

Memorandum

Environmental
Resources
Management

To: Edwin Madera, Raytheon Company

Cc:

From: ERM Project Team

Date: 12 August 2005

Subject: In-Situ Chemical Reduction (ISCR)
Bench-Scale Test Findings
Wayland, Massachusetts

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ERM's Remediation Treatability Lab (RTL) conducted an In-Situ Chemical Reduction (ISCR) test on a soil sample from the referenced project location in Wayland, Massachusetts.

INTRODUCTION

One composite soil sample was collected from soil borings MW-551, MW-552 and MW-553 from an approximate depth of 18 to 25 feet below ground surface from the Wayland site. This soil sample was contained within a single sealed five gallon plastic bucket, containing approximately 10 kg of saturated soil and groundwater. The soil sample was received at the RTL on 6 June 2005.

The soils were visually classified as grey to brown fine sand and silt, with some root fragments. The sample exhibited a sulfur-organic odor, consistent with a wetland soil.

ERM's office in Boston, Massachusetts requested that an ISCR treatability evaluation be conducted on the sample provided. As part of this testing, ERM measured the concentrations of metals (iron and manganese, using EPA Method 6010), total organic carbon and oxidation-reduction potential (ORP):

Initial Soil Chemistry

Sample ID	Metals (Total)		Total Organic Carbon (percent)	ORP (mV)
	Iron (mg/kg)	Manganese (mg/kg)		
Composite	7,800	120	0.726%	-60

Organic carbon values are in the range of anticipated soil values for slightly organic soils. ORP values confirm slightly reducing conditions supportive of ferrous iron (Fe^{+2}) versus ferric iron (Fe^{+3}).

BASIS OF TESTING

ISCR is a process where ambient ORP conditions are chemically altered to create highly reducing conditions (less than - 400 millivolts (mV)). Highly reduced conditions are anaerobic (i.e., no oxygen) approaching or below methanogenic conditions encountered at approximately - 300 mV. The presence of highly reduced conditions is supportive of anaerobic biological reductive dechlorination (BRD) and (potentially) abiotic reduction using native metals (i.e., iron).

The purpose of this bench-scale test was two fold:

1. Determine the amount of reductant (sodium dithionite) required to impart highly reducing conditions on the soils.
2. Measure the changes in spiked TCE concentrations in reduced soil samples over time.

A test procedure was designed to evaluate each item sequentially. It must be noted that this test procedure was designed to evaluate the potential for abiotic reduction only. The test procedure was not rigorous enough to provide design level data, but selected to evaluate "proof of concept" only.

METHOD AND RESULTS

ERM selected the use of sodium dithionite ($\text{Na}_2\text{S}_2\text{O}_4$) as the reducing agent for this test. Although other reducing agents are commercially available (e.g., sodium thiosulfate, calcium polysulfide and manganous sulfate), sodium dithionite was selected as it is frequently added in zero valent iron (ZVI) treatability testing to ensure maintenance of reducing conditions.

Part 1 - Reductant Dosing

Initially, duplicate 200-gram soil samples were weighed and placed into virgin glass sample reactors. The baseline ORP was measured in each sample to confirm the starting ORP (average ORP of - 74 mV).

A 5% sodium dithionite solution (w/w) was then titrated into the reactor and resultant changes in ORP measured over time. The titration was sequentially continued until stabilization in the ORP occurred. [Table 1](#) summarizes the results of the titration.

Part 1 revealed:

- Less than 0.002 grams of sodium dithionite per kilogram (g/kg) of soil was needed to impart highly reducing conditions.
- The ORP stabilized at approximately - 400 to - 500 mV. Additional dosing appeared unable to further reduce these conditions.

This test illustrated that a comparatively small quantity of dithionite can impart highly reducing conditions. Based upon this bench-scale test, a dithionite dose approximately five times the amount required (0.01 g/kg) was selected to provide excess reductant.

