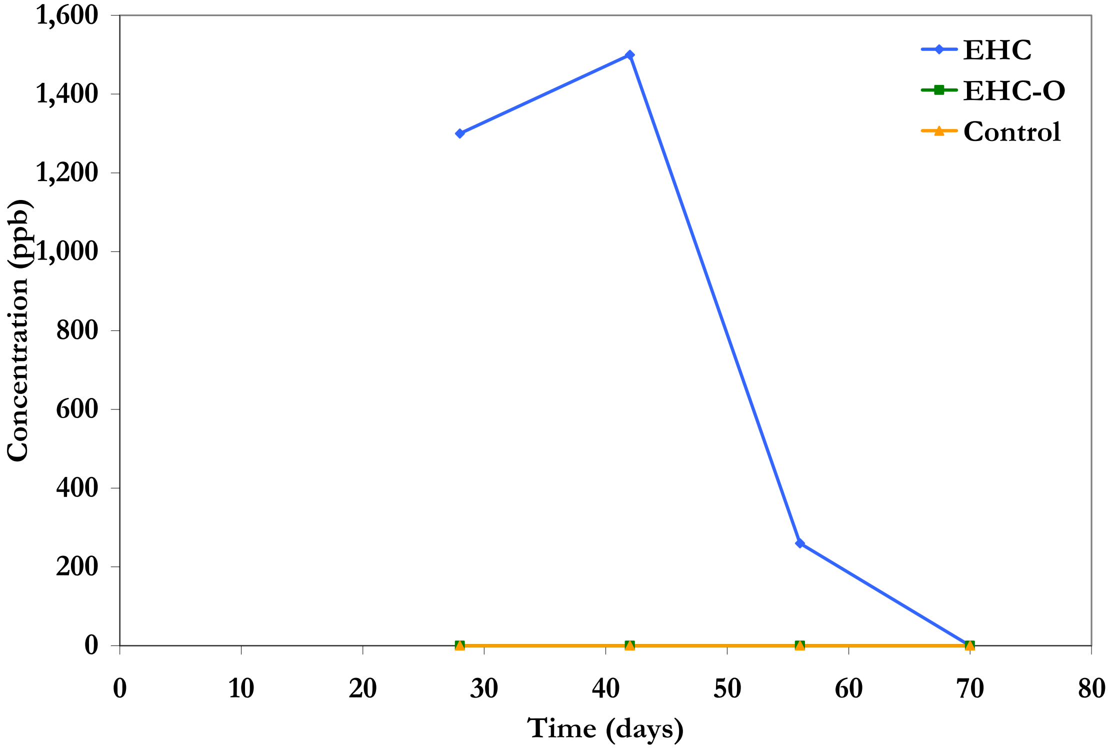

Figure 5: Influence of EHC on toluene concentrations in the saturated soil

MSDS SHEETS

EHC and EHC-O

ADVENTUS
REMEDIATION TECHNOLOGIES

Safety Data

MATERIAL SAFETY DATA SHEET: **EHC™ 2007Fe50**

1. PRODUCT IDENTIFICATION:

PRODUCT IDENTIFICATION:	EHC™ 2007Fe50
PRODUCT USE:	Bioremediation product for the remediation of contaminated soil and groundwater only. Not for use in potable drinking water.

MANUFACTURER:

Adventus Remediation Technologies
1345 Fewster Drive
Mississauga, Ontario
L4W 2A5

EMERGENCY PHONE:

Office Hours: 905-273-5374
After Hours: 416-457-9491

TRANSPORTATION OF DANGEROUS GOOD CLASSIFICATION:
Not Regulated

WHMIS CLASSIFICATION:
Not Regulated

2. INGREDIENTS

CHEMICAL NAME:	CAS#	TLV (mg/m3)	LD low (mg/Kg)
Organic Amendment	N/D	N/E	N/E
Iron	1309-37-1	5 (as iron oxide fume)	N/E
Carbon	1333-86-4	3.5 (as carbon black)	N/E
Silicon	7440-21-3	5	N/E

