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February 6, 2013

Robert Reinhart
US EPA Region 1
11 Technology Drive
North Chelmsford, MA 01863-2431

Subject: Brownfields Program Quality Assurance Project Plan Addendum NB-H
City of New Bedford Brownfields Program
Former Payne Cutlery Site
295 Phillips Avenue
New Bedford, Massachusetts

Dear Mr. Reinhart:

On behalf of the City of New Bedford, TRC Environmental Corporation is pleased to submit this Quality Assurance Project Plan (QAPP), Addendum NB-H for the above-referenced property located at 295 Phillips Avenue in New Bedford, Massachusetts (the "Site") for your review and approval. The attached QAPP Addendum presents the proposed scope of work for supplemental groundwater and soil sampling at the Former Payne Cutlery Site.

Please note that EPA previously approved QAPP Addendum NB-G in March 2012 (EPA RFA #06135) also from this Site.

Please also note that TRC's Generic Brownfields QAPP (EPA RFA# 13028, Revision 2.0) is referenced throughout this QAPP Addendum.

If you have any questions, please contact either of the undersigned at (978) 970-5600.

Sincerely,

Alfred C. Leonard, LSP
Senior Project Engineer

Paul Arnold
Program Manager

Enclosure

cc: Cheryl Henlin, City of New Bedford
Laurie O'Connor, EPA
TRC Project File

Brownfields Program Quality Assurance Project Plan
Addendum NB-H
City of New Bedford

Former Payne Cutlery Site
295 Phillips Avenue
New Bedford, Massachusetts

Prepared for:

City of New Bedford
133 Williams Street
New Bedford, MA 02740

Prepared By:

TRC Environmental Corporation
Wannalancit Mills
650 Suffolk Street
Lowell, MA 01854

(978) 970-5600

February 2013

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Attachment B ASTM Method for Measuring PNOD

1.0 FORM A – TITLE AND APPROVAL PAGE

Document Title: Brownfields Program Quality Assurance Project Plan (QAPP), Addendum NB-H, Former Payne Cutlery, 295 Phillips Avenue, New Bedford, Massachusetts.

EPA QA RFA Number: _____
(TRC's Generic QAPP: EPA RFA# 13028)

Prepared By:
TRC Environmental Corporation
Wannalancit Mills
650 Suffolk Street
Lowell, MA 01854
Phone: (978) 970-5600

QAPP Date: 2/6/2013

QAPP Revision Number: 0

The signatures below indicate approval of this QAPP Addendum.

EPA QA Officer: _____
Signature

Robert Reinhart
Printed Name/Date

EPA Project Officer: _____
Signature

Laurie O'Connor
Printed Name/Date

TRC Project Manager: _____
Signature

Alfred Leonard 2-6-2013
Printed Name/Date

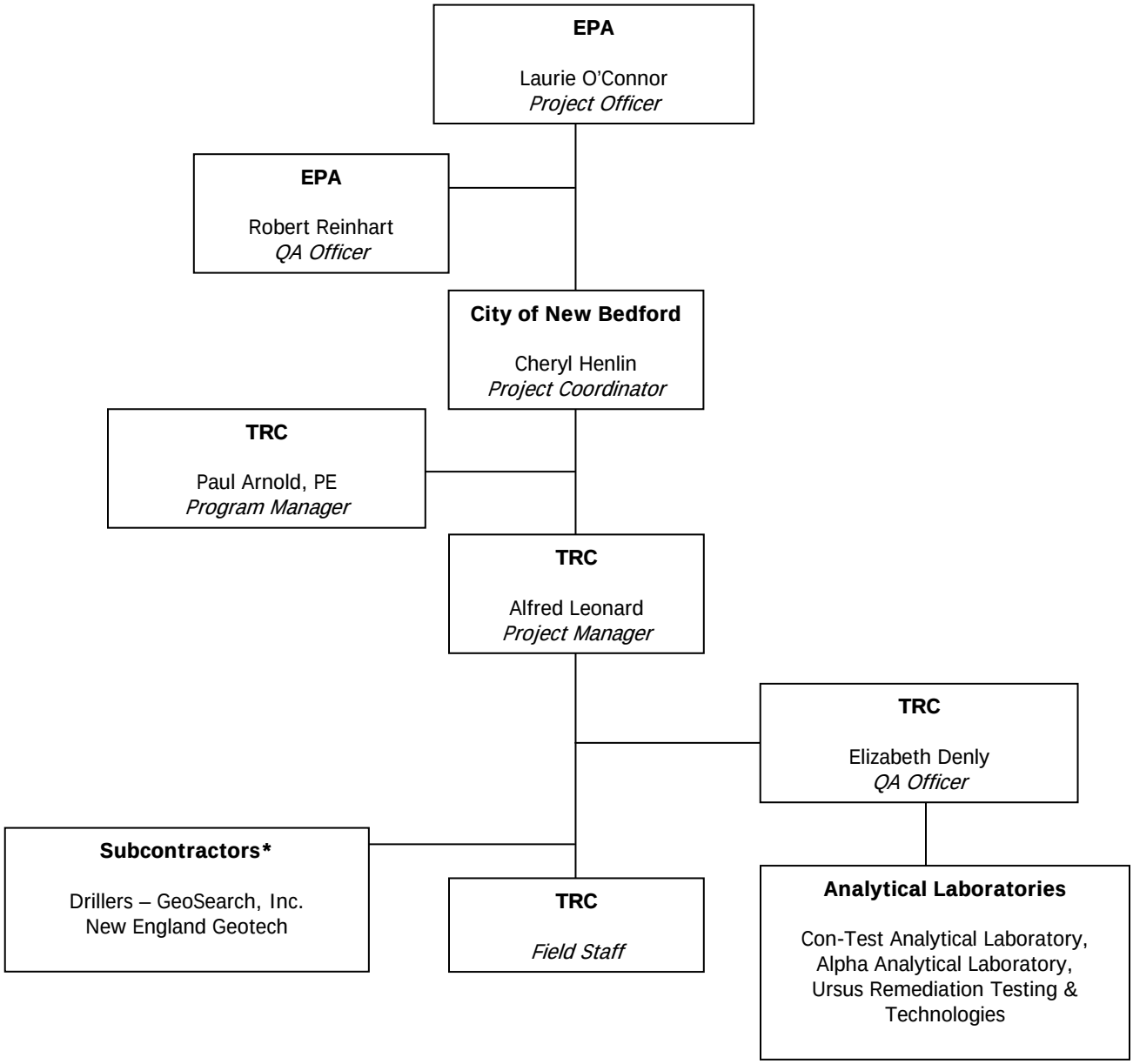
TRC Project QA Officer: _____ for E.D.
Signature