Part 2

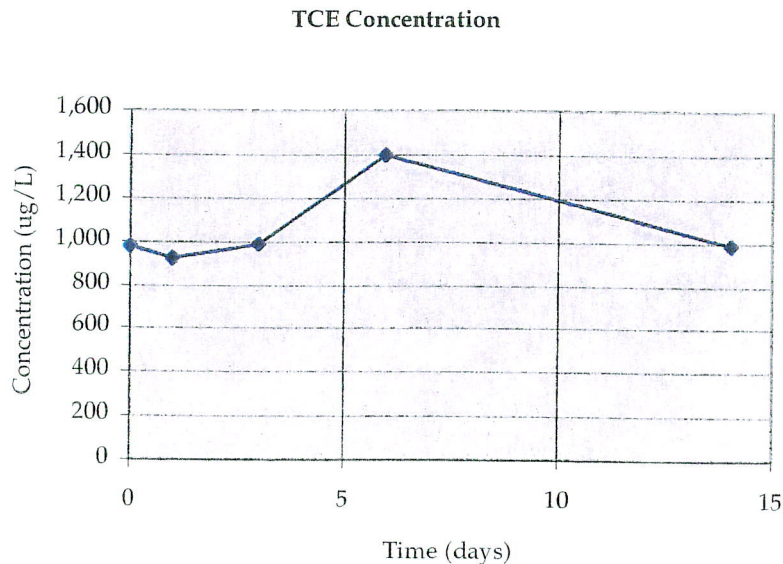
Five, 200-gram soil samples were weighed and placed into virgin glass sample reactors. The dithionite (selected in [Part 1](#)) was then added to each reactor to provide excess dithionite (approximate dose of 2 grams or 0.01 g/kg). TCE was spiked into each sample (to achieve a target concentration of approximately 5 mg/L in water) and the jar filled with deionized water to create a zero headspace reactor.

The samples were then allowed to react and periodically sacrificed and the water fraction analyzed for volatiles using Method 8260 (TCE only). The samples were allowed to react and sacrificed after one, three, six and 14 days of reaction time. [Table 2](#) and the following plot illustrate the TCE results for the samples.

Part 2 revealed:

- Although some TCE was lost in preparation (volatization and soil sorption), the control sample exhibited 980ug/L TCE. This value, therefore, likely represents the time zero concentration.
- Although the initial sampling revealed a slight decline in concentration, the concentrations of TCE remained essentially unchanged throughout the testing period.

Based upon this testing, the abiotic destruction of TCE in soils was not observed in the first 14 days of reaction time.



SUMMARY AND ADDITIONAL STUDY

ERM offers the following comments regarding the testing to date:

- Although abiotic reduction of TCE was not observed in the first 14 days, highly reducing conditions were imparted and maintained by the use of relatively small quantities of sodium dithionite. Pilot scale ISCR programs dose at five times stoichiometric equivalent of natural iron (approximately one order of magnitude higher reductant dosing completed in this protocol); thus, the reductant dose may have been insufficient to fully reduce all the natural iron in the reactor.
- The imposition of highly reducing conditions with a small dose of reductant suggests that sodium dithionite could be employed in concert with substrate (and nutrients) to promote and enhance biological reductive dechlorination (BRD).
- The bench-scale test also ran for only 14 days. It was designed to test abiotic processes only. Additional time may be required for the kinetics of the reaction mechanisms to become facultative such that TCE decreases may be observed following a longer reaction time (i.e., greater than 45 days).

ERM could design further bench-scale activities with a concurrent control, to evaluate additional test condition(s) such as:

- Higher reductant dosing,
- BRD enhancement, or
- Extended run times

Any additional bench-scale testing should also incorporate the measurement of reductant residual and ORP at each sampling event.

Attachments: Table 1: Sodium Dithionite Application to Soils
 Table 2: Spiked TCE Degradation Using Sodium Dithionite
 Alpha Analytical Laboratories report, 15 July 2005
 Chain of Custody, 22 June 2005

Table 1
Sodium Dithionite Application to Soils
 Part 1 Test Results (July 2005)
 Raytheon/Wayland

Procedure:

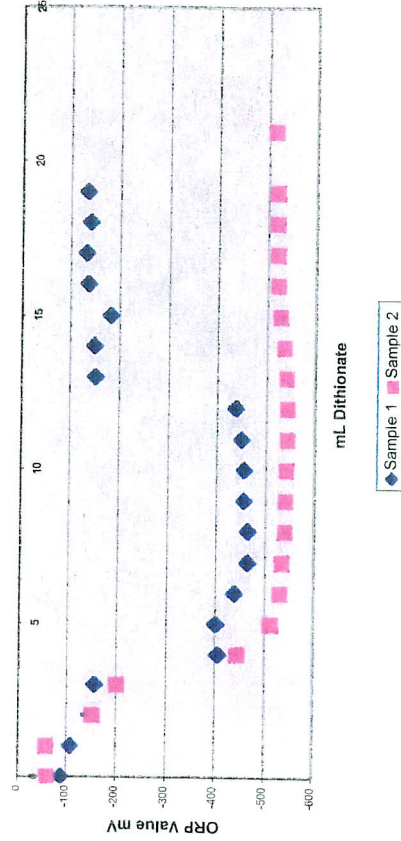
Prepared two (2) 200 gram soil sample aliquots, measure ORP (to confirm no/limited impact from DI water addition)
 Sequentially titrated 5% solution ($\text{Na}_2\text{S}_2\text{O}_8$, w/w basis, i.e., dilute field concentration) into jars and measured ORP

Results:

ORP Results, measured by Hanna 9025 ORP probe:

Sodium Dithionite ($\text{Na}_2\text{S}_2\text{O}_4$) Added (ml)	ORP Results (mV)		Applied Sodium Dithionite (grams)	Applied Sodium Dithionite (g/kg)
	Sample 1	Sample 2		
0	-88	-60	0.00	0.000
+20mL DI water	N/A	-57	0.00	0.000
1	-108	-152	0.05	0.000
2	-148	-201	0.10	0.001
3	-156	-444	0.15	0.001
4	-405	-510	0.20	0.001
5	-400	-529	0.25	0.001
6	-437	-533	0.30	0.002
7	-463	-539	0.35	0.002
8	-463	-540	0.40	0.002
9	-455	-541	0.45	0.002
10	-455	-543	0.50	0.003
11	-449	-543	0.55	0.003
12	-437	-540	0.60	0.003
13	-152	-535	0.65	0.003
14	-149	-526	0.70	0.004
15	-181	-521	0.75	0.004
16	-136	-519	0.80	0.004
17	-132	-517	0.85	0.004
18	-140	-517	0.90	0.005
19	-134	-514	0.95	0.005
29	-377	-469	1.45	0.007
39	-400	-469	1.95	0.010
51	-388	-460	2.55	0.013
Sample Weight (g)	200	200		

ORP Results (0-19mL Dithionate)



ORP Results (0-51 mL Dithionate)

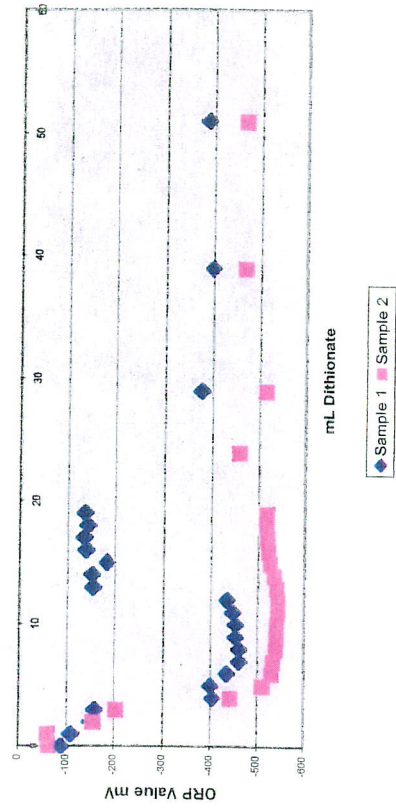


Table 2
Spiked TCE Degradation Using Sodium Dithionite
 Part 2 Test Results (July 2005)
 Raytheon/Wayland

Procedure:

Prepared eight (8) 200 gram soil sample aliquots
 Added 2 g sodium dithionite to 200 g soil (dose approximately 0.01 g/kg, excess) by applying 40 ml 5% solution (Na₂S₂O₄, w/w basis)
 Spiked the sample with TCE to 5 mg/L (water concentration) and filled jar headspace with DI water

Results:

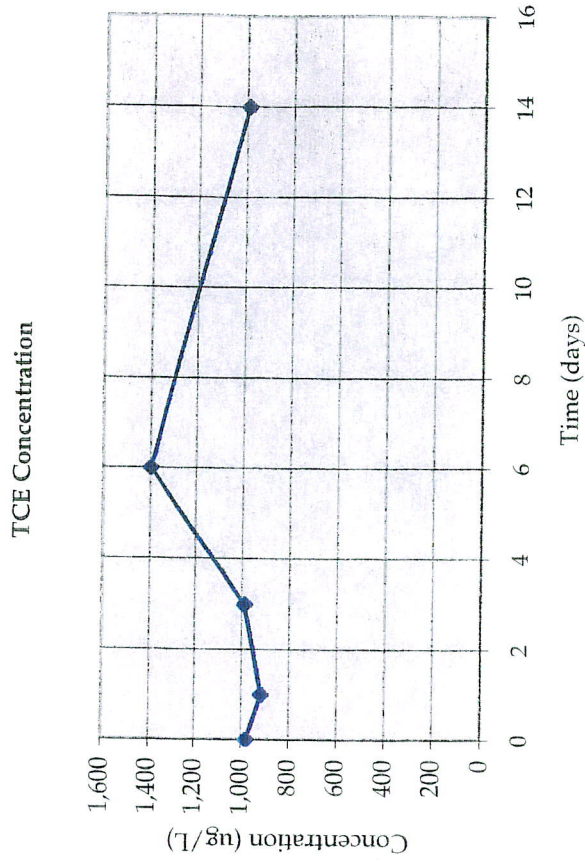
Sacrificed samples periodically and measured TCE concentration, i.e.,

Sample (days)	TCE Concentration (ug/L)	Notes
0	980	"Control sample"
1	920	
3	990	
6	1400	
14	990	

Note: Initial spike and control differ due to TCE sorption

Additional Analytical:

Total Solids 66%
 TOC 0.726%
 Total Metals 7,800 mg/kg
 Iron 120 mg/kg
 Manganese



ALPHA ANALYTICAL LABORATORIES

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(508) 898-9220 www.alphalab.com

MA:M-MA086 NH:200301-A CT:PH-0574 ME:MA086 RI:65 NY:11148 NJ:MA935 Army:USACE

CERTIFICATE OF ANALYSIS

Client: ERM-New England Laboratory Job Number: L0507011
Address: 399 Boylston Street
6th Floor
Boston, MA 02116 Date Received: 23-JUN-2005
Attn: Mr. Tim Pac Date Reported: 19-JUL-2005
Project Number: Delivery Method: Alpha
Site: RAYTHEON /WAYLAND

ALPHA SAMPLE NUMBER	CLIENT IDENTIFICATION	SAMPLE LOCATION
L0507011-01	SOIL	WAYLAND, MA
L0507011-02	SOIL	WAYLAND, MA
L0507011-03	CONTROL	WAYLAND, MA
L0507011-04	DAY 1	WAYLAND, MA
L0507011-05	DAY 3	WAYLAND, MA
L0507011-06	DAY 6	WAYLAND, MA
L0507011-07	DAY 14	WAYLAND, MA

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

Authorized by: Scott McLean

This document electronically signed

ALPHA ANALYTICAL LABORATORIES
NARRATIVE REPORT

Laboratory Job Number: L0507011

TCE Reductive Treatability Study

ERM placed 200 g soil in 120 ml soil volatile jars with Teflon lined caps. As directed by ERM, Alpha added 38 ml 5% sodium dithionite solution (previously prepared by ERM) to five soil jars. Trichloroethene was spiked to four jars at a ration of 5 mg/L in the sodium dithionite solution. An additional jar was used as a control and had trichloroethene spiked into laboratory DI water. All jars had zero headspace and were placed in a 20 °C incubator.

The liquid portion of the Control and the Day 1 samples were sacrificed after 24 hours for analysis of volatiles by CG/MS. Samples were also sacrificed at 3, 5 and 14 days, for volatile analysis of the liquid portion, as directed by ERM. The liquid portion of the Day 14 sample was also analyzed for ORP.