3. PHYSICAL DATA

Physical state	Solid	Melting point	1371-1480°F
Odour threshold	N/A	Boiling point	3000°C
Density	0.75 Kg/L	Vapour pressure (mm Hg)	1 @ 1787°C
pH	N/A	Vapour density (air=1)	N/A
Solubility in water	Insoluble	Evaporation rate	N/A
Coeff. of water/oil	N/A		
Appearance & odour	Odourless, Tan/Brown Flakes		

4. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Deg. C PMCC): N/A

	LOWER	UPPER
FLAMMABLE LIMITS IN AIR % BY VOLUME:	N/A	N/A
AUTO IGNITION TEMP (Deg. C):	N/A	

EXTINGUISHING MEDIA: Dry chemicals or sand or universal type foam.

SPECIAL PROCEDURES:
Firefighters should wear SCBA and protective clothing.

UNUSUAL FIRE AND EXPLOSION HAZARDS:

Dust can present fire and explosion hazards when exposed to fire, chemical reaction, or contact with powerful oxidizers.

5. REACTIVITY DATA

STABILITY (NORMAL COND.):
Stable: X **Unstable:**

CONDITIONS TO AVOID:	Contact with powerful oxidizers such as strong acids.
INCOMPATIBILITY (Materials to Avoid):	Powerful oxidizers such as strong acids.
HAZARDOUS DECOMPOSITION PRODUCTS:	Hydrogen, Carbon monoxide, Carbon dioxide.

6. TOXICOLOGICAL PROPERTIES

ROUTE OF ENTRY:
Inhalation
Ingestion (not likely)

HEALTH HAZARDS:

Acute overexposure may cause eye, nose, mouth and skin irritation.

Carcinogenicity:	No Information Available
Signs and Symptoms of Exposure:	No Information Available
Medical Conditions Generally Aggravated by Exposure:	No Information Available

7. PREVENTIVE MEASURES

PERSONAL PROTECTIVE EQUIPMENT:

Eye Protection: X **Gloves:** X **Clothing:**

RESPIRATORY PROTECTION:
Use dust mask in severe conditions.
Use good housekeeping practices to keep dust to a minimum.

VENTILATION REQUIREMENTS:
Not normally required.

SPILL AND LEAK PROCEDURES:
Sweep up and return to container.

WASTE DISPOSAL:
Sanitary landfill. Follow Federal, State and Local guidelines.

HANDLING PROCEDURES:
Wear safety glasses for normal use. Avoid generating excessive dust, wear dust mask in severe conditions.

STORAGE REQUIREMENTS:
Do not store near powerful oxidizers such as strong acids. Keep dry.

SPECIAL HANDLING INFORMATION:
Treat as a nuisance dust

8. FIRST AID MEASURES

INHALATION: Remove to fresh air. Seek medical attention.
INGESTION: Seek medical attention.
SKIN CONTACT: Brush off excess. Wash with soap and water.
EYE CONTACT: Flush with running water. Seek medical attention.

9. OTHER INFORMATION

None

10. PREPARATION INFORMATION

Prepared By: Adventus Remediation Technologies
1345 Fewster Drive
Mississauga, Ontario
L4W 2A5

Date Prep./Rev.: 9/15/04
Print Date: 9/15/04
Phone: 905-273-5374
Fax: 905-273-4367

Definitions:

N/D - No Data
A= Oral rat LD50
D= Estimated 1000
C= Ceiling limit

N/A - Not Applicable
B= Oral rat
E= Arbitrary 2000

N/E - Not Established
LD low C= Oral LD50/LD low other animal
F= Other route prefix

< - Less than
> - Greater than

EHC™ is a trademark of Adventus Intellectual Property Inc.

1. PRODUCT IDENTIFICATION:

PRODUCT IDENTIFICATION: EHC-O
PRODUCT USE: Soil and water treatment.