Elizabeth Denly 2/6/2013
Printed Name/Date

2.0 FORM B – PROJECT ORGANIZATION AND RESPONSIBILITY

2.1 Project Organization

The following chart presents the organizational structure for this program.



*Other qualified subcontractors may be substituted due to schedule availability or specific equipment requirements.

2.2 Project Responsibilities and Contact Information

The laboratories selected for this program are Con-Test Analytical of East Longmeadow, Massachusetts (Con-Test), Alpha Analytical of Westborough, Massachusetts (Alpha), and Ursus Remediation Testing & Technologies, LLC of Mount Horeb, Wisconsin (Ursus). Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a summary of project responsibilities and contact information for the EPA QA Officer, TRC Program Manager, TRC QA Officer, Con-Test and Alpha. Contact information for the remaining team members (EPA Project Officer, City of New Bedford Project Coordinator, the TRC Project Manager, Ursus and other subcontractors) is provided below.

EPA Project Officer:

Contact Information:

Contact:	Laurie O'Connor
Address:	USEPA Region 1
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City of New Bedford Project Coordinator:

Contact Information:

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	133 Williams Street, Room 304
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TRC Project Manager:

Contact Information:

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Address:	TRC Environmental Corp.
	650 Suffolk Street
	Lowell, MA 01854
Phone:	(978) 656-3689
Email:	aleonard@trcsolutions.com

Other Subcontractors:

Contact Information:

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	Fitchburg, MA 01420
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Contact:	Andrew Wenzel
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Email:	Andrew.Wenzel@ursusremediationtesting.com

Note:
* Other qualified subcontractors may be substituted due to schedule availability or specific equipment requirements.

3.0 FORM C – PROBLEM DEFINITION

3.1 Background

The former Payne Cutlery Corporation (Payne) is located at 295 Phillips Avenue in New Bedford, Massachusetts (the "Site"). The Site is identified by the City of New Bedford Tax Assessor's Office on Map 98 as parcels 3, 23 and 264, and totals approximately 3.3 acres. A two-story brick building existed on the Site until 2000. The Site has a history of industrial use, dating from the early 1900s when it was developed for cotton fabric milling operations, until 1988 when the Site was used by Payne in the manufacture of shears and manicure implements. Payne occupied the site between 1963 and 1988. During this time, Site activities included cold pressing of steel, metal grinding, degreasing of metal with trichloroethene (TCE), as well as chromium and nickel electroplating. After Payne filed for bankruptcy in 1988, the Site was used for a number of activities, including a hazardous materials storage business and an automobile body repair facility. In 2010, the City of New Bedford constructed a parking lot in the southeastern portion of the Site.

Two Massachusetts Department of Environmental Protection (MassDEP) Release Tracking Numbers (RTNs) are associated with the Site. The first RTN (4-404) is associated with a reported release of petroleum-based oil in April 1987 prior to the establishment of the 1993 Massachusetts Contingency Plan (MCP; 310 CMR 40.0000) revisions. The Site was previously categorized as a *Transition Site* pursuant to the pre-1993 MCP. The second RTN (4-15373) is associated with a reported release of TCE in February 2001, which warranted the performance of an Immediate Response Action (IRA) at the Site under the MCP. An IRA Completion Report has not been submitted for this Site to date. The Site is in default under Tier Classification obligations relative to the MCP (310 CMR 40.0500) for both RTNs.