Volatile Organics

L0507011-05 through -07 has elevated limits of detection due to the 25x dilutions required by the elevated concentrations of target compounds in the sample. Cis-1,2 dichloroethene was also detected in the Day 1 sample at 120 ug/L, in the Day 6 sample at 120 ug/L, and in the Day 14 sample at 110 ug/L.

ALPHA ANALYTICAL LABORATORIES
 CERTIFICATE OF ANALYSIS

MA:M-MA086 NH:200301-A CT:PH-0574 ME:MA086 RI:65 NY:11148 NJ:MA935 Army:USACE

Laboratory Sample Number: L0507011-01

Date Collected:

SOIL

Date Received : 23-JUN-2005

Sample Matrix:

SOIL

Date Reported : 19-JUL-2005

Condition of Sample: Satisfactory

Field Prep: None

Number & Type of Containers: 1-Other

PARAMETER	RESULT	UNITS	RDL	REF METHOD	DATE		ID
					PREP	ANAL	
Solids, Total	66.	%	0.10	30 2540G		0624 17:00	EJ
Total Organic Carbon	0.726	%	0.015	13		0707 11:30	JS
COD in Soil				4105220			DT
COD	19000	mg/kg	1200	4105220			DT
Total Metals				1 3051			
Iron, Total	7800	mg/kg	3.0	1 6010B	0627 16:45	0628 09:53	RW
Manganese, Total	120	mg/kg	0.60	1 6010B	0627 16:45	0628 09:53	RW

Comments: Complete list of References and Glossary of Terms found in Addendum I

ALPHA ANALYTICAL LABORATORIES
CERTIFICATE OF ANALYSIS

MA:M-MA086 NH:200301-A CT:PH-0574 ME:MA086 RI:65 NY:11148 NJ:MA935 Army:USACE

Laboratory Sample Number: L0507011-02

Date Collected:

SOIL

Date Received : 23-JUN-2005

Sample Matrix:

SOIL

Date Reported : 19-JUL-2005

Condition of Sample: Satisfactory

Field Prep: None

Number & Type of Containers: 8-Vial

PARAMETER	RESULT	UNITS	RDL	REF METHOD	DATE		ID
					PREP	ANAL	

***** THIS SAMPLE IS ON HOLD *****

Comments: Complete list of References and Glossary of Terms found in Addendum I

ALPHA ANALYTICAL LABORATORIES
 QUALITY ASSURANCE BATCH DUPLICATE ANALYSIS

Laboratory Job Number: L0507011

Parameter	Value 1	Value 2	Units	RPD	RPD Limits
Solids, Total for sample(s) 01 (L0507017-02, WG205756-1)					
Solids, Total	92.	92.	%	0	
Total Organic Carbon for sample(s) 01 (L0507011-01, WG206863-3)					
Total Organic Carbon	0.726	0.704	%	3	20
Oxidation/Reduction Potential for sample(s) 07 (L0507924-20, WG207849-2)					
Oxidation/Reduction Potential	29.	30.	mv	3	
List for sample(s) 01 (L0507011-01, WG207604-4)					
COD	19000	19000	mg/kg	0	

ALPHA ANALYTICAL LABORATORIES
 QUALITY ASSURANCE BATCH SPIKE ANALYSES

Laboratory Job Number: L0507011

Parameter	% Recovery	QC Criteria
Total Organic Carbon LCS for sample(s) 01 (WG206863-2)		
Total Organic Carbon	91	90-110
Oxidation/Reduction Potential LCS for sample(s) 07 (WG207849-1)		
Oxidation/Reduction Potential	102	
List LCS for sample(s) 01 (WG207604-2)		
COD	97	
Total Metals LCS for sample(s) 01 (WG205949-4)		
Iron, Total	98	70-140
Manganese, Total	90	70-140
Volatile Organics by GC/MS 8260 LCS for sample(s) 05 (WG206590-3)		
Chlorobenzene	97	
Benzene	103	
Toluene	90	
1,1-Dichloroethene	102	
Trichloroethene	96	
Surrogate(s)		
1,2-Dichloroethane-d4	92	
Toluene-d8	93	
4-Bromofluorobenzene	96	
Dibromofluoromethane	102	
Volatile Organics by GC/MS 8260 LCS for sample(s) 06 (WG206590-7)		
Chlorobenzene	106	
Benzene	110	
Toluene	103	
1,1-Dichloroethene	112	
Trichloroethene	107	
Surrogate(s)		
1,2-Dichloroethane-d4	96	
Toluene-d8	93	
4-Bromofluorobenzene	97	
Dibromofluoromethane	105	
Volatile Organics by GC/MS 8260 LCS for sample(s) 07 (WG206747-11)		
Chlorobenzene	103	
Benzene	103	
Toluene	103	
1,1-Dichloroethene	101	
Trichloroethene	102	
Surrogate(s)		
1,2-Dichloroethane-d4	106	
Toluene-d8	97	