MANUFACTURER:

Adventus Remediation Technologies Inc.
1345 Fewster Drive
Mississauga, Ontario
L4W 2A5

EMERGENCY PHONE:

Office Hours: 905-273-5374
After Hours: 416-457-9491

TRANSPORTATION OF DANGEROUS GOOD CLASSIFICATION:
Oxidizing Solid, n.o.s. (Calcium Peroxide), Class 5.1, PG II, UN1479

WHMIS CLASSIFICATION:
Oxidizer

2. COMPOSITION/INFORMATION ON INGREDIENTS

Ingredients	**Chemical Formula**	**CAS No.**	**Percentage**
Calcium Peroxide	CaO_2	1305-79-9	45%-70%
Calcium Hydroxide	$Ca(OH)_2$	1305-62-0	10%-20%
Sodium, Calcium Aluminosilicate, Hydrated	$Ca_2(Na,K)_2Al_gSi_{28}O_{72}\ 24H_2O$	12172-10-3	20%-30%

3. PHYSICAL DATA

Appearance	White
Physical state	Solid
Odor threshold	None
Bulk Density	500~650g/L
Solubility in Water	Insoluble
pH	~11
Appearance	White
Decomposition Temperature	Self-accelerating decomposition with oxygen release starting from 275 degrees Celsius

4. HAZARDS IDENTIFICATION

Emergency overview
Oxidizing agent, contact with other material may cause fire. Under fire conditions this material may decompose and release oxygen that intensifies fire. This product also contains crystalline silica. Long tern exposure to hazardous levels of silica dusts can cause lung disease (silicosis). The World Health Organization had indicated that there is limited evidence that crystalline silica is carcinogenic to humans, but the NTP and OSHA have not classified this ingredient as carcinogenic.

Potential Health Effects:

General	Irritating to mucous membrane and eyes.
Inhalation	Irritating to respiratory tract. Long term inhalation of elevated levels may cause lung disease (silicosis).
Eye contact	May cause irritation to the eyes; Risks of serious or permanent eye lesions.
Skin contact	May cause skin irritation.
Ingestion	Irritation of the mouth and throat with nausea and vomiting.

5. FIRST AID MEASURES

Inhalation	Remove affected person to fresh air. Seek medical attention if effects persist.
Eye contact	Flush eyes with running water for at least 15 minutes with eyelids held open. Seek specialist advice.
Skin contact	Wash affected skin with soap and mild detergent and large amounts of water.
Ingestion	If the person is conscious and not convulsing, give 2-4 cupfuls of water to dilute the chemical and seek medical attention immediately. Do not induce vomiting.

6. FIRE FIGHTING MEASURE

Flash Point

- Not applicable

Flammability

- Not applicable

Ignition Temperature

- Not applicable

Danger of Explosion

- Non-explosive

Extinguishing Media

- Water

Fire Hazards

- Oxidizer. Storage vessels involved in a fire may vent gas or rupture due to internal pressure. Damp material may decompose exothermically and ignite combustibles. Oxygen release due to exothermic decomposition may support combustion. May ignite other combustible materials. Avoid contact with incompatible materials such as heavy metals, reducing agents, acids, bases, combustible (wood, papers, cloths etc.) Thermal decomposition releases oxygen and heat. Pressure bursts may occur due to gas evolution. Pressurization if confined when heated or decomposing. Containers may burst violently.

Fire Fighting Measures

- Evacuate all non-essential personnel
- Wear protective clothing and self-contained breathing apparatus.
- Remain upwind of fire to avoid hazardous vapors and decomposition products.
- Use water spray to cool fire- exposed containers.

7. ACCIDENTAL RELEASE MEASURES

Spill Clean-up Procedure

- Oxidizer. Eliminate all sources of ignition. Evacuate unprotected personnel from equipment recommendations found in Section 9. Never exceed any occupational exposure limit.
- Shovel or sweep material into plastic bags or vented containers for disposal. Do not return spilled or contaminated material to inventory. Avoid making dust.
- Flush remaining area with water to remove trace residue and dispose of properly. Avoid direct discharge to sewers and surface waters. Notify authorities if entry occurs.
- Do not touch or walk through spilled material. Keep away from combustibles (wood, paper, oils, etc.). Do not return product to container because of risk of contamination.