3.2 Previous Investigations

Hazardous substances formerly used and stored on the Site are consistent with metal plating operations and manufacture of rubber and plastic. A technical report by Roy F. Weston, Incorporated (Weston) included a 21-page table listing a complete inventory of the building conducted in 1992. Hazardous substances identified as part of this inventory appeared to be left over from metal plating processes or manufacture of polymers for plastic and rubber tool grips.

Previous investigations reported that one 20,000-gallon underground storage tank (UST) and one 8,500-gallon No. 4 fuel oil UST were removed from the Site in November 1962 and September 2000, respectively; however, their exact locations are unknown. Three aboveground storage tanks (ASTs) were identified by previous reports, including a 50-gallon heating oil tank and two ASTs of unspecified volume and contents. All tanks were reportedly removed as part of building demolition.

Two investigations in 1987 documented numerous drums containing potentially hazardous materials in the building. The earlier of these two investigations was performed by Mabbett, Capaccio, & Associates, Incorporated (MCA), and included a limited subsurface investigation beneath the concrete floor at the Site. This investigation concluded that Site soils were contaminated with TCE, chromium, nickel, lead, petroleum products, and acid (based on low pH readings). The report further

stated that "a significant potential exists for contamination of groundwater at the Site." MCA's 1987 report also noted several leaks in the roof of the building.

In September 1987, GHR Engineering Associates (GHR) produced an environmental assessment report documenting soil boring and well installation activities at the subject site. GHR reported the presence of TCE and nickel in subsurface soil. TCE was detected above current Method 1 soil cleanup standards. GHR also analyzed for the presence of polychlorinated biphenyls (PCBs) in soil, all results for which were non-detect except one sample with 1.44 milligrams per kilogram (mg/kg) PCBs, which is below current applicable MCP Method 1 soil cleanup standards. GHR's groundwater investigation detected copper, thallium, antimony, nickel, TCE, tetrachloroethene (PCE), and chloroform. TCE, PCE, and nickel were detected above the current applicable Method 1 groundwater cleanup standards.

During the 1990s, the Site building fell into further disrepair, with several reports noting large holes in the floor and roof of the structure. In 1992, prompted by City of New Bedford fire department requests, MassDEP made a request to the EPA for assistance in stabilizing the hazardous conditions at the Site. On August 20, 1992, EPA began actions to investigate contamination and to remove hazardous materials from the Site. The investigation named Joseph F. Oliveira (owner), A-1 Storage, Incorporated, Nu-Traffic, Incorporated, Erie Chemical Sales, and Payne Cutlery Corporation as respondents compelled to perform removal activities. On September 16, 1992, an inventory was conducted by an EPA Removal Team. The inventory indicated approximately 4,900 55-gallon drums, packages and various sized containers storing known and unknown substances, including hazardous materials. The containers were reportedly in varying states of deterioration, including some leaking and overturned drums. EPA supervised a two-part removal of hazardous materials at the Site from November 3, 1992 until the completion of the removal on July 20, 1993. The first part of the removal was funded by EPA and included removal of the materials associated with Payne Cutlery's operations. Following this removal, Erie Chemical Sales, as part of its agreement with EPA, completed the removal of materials associated with its operations at the Site.

In February 2000, Cygnus Group, Inc. (CGI) commenced a subsurface investigation at the Site funded by an EPA Brownfields Pilot Grant. CGI identified TCE contamination in Site soil and groundwater, as well as other volatile and extractable petroleum hydrocarbons (VPH and EPH). CGI identified a release or threat of release condition that warranted an IRA based on concentrations of total volatile organic compounds (VOCs) in groundwater greater than 5 milligrams per liter (mg/L) within 30 feet of an occupied residential structure, where groundwater is less than 15 feet below ground surface (approximate depth to groundwater at the Site ranges from 8 to 12 feet below ground surface.) TCE has been detected in groundwater (in monitoring well CGW-8) at concentrations of up to 89,000 micrograms per liter (ug/L) upgradient of residential buildings (e.g., Taber Mills). TCE has exceeded the 1-percent pure phase solubility threshold indicative of Dense Non-Aqueous Phase Liquids (DNAPLs) in several monitoring wells (including CDW-8, based on aqueous headspace field screening). Gas chromatographic (GC) aqueous headspace screening data were used by CGI to identify monitoring well installation locations. Refer to Figure C-2 in the March 2012 QAPP Addendum NB-G (EPA RFA #06135) for the GC data and other historical groundwater sampling results.