ALPHA ANALYTICAL LABORATORIES
QUALITY ASSURANCE BATCH SPIKE ANALYSES

Laboratory Job Number: L0507011

Continued

Parameter	% Recovery	QC Criteria
Volatile Organics by GC/MS 8260 LCS for sample(s) 07 (WG206747-11)		
4-Bromofluorobenzene	105	
Dibromofluoromethane	97	
List SPIKE for sample(s) 01 (L0507011-01, WG207604-3)		
COD	92	
Total Metals SPIKE for sample(s) 01 (L0506835-01, WG205949-2)		
Iron, Total	0	70-140
Manganese, Total	0	70-140

ALPHA ANALYTICAL LABORATORIES
 QUALITY ASSURANCE BATCH MS/MSD ANALYSIS

Laboratory Job Number: L0507011

Parameter	MS %	MSD %	RPD	RPD Limit	MS/MSD Limits
Volatile Organics by GC/MS 8260 for sample(s) 03-04 (L0506968-01, WG205970-2)					
Chlorobenzene	101	97	4		
Benzene	107	100	7		
Toluene	104	100	4		
1,1-Dichloroethene	100	93	7		
Trichloroethene	101	96	5		
Surrogate(s)					
1,2-Dichloroethane-d4	86	87	1		
Toluene-d8	94	95	1		
4-Bromofluorobenzene	87	94	8		
Dibromofluoromethane	96	95	1		
Volatile Organics by GC/MS 8260 for sample(s) 05-06 (L0507271-04, WG206590-2)					
Chlorobenzene	109	104	5		
Benzene	113	107	5		
Toluene	107	103	4		
1,1-Dichloroethene	116	106	9		
Trichloroethene	116	106	9		
Surrogate(s)					
1,2-Dichloroethane-d4	99	97	2		
Toluene-d8	94	96	2		
4-Bromofluorobenzene	93	96	3		
Dibromofluoromethane	106	105	1		
Volatile Organics by GC/MS 8260 for sample(s) 07 (L0507312-02, WG206747-2)					
Chlorobenzene	109	110	1		
Benzene	112	112	0		
Toluene	109	108	1		
1,1-Dichloroethene	116	110	5		
Trichloroethene	113	113	0		
Surrogate(s)					
1,2-Dichloroethane-d4	102	113	10		
Toluene-d8	100	101	1		
4-Bromofluorobenzene	103	104	1		
Dibromofluoromethane	101	99	2		

**ALPHA ANALYTICAL LABORATORIES
QUALITY ASSURANCE BATCH BLANK ANALYSIS**

Laboratory Job Number: L0507011

PARAMETER	RESULT	UNITS	RDL	REF METHOD	DATE PREP ANAL	ID
Blank Analysis for sample(s) 01 (WG206863-1)						
Total Organic Carbon	ND	%	0.010	13	0707 11:30	JS
Blank Analysis for sample(s) 01 (WG207604-1)						
COD in Soil				4105220	0715 08:00	DT
COD	ND	mg/kg	200	4105220		DT
Blank Analysis for sample(s) 01 (WG205949-3)						
Total Metals				1 3051		
Iron, Total	ND	mg/kg	2.0	1 6010B	0627 16:45 0628 08:24	RW
Manganese, Total	ND	mg/kg	0.40	1 6010B	0627 16:45 0628 08:24	RW
Blank Analysis for sample(s) 03-04 (WG205970-6)						
Volatile Organics by GC/MS 8260				1 8260B	0629 07:31	TT
Methylene chloride	ND	ug/l	5.0			
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			
1,1-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			
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			