8. HANDLING AND STORAGE

Storage

- Oxidizer. Store in a cool, well-ventilated area away from all source of ignition and out of direct sunlight. Store in a dry location away from heat.
- Keep away from incompatible materials. Keep containers tightly closed. Do not store in unlabeled or mislabeled containers.
- Protect from moisture. Do not store near combustible materials. Keep containers well sealed. Ensure pressure relief and adequate ventilation.
- Store separately from organics and reducing materials. Avoid contamination that may lead to decomposition.

Handling

- Avoid contact with eyes, skin, and clothing. Use with adequate ventilation.
- Do not swallow. Avoid breathing vapors, mists, or dust. Do not eat, drink, or smoke in work area.
- Prevent contact with combustible or organic materials.
- Label containers and keep them tightly closed when not in use.
- Wash thoroughly after handling.

9. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls

- General room ventilation is required. Local exhaust ventilation, process enclosures or other engineers controls may be needed to maintain airborne levels below recommended exposure limits. Avoid creating dust or mist. Maintain adequate ventilation. Do not use in closed or confined spaces. Keep levels below exposure limits. To determine exposure limits, monitoring should be performed regularly.

Respiratory Protection

- For many conditions, no respiratory protection may be needed; however, in dusty or unknown atmospheres or when exposures exceed limit values, wear a NIOSH approved respirator.

Eye/Face Protection

- Wear chemical safety goggles and a full face shield while handling this product.

Skin Protection

- Prevent contact with this product. Wear gloves and protective clothing depending on condition of use. Protective gloves: Chemical-resistant (Recommended materials: PVC, neoprene or rubber)

Other Protective Equipment

- Eye-wash station
- Safety shower
- Impervious clothing
- Rubber boots

General Hygiene Considerations

- Wash with soap and water before meal times and at the end of each work shift. Good manufacturing practices require gross amounts of any chemical removed from skin as soon as practical, especially before eating or smoking.

10. STABILITY AND REACTIVITY

Stability

- Stable under normal conditions

Condition to Avoid

- Water
- Acids
- Bases
- Salts of heavy metals
- Reducing agents
- Organic materials
- Flammable substances

Hazardous Decomposition Products
- Oxygen which supports combustion

11. TOXICOLOGICAL INFORMATION

- LD50 Oral: Min.2000 mg/kg, rat
- LD50 Dermal: Min. 2000mg/kg, rat
- LD50 Inhalation: Min. 4580 mg/kg, rat

12. ECOLOGICAL INFORMATION

Ecotoxicological Information
- Hazards for the environment is limited due to the product properties of no bioaccumulation, weak solubility and precipitation in aquatic environment.

Chemical Fate Information
- As indicated by chemical properties oxygen is released into the environment.

13. DISPOSAL CONSIDERATIONS

Waste Treatment
- Dispose of in an approved waste facility operated by an authorized contractor in compliance with local regulations.

Package Treatment
- The empty and clean containers are to be recycled or disposed of in conformity with local regulations.

14. TRANSPORT INFORMATION

- Proper Shipping Name: EHC-O
- Hazard Class: 5.1
- Labels: 5.1 (Oxidizer)
- Packing Group: II

15. REGULATORY INFORMATION

SARA Section	Yes
SARA (313) Chemicals	No
EPA TSCA Inventory	Appears
Canadian WHMIS Classification	C, D2B
Canadian DSL	Appears
EINECS Inventory	Appears

16. PREPARATION INFORMATION

Prepared By:

Adventus Remediation Technologies Inc.
1345 Fewster Drive
Mississauga, Ontario
L4W 2A5

Date Prep./Rev: 7/10/06
Print Date: 7/10/06
Phone: 905-273-5374
Fax: 905-273-4367