As a result of these data and the proximity of occupied residences, indoor air quality samples were taken in downgradient homes using SUMMA-type passivated stainless steel canisters on March 27 and 29, 2000. A second round of indoor air quality sampling was conducted between March 27 and June 15, 2001 in select residences on Coffin Street (including Taber Mills). TCE and petroleum constituents were detected in several residences at concentrations greater than MassDEP Residential Threshold Values (TVs). MassDEP used the CGI air monitoring data to conduct an Imminent Hazard analysis and concluded that no conditions were identified which required immediate actions to protect the health and safety of the public. MassDEP did, however, recommend further investigation.

In March 2000, the City of New Bedford took possession of the Site for tax purposes. In May, 2000 Vanesse Hangen Brustlin (VHB), the general contractor for the building demolition, removed additional contents of the building that were reportedly disposed of as hazardous waste.

Between March 27 and June 15, 2001, CGI conducted additional subsurface investigation of the Site, including the installation of seven new monitoring wells (CGW-11 through CGW-17). Soil and groundwater samples were collected for analysis from these well locations. Notable results from these and previous groundwater investigations at the Site are summarized in Figure C-2 of the March 2012 QAPP Addendum NB-G (EPA RFA #06135).

In 2010, the City of New Bedford constructed a parking lot in a portion of the Site. In accordance with MCP regulations, soil management associated with this construction project was conducted as a Release Abatement Measure (RAM) under RTN 4-15373. The RAM Plan was filed in November 2009, soil management activities were completed in the spring and summer of 2010, and RAM Status Reports were filed in March and November 2010. A RAM Completion Report was filed in December 2012.

In 2012 TRC installed four new monitoring wells (TRC-1 through TRC-4) and collected groundwater, soil vapor, and indoor air samples. Groundwater samples were collected from 11 new and previously existing monitoring wells. Thirteen soil vapor sample points were installed in subsurface and subslab locations (within or adjacent to residences and within Taber Mill Apartments) and 24 soil vapor samples were collected during two different sampling events. Indoor air samples were collected from four locations within Taber Mill Apartments.

Tables C-1 and C-2 summarize the soil and groundwater data generated from 1987 through 2001. Table C-3 summarizes the 2012 groundwater analytical data. Figure C-1 shows historical soil boring and monitoring well locations. Historical soil vapor and indoor air data do not pertain to investigations under this QAPP and have therefore not been provided.

Based in part on the results of the indoor air and groundwater investigations performed in 2012, TRC prepared an Assessment of Brownfield Cleanup Alternatives (ABCA) which produced a recommendation for modifications to the existing basement ventilation system at Taber Mill and permanganate injection within the TCE source area. Both remedies will be implemented under a Brownfields Cleanup Grant before March 31, 2013.

3.3 Purpose of Investigation

The objective of this project is to perform additional Site investigative activities that will include characterization of chlorinated VOC concentrations in groundwater and soil, collection of soil samples to assess permanganate treatability characteristics, and collection of groundwater samples subsequent to permanganate injection to provide data to be presented in an IRA Status (or Completion) Report and an Interim Phase II Report to be submitted to MassDEP.

The specific investigation tasks are as follows:

- Install four additional monitoring wells to further assess the nature and extent of chlorinated solvent impacts to groundwater beneath the Site and the neighboring area;
- Install one groundwater monitoring well to replace a well (TRC-3) that was destroyed subsequent to installation in 2012;
- Collect one or two soil samples for treatability parameters to facilitate evaluations of remedial options at the Site; and
- Collect up to six groundwater samples from selected monitoring wells subsequent to permanganate injection.

In February 2013, following the installation of the four additional monitoring wells under the Brownfields Assessment Grant that is associated with this QAPP, six groundwater samples will be collected from selected monitoring wells under the Brownfields Cleanup Grant. Collection of groundwater samples from these monitoring wells (plus existing wells TRC-4 and CGW-8) will be performed under both of the Brownfields grants. Baseline (pre-injection) sampling and the first round of post-injection sampling will be conducted under the Brownfields Cleanup Grant. The second round of post-injection sampling will be performed under the Brownfields Assessment Grant and is discussed in this QAPP Addendum. The first sample round is discussed in QAPP Addendum NB-I and is not further discussed in this QAPP Addendum.

TABLE C-1
Summary of Analytical Results for Soil Samples -1988 through 2001
Payne Cutlery
New Bedford, Massachusetts