ALPHA ANALYTICAL LABORATORIES
 QUALITY ASSURANCE BATCH BLANK ANALYSIS

Laboratory Job Number: L0507011

Continued

PARAMETER	RESULT	UNITS	RDL	REF METHOD	DATE		ID
					PREP	ANAL	
Blank Analysis for sample(s) 03-04 (WG205970-6)							
Volatile Organics by GC/MS 8260 cont'd							
				1	8260B		0629 07:31 TT
p/m-Xylene	ND	ug/l	1.0				
o-Xylene	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				
Iodomethane	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				
Acrolein	ND	ug/l	12.				
Acrylonitrile	ND	ug/l	5.0				
Bromochloromethane	ND	ug/l	2.5				
Tetrahydrofuran	ND	ug/l	10.				
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				
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	1.0				
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(s)	Recovery			QC Criteria			
1,2-Dichloroethane-d4	94.0	%					
Toluene-d8	91.0	%					

ALPHA ANALYTICAL LABORATORIES
 QUALITY ASSURANCE BATCH BLANK ANALYSIS

Laboratory Job Number: L0507011

Continued

PARAMETER	RESULT	UNITS	RDL	REF METHOD	DATE		ID
					PREP	ANAL	
Blank Analysis for sample(s) 03-04 (WG205970-6)							
Volatile Organics by GC/MS 8260 cont'd							
4-Bromofluorobenzene	98.0	%		1 8260B		0629 07:31	TT
Dibromofluoromethane	99.0	%					
Blank Analysis for sample(s) 05 (WG206590-4)							
Volatile Organics by GC/MS 8260							
Methylene chloride	ND	ug/l	5.0	1 8260B		0701 10:35	RY
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				
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				
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				
cis-1,2-Dichloroethene	ND	ug/l	0.50				
Dichlorodifluoromethane	ND	ug/l	5.0				
Naphthalene	ND	ug/l	2.5				
Surrogate(s)	Recovery		QC Criteria				
1,2-Dichloroethane-d4	93.0	%					
Toluene-d8	93.0	%					
4-Bromofluorobenzene	95.0	%					

ALPHA ANALYTICAL LABORATORIES
 QUALITY ASSURANCE BATCH BLANK ANALYSIS

Laboratory Job Number: L0507011

Continued

PARAMETER	RESULT	UNITS	RDL	REF METHOD	DATE		ID
					PREP	ANAL	
Blank Analysis for sample(s) 05 (WG206590-4)							
Volatile Organics by GC/MS 8260 cont'd							
Dibromofluoromethane	98.0	%		1 8260B		0701 10:35	RY
Blank Analysis for sample(s) 06 (WG206590-8)							
Volatile Organics by GC/MS 8260							
Methylene chloride	ND	ug/l	5.0	1 8260B		0705 11:07	RY
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				
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				
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				
cis-1,2-Dichloroethene	ND	ug/l	0.50				
Dichlorodifluoromethane	ND	ug/l	5.0				
Naphthalene	ND	ug/l	2.5				
Surrogate(s)	Recovery			QC Criteria			
1,2-Dichloroethane-d4	100.	%					
Toluene-d8	96.0	%					
4-Bromofluorobenzene	100.	%					
Dibromofluoromethane	103.	%					

ALPHA ANALYTICAL LABORATORIES
QUALITY ASSURANCE BATCH BLANK ANALYSIS

Laboratory Job Number: L0507011

Continued

PARAMETER	RESULT	UNITS	RDL	REF METHOD	DATE		ID
					PREP	ANAL	
Blank Analysis for sample(s) 07 (WG206747-12)							
Volatile Organics by GC/MS 8260				1 8260B		0712 10:06 RY	
Methylene chloride	ND	ug/l	5.0				
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				
1,1-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				
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				
cis-1,2-Dichloroethene	ND	ug/l	0.50				
Dibromomethane	ND	ug/l	5.0				
1,4-Dichlorobutane	ND	ug/l	5.0				
Iodomethane	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				