Analysis	Analyte	Sample Location:		MCA-1		MCA-2		MCA-3		MCA-4		MCA-5		MCA-6		MCA-7		MCA-8		MCA-9		MCA-10		MCA-11		MW-1			MW-4
		Sample ID:		MCA-1 A	MCA-1 B	MCA-2 A	MCA-2 B	MCA-3 A	MCA-3 B	MCA-4 A	MCA-4 B	MCA-5 A	MCA-5 B	MCA-6 A	MCA-6 B	MCA-7 A	MCA-7 B	MCA-8 A	MCA-8 B	MCA-9 A	MCA-9 B	MCA-10 A	MCA-10 B	MCA-11 A	MCA-11 B	MW-1	MW-1	MW-1	MW-4
		Screen Interval (ft.):		0.0-0.5	1.5-2.0	0.0-0.5	1.5-2.0	0.0-0.6	1.0-1.5	0.0-0.6	1.5-2.0	0.0-0.5	1.5-2.0	0.0-0.5	1.5-2.0	0.0-0.5	1.5-2.0	0.0-1.5	1.5-2.0	0.0-0.5	1.5-2.0	0.0-0.5	1.0-1.5	0.0-0.5	1.5-2.0	0.5-2.0	5.0-6.5	10.0-11.5	5.0-6.5
		Sample Date:		2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	2/25/1987	7/3/1987	7/3/1987	7/3/1987	6/25/1987
		S-1/GW-2	S-1/GW-3																										
Organics																													
(mg/kg)	C9-C10 Aromatics	100	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	C9-C18 Aliphatics	1,000	1,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Benzo(a)anthracene	7	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Chrysene	70	70	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Benzo(b)fluoranthene	7	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Benzo(a)pyrene	2	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Indeno(1,2,3-cd)pyrene	7	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Dibenzo(a,h)anthracene	0.7	0.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Trichloroethylene	2	90	**0.007**	**0.007**	**0.015**	**0.025**	**0.073**	**0.06**	**0.125**	**0.55**	**30**	**60**	**0.15**	**0.10**	**1.4**	**3.0**	**10**	**0.8**	**0.5**	**0.015**	**0.015**	**0.015**	**0.015**	**0.015**	**0.016**	0.015 U	**1.3**	NA
Metals																													
(mg/kg)	Nickel	20	20	NA	NA	NA	2.0 U	**1.6**	**620**	NA	**870**	NA	**49**	NA	**220**	NA	NA	**280**	NA	**29**	NA	NA	**15**	NA	**58**	NA	NA	NA	**0.14**
	Chromium	30	30	NA	NA	NA	NA	**350**	**120**	NA	**130**	NA	**92**	NA	NA	NA	NA	**310**	NA	**74**	NA	NA	NA	NA	**45**	NA	NA	NA	NA

Note:
mg/kg - milligrams per kilogram (dry weight) or parts per million (ppm).
NA - Sample not analyzed for the listed analyte.
U - Compound was not detected at specified quantitation limit.
Values in **Bold** indicate the compound was detected.
Values shown in Bold and shaded type exceed one or more of the listed standards.
EPH - Extractable Petroleum Hydrocarbons.

TABLE C-1
Summary of Analytical Results for Soil Samples -1988 through 2001
Payne Cutlery
New Bedford, Massachusetts

Analysis	Analyte	Sample Location:		CGW-1	CGW-2	CGW-3		CGW-4	CGW-5	CGW-6	CGW-7	CGW-8		CGW-9	CGW-10	CGW-11	CGW-12	
		Sample ID:		CGW-1/S-3	CGW-2/S-3	CGW-3/S-3	CGW-3/S-3D	CGW-4/S-3	CGW-5/S-3	CGW-6/S-3	CGW-7/S-3	CGW-8/S-3	CGW-8/S-3D	CGW-9/S-3	CGW-10/S-3	CGW-11/S-3	CGW-12/S-1	CGW-12/S-2
		Screen Interval (ft.):		10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-12	0-2	5-7
		Sample Date:		2/24/2000	2/24/2000	2/24/2000	2/24/2000	2/24/2000	2/25/2000	2/25/2000	2/25/2000	2/25/2000	2/25/2000	2/25/2000	4/10/2001	4/10/2001	5/29/2001	5/29/2001
		S-1/GW-2	S-1/GW-3				Field Dup						Field Dup					
Organics																		
(mg/kg)	C9-C10 Aromatics	100	100	7.2 U	11.8 U	**110**	**110**	10.0 U	6.8 U	6.7 U	8.3 U	6.4 U	5.7 U	8.9 U	NA	NA	NA	5.9 U
	C9-C18 Aliphatics	1,000	1,000	3.3 U	3.2 U	**840**	**950**	3.3 U	3.2 U	3.1 U	3.2 U	3.1 U	3.1 U	3.2 U	NA	NA	**5.4**	3.2 U
	Benzo(a)anthracene	7	7	0.55 U	0.54 U	0.52 U	1.08 U	0.54 U	0.54 U	0.52 U	0.53 U	0.52 U	0.52 U	0.54 U	NA	NA	**12**	0.53 U
	Chrysene	70	70	0.55 U	0.54 U	0.52 U	1.08 U	0.54 U	0.54 U	0.52 U	0.53 U	0.52 U	0.52 U	0.54 U	NA	NA	**11**	0.53 U
	Benzo(b)fluoranthene	7	7	0.55 U	0.54 U	0.52 U	1.08 U	0.54 U	0.54 U	0.52 U	0.53 U	0.52 U	0.52 U	0.54 U	NA	NA	**12**	0.53 U
	Benzo(a)pyrene	2	2	0.55 U	0.54 U	0.52 U	1.08 U	0.54 U	0.54 U	0.52 U	0.53 U	0.52 U	0.52 U	0.54 U	NA	NA	**9.2**	0.53 U
	Indeno(1,2,3-cd)pyrene	7	7	0.55 U	0.54 U	0.52 U	1.08 U	0.54 U	0.54 U	0.52 U	0.53 U	0.52 U	0.52 U	0.54 U	NA	NA	**7.7**	0.53 U
	Dibenzo(a,h)anthracene	0.7	0.7	0.55 U	0.54 U	0.52 U	1.08 U	0.54 U	0.54 U	0.52 U	0.53 U	0.52 U	0.52 U	0.54 U	NA	NA	**7.7**	0.53 U
	Trichloroethylene	2	90	0.081 U	0.055 U	0.072 U	0.10 U	0.078 U	0.066 U	0.085 U	**0.17**	**4.7**	**3.9**	**0.78**	0.001 U	**0.01**	**0.0045**	0.059 U
Metals																		
(mg/kg)	Nickel	20	20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Chromium	30	30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note:
mg/kg - milligrams per kilogram (dry weight) or parts per million (ppm).
NA - Sample not analyzed for the listed analyte.
E - Value exceeds calibration range.
U - Compound was not detected at specified quantitation limit.
Values in **Bold** indicate the compound was detected.
Values shown in Bold and shaded type exceed one or more of the listed standards.
EPH - Extractable Petroleum Hydrocarbons.

TABLE C-1
Summary of Analytical Results for Soil Samples -1988 through 2001
Payne Cutlery
New Bedford, Massachusetts

Analysis	Analyte	Sample Location:		CGW-13			CGW-14		CGW-15		CGW-16		CGW-17				SB-1	SB-2	SS-1
		Sample ID:		CGW-13/S-1	CGW-13/S-2	CGW-13/S-2D	CGW-14/S-1	CGW-14/S-4	CGW-15/S-1	CGW-15/S-2	CGW-16/S-1	CGW-16/S-2	CGW-17/S-1	CGW-17/S-2	CGW-17/S-3	CGW-17/S-4	SB-1/S-3	SB-2/S-3	SS-1
		Screen Interval (ft.):		0-2	5-7	5-7	0-2	15-17	0-2	5-7	0-2	5-7	TFAF	TFAF	TFAF	TFAF	7-11	7-11	0-0.5
		Sample Date:		5/29/2001	5/29/2001	5/29/2001	5/29/2001	5/30/2001	5/30/2001	5/30/2001	5/30/2001	5/30/2001	5/30/2001	5/30/2001	5/30/2001	5/30/2001	3/6/2000	3/6/2000	Unknown
		S-1/GW-2	S-1/GW-3			Field Dup													
Organics																			
(mg/kg)	C9-C10 Aromatics	100	100	NA	NA	NA	NA	5.9 U	NA	6.1 U	NA	NA	6.6 U	6.8 U	6.4 U	4.3 U	9.8 U	7.2 U	7.6 U
	C9-C18 Aliphatics	1,000	1,000	**9.5**	**1.6**	**1.6**	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	3.1 U	NA	NA	NA	NA	3.2 U	3.2 U	**7.3**
	Benzo(a)anthracene	7	7	**8.7**	0.53 U	0.54 U	**1.8**	0.55 U	**1.50**	0.55 U	0.55 U	0.52 U	NA	NA	NA	NA	0.5 U	0.52 U	**1.3**
	Chrysene	70	70	**8.2**	0.53 U	0.54 U	**1.0**	0.55 U	**0.93**	0.55 U	0.55 U	0.52 U	NA	NA	NA	NA	0.5 U	0.52 U	**1.7**
	Benzo(b)fluoranthene	7	7	**9.0**	0.53 U	0.54 U	**1.5**	0.55 U	**1.30**	0.55 U	0.55 U	0.52 U	NA	NA	NA	NA	0.5 U	0.52 U	**1.7**
	Benzo(a)pyrene	2	2	**6.0**	0.53 U	0.54 U	**1.2**	0.55 U	**1.10**	0.55 U	0.55 U	0.52 U	NA	NA	NA	NA	0.5 U	0.52 U	**1.3**
	Indeno(1,2,3-cd)pyrene	7	7	**4.9**	0.53 U	0.54 U	**1.0**	0.55 U	**0.96**	0.55 U	0.55 U	0.52 U	NA	NA	NA	NA	0.5 U	0.52 U	**1.4**
	Dibenzo(a,h)anthracene	0.7	0.7	**4.9**	0.53 U	0.54 U	**1.0**	0.55 U	**0.96**	0.55 U	0.55 U	0.52 U	NA	NA	NA	NA	0.5 U	0.52 U	**1.4**
	Trichloroethylene	2	90	**0.029**	0.048 U	NA	**0.098**	0.059 U	**71**	**1.40**	**530**	NA	**57 E**	**33 E**	**41 E**	**19 E**	0.002 U	0.002 U	0.085 U
Metals																			
(mg/kg)	Nickel	20	20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Chromium	30	30	**120**	NA	**3.0**	**34**	**7.5**	NA	NA	**78**	**4.0**	NA	NA	NA	NA	NA	NA	NA

Note:
mg/kg - milligrams per kilogram (dry weight) or parts per million (ppm).
NA - Sample not analyzed for the listed analyte.
E - Value exceeds calibration range.
U - Compound was not detected at specified quantitation limit.
Values in **Bold** indicate the compound was detected.
Values shown in Bold and shaded type exceed one or more of the listed standards.
EPH - Extractable Petroleum Hydrocarbons.