ALPHA ANALYTICAL LABORATORIES
 QUALITY ASSURANCE BATCH BLANK ANALYSIS

Laboratory Job Number: L0507011

Continued

PARAMETER	RESULT	UNITS	RDL	REF METHOD	DATE		ID
					PREP	ANAL	
Blank Analysis for sample(s) 07 (WG206747-12)							
Volatile Organics by GC/MS 8260 cont'd				1 8260B		0712 10:06	RY
2-Hexanone	ND	ug/l	5.0				
Ethyl methacrylate	ND	ug/l	5.0				
Acrolein	ND	ug/l	12.				
Acrylonitrile	ND	ug/l	5.0				
Bromochloromethane	ND	ug/l	2.5				
Tetrahydrofuran	ND	ug/l	10.				
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				
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	1.0				
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(s)	Recovery			QC Criteria			
1,2-Dichloroethane-d4	118.	%					
Toluene-d8	100.	%					
4-Bromofluorobenzene	108.	%					
Dibromofluoromethane	108.	%					

ALPHA ANALYTICAL LABORATORIES
ADDENDUM I

REFERENCES

1. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. EPA SW-846. Third Edition. Updates I - IIIA, 1997.
12. Annual Book of ASTM Standards. American Society for Testing and Materials.
13. Determination of Total Organic Carbon in Sediment. U.S. EPA, Region II. July 27, 1988.
30. Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WPCF. 18th Edition. 1992.

GLOSSARY OF TERMS AND SYMBOLS

REF Reference number in which test method may be found.
METHOD Method number by which analysis was performed.
ID Initials of the analyst.
ND Not detected in comparison to the reported detection limit.
NI Not Ignitable.
ug/cart Micrograms per Cartridge.

LIMITATION OF LIABILITIES

Alpha Analytical, Inc. performs services with reasonable care and diligence normal to the analytical testing laboratory industry. In the event of an error, the sole and exclusive responsibility of Alpha Analytical, Inc., shall be to re-perform the work at it's own expense. In no event shall Alpha Analytical, Inc. be held liable for any incidental consequential or special damages, including but not limited to, damages in any way connected with the use of, interpretation of, information or analysis provided by Alpha Analytical, Inc.

We strongly urge our clients to comply with EPA protocol regarding sample volume, preservation, cooling, containers, sampling procedures, holding times and splitting of samples in the field.



CHAIN OF CUSTODY

PAGE 1 OF 1

Eight Walkup Drive Westborough, MA 01581
TEL: 508-898-9220 FAX: 508-898-9193

Client Information

Client:

Address:

Phone:

Fax:

Email: tim.pac@erm.com

These samples have been previously analyzed by Alpha

Other Project Specific Requirements/Comments/Detection Limits:

Treatability work per email from T. Auct +
Jim Occasioni (Alpha)

Project Information

Project Name: Raytheon/Wayland

Project Location: Wayland, MA

Project #:

Project Manager: Tim Pac

ALPHA Quote #:

Turn-Around Time

Standard RUSH (only confirmed if pre-approved!)

Date Due: 7/8/05 Time:

ALPHA Job # 0507011

Billing Information

Same as Client info PO #:

Report Information - Data Deliverables

FAX EMAIL
 ADEX Add'l Deliverables

Regulatory Requirements/Report Limits

State/Fed Program MA Criteria

MCP PRESUMPTIVE CERTAINTY - THESE QUESTIONS MUST BE ANSWERED

Yes No Are MCP Analytical Methods Required?
 Yes No Are Drinking Water Samples Submitted?
 Yes No Have you met minimum field QC requirements?

ANALYSIS	200 s. sample	Iron (total) * Manganese (total) * Rem Bact	Sample Specific Comments
TDS Reductive (200 s. sample)	✓		Provided 8 sample containers for treatability + 1 5 gal pal for methods
Iron (total) *	✓		Spike containers to 5ppm TDS + Seaflex @ 1, 3, 5 + 10 dys -
Manganese (total) *			
Rem Bact			

- SAMPLE HANDLING**
- Filtration
 - Done
 - Not needed
 - Lab to do
 - Preservation
 - Lab to do
- (Please specify below)

QUESTIONS ABOVE MUST BE ANSWERED FOR PRESUMPTIVE CERTAINTY

IS YOUR PROJECT MCP ?

Relinquished By: [Signature]

Date/Time: 6/22/05

Received By: [Signature]

Date/Time: 6/23/05 14:00

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. See reverse side.