TABLE C-2
Summary of Analytical Results for Groundwater Samples - 1987 through 2001
Payne Cutlery
New Bedford, Massachusetts

Analysis	Analyte		Sample Location:	CGW-1	CGW-2	CGW-3	CGW-4	CGW-5	CGW-6	CGW-7	CGW-8	CGW-9	CGW-10	CGW-11	CGW-12	CGW-13	CGW-14	CGW-15	CGW-16	CGW-17		CW-1	CW-2
			Sample ID:	CGW-1	CGW-2	CGW-3	CGW-4	CGW-5	CGW-6	CGW-7	CGW-8	CGW-9	CGW-10	CGW-11	CGW-12	CGW-13	CGW-14	CGW-15	CGW-16	CGW-17	CGW-17	CW-1	CW-2
			Screeen Interval (ft.):										5-15	4-14	4-14	2-12	5-15	4-14	5-15	5-20	5-20	9-14	9.9-14.9
			Sample Date:	3/2/2000	3/2/2000	3/2/2000	3/2/2000	3/2/2000	3/2/2000	3/2-10/2000	3/2/2000	3/2/2000	6/15/2001	6/15/2001	6/15/2001	6/15/2001	6/15/2001	6/15/2001	6/15/2001	6/15/2001	6/15/2001	2/14/2001	2/14/2001
		GW-2	**GW-3**																		Field Dup		
VPH																							
(ug/L)	C5 to C8 Aliphatics	3,000	50,000	240 U	240 U	240 U	240 U	240 U	240 U	**950**	**29,000**	**4,000**	NA	NA	240 U	2400 U	240 U	240 U	240 U	**3,000**	**2,800**	NA	NA
	C9 to C12 Aliphatics	5,000	50,000	100 U	100 U	**240**	100 U	100 U	100 U	100 U	100 U	**3,800**	NA	NA	100 U	**1,300**	100 U	100 U	100 U	100 U	100 U	NA	NA
	C9 to C10 Aromatics	7,000	50,000	70 U	70 U	**200**	140 U	70 U	70 U	70 U	**300**	**5,700**	NA	NA	**5.4**	**320**	**5.1**	5 U	5 U	**16**	**17**	NA	NA
EPH																							
(ug/L)	C9 to C18 Aliphatics	5,000	50,000	38 U	38 U	**410**	56 U	31 U	NA	45 U	40 U	**7,900**	NA	NA	ND	ND	ND	ND	ND	ND	ND	NA	NA
	C19 to C36 Aliphatics	NS	50,000	51 U	51 U	51 U	48 U	42 U	NA	60 U	53 U	**20,000**	NA	NA	ND	ND	ND	ND	ND	ND	ND	NA	NA
	C11 to C22 Aromatics	50,000	5,000	110 U	110 U	**560**	100 U	88 U	NA	70 U	110 U	**4,000**	NA	NA	ND	ND	ND	ND	ND	ND	ND	NA	NA
VOCs																							
(ug/L)	Trichloroethylene	30	5,000	2 U	2 U	**1**	2 U	2 U	2 U	**2,100**	**89,000**	**2,400**	2 U	**22**	2 U	**15 J**	**120**	**94**	**140**	**8,400**	**8,700**	5 U	5 U
	Tetrachloroethylene	50	30,000	NA	NA	NA	NA	NA	NA	NA	2000 U	NA	NA	NA	NA	NA	NA	NA	NA	**110**	**140**	NA	NA
	Dichloroethylene, cis-1,2-	100	50,000	NA	NA	NA	NA	NA	NA	NA	2000 U	NA	NA	NA	NA	NA	NA	NA	NA	**240**	**240**	NA	NA

Note:
ug/L - micrograms per liter.
NA - Sample not analyzed for the listed analyte.
ND - Not detected; Reporting limit not provided.
NP - Not provided.
Values in **Bold** indicate the compound was detected.
Values shown in Bold and shaded type exceed one or more of the listed standards.
VPH - Volatile Petroleum Hydrocarbons.
EPH - Extractable Petroleum Hydrocarbons.
VOCs - Volatile Organic Compounds.

TABLE C-2
Summary of Analytical Results for Groundwater Samples - 1987 through 2001
Payne Cutlery
New Bedford, Massachusetts

Analysis	Analyte		Sample Location:	CW-3	CW-4	CW-5	CW-6	CW-7	CW-8	CW-9	CW-10	CW-11	BMW-1	MW-1	MW-2		MW-2A	MW-3A	MW-4	MW-5	SB-1	SB-2
			Sample ID:	CW-3	CW-4	CW-5	CW-6	CW-7	CW-8	CW-9	CW-10	CW-11	BMW-1	MW-1 (GHR)	MW-2 (GHR)	MW-2 (GHR)	MW-2A (GHR)	MW-3A (GHR)	MW-4 (GHR)	MW-5 (GHR)	SB-1	SB-2
			Screeen Interval (ft.):	9.3-14.3	8-13	10.6-15.6	10-15	9.5-14.5	9-14	9.5-15.4	9.3-14.3	9.5-14.5		4-14	19-29	22-27	5-15	10-20	5-15	5-15		
			Sample Date:	2/14/2001	2/14/2001	2/15/2001	2/15/2001	2/15/2001	2/15/2001	2/15/2001	2/15/2001	2/15/2001		7/14/1987	7/14/1987	7/14/1987	7/14/1987	7/14/1987	7/14/1987	7/14/1987	3/7/2000	3/7-10/2000
		GW-2	**GW-3**																			
VPH																						
(ug/L)	C5 to C8 Aliphatics	3,000	50,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	240 U	NA	NA	NA	NA	NA	NA	NA	240 U	240 U
	C9 to C12 Aliphatics	5,000	50,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	100 U	NA	NA	NA	NA	NA	NA	NA	100 U	100 U
	C9 to C10 Aromatics	7,000	50,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	70 U	NA	NA	NA	NA	NA	NA	NA	70 U	70 U
EPH																						
(ug/L)	C9 to C18 Aliphatics	5,000	50,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	31 U	NA	NA	NA	NA	NA	NA	NA	39 U	44 U
	C19 to C36 Aliphatics	NS	50,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	41 U	NA	NA	NA	NA	NA	NA	NA	53 U	59 U
	C11 to C22 Aromatics	50,000	5,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	87 U	NA	NA	NA	NA	NA	NA	NA	210 U	120 U
VOCs																						
(ug/L)	Trichloroethylene	30	5,000	5 U	5 U	5 U	5 U	**260**	**15,000**	**16**	5 U	**7,900**	**20**	**53,000**	NP	NP	NP	**3.2**	**26**	NP	2 U	**5**
	Tetrachloroethylene	50	30,000	NA	NA	NA	NA	NA	**140**	NA	NA	**180**	NA	**560**	NA	NA	NA	NA	NA	NA	NA	NA
	Dichloroethylene, cis-1,2-	100	50,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**6,290**	NA	NA	NA	NA	NA	NA	NA	NA

Note:
ug/L - micrograms per liter.
NA - Sample not analyzed for the listed analyte.
ND - Not detected; Reporting limit not provided.
NP - Not provided.
Values in **Bold** indicate the compound was detected.
Values shown in Bold and shaded type exceed one or more of the listed standards.
VPH - Volatile Petroleum Hydrocarbons.
EPH - Extractable Petroleum Hydrocarbons.
VOCs - Volatile Organic Compounds.

Table C-3: Summary of for Groundwater Analytical Results -- April 2012
Payne Cutlery
New Bedford, Massachusetts

Analysis	Analyte		Sample ID:	CGW-8		CGW-10	CGW-11	CGW-14	CGW-15	CGW-16	CGW-17	TRC-1	TRC-2	TRC-3	TRC-4
			Sample Date:	4/5/2012	4/5/2012	4/5/2012	4/11/2012	4/5/2012	4/5/2012	4/5/2012	4/5/2012	4/4/2012	4/4/2012	4/4/2012	4/4/2012
		GW-2	GW-3		Field Dup										
VOCs															
(ug/L)	Acetone	50,000	50,000	5,000 U	5,000 U	10 U	50 U	**10**	10 U	10 U	10 U	10 U	20 U	200 U	200 U
	tert-Amyl Methyl Ether (TAME)	NS	NS	250 U	250 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	10 U	10 U
	Benzene	2,000	10,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Bromobenzene	NS	NS	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Bromochloromethane	NS	NS	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Bromodichloromethane	6	50,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Bromoform	700	50,000	500 U	500 U	1.0 U	5.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Bromomethane	7	800	2,500 U	2,500 U	5.0 U	2.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	10 U	100 U	100 U
	2-Butanone (MEK)	50,000	50,000	5,000 U	5,000 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	20 U	200 U	200 U
	n-Butylbenzene	7,000(1)	50,000(1)	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	sec-Butylbenzene	7,000(1)	50,000(1)	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	tert-Butylbenzene	7,000(1)	50,000(1)	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	tert-Butyl Ethyl Ether (TBEE)	NS	NS	250 U	250 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	10 U	10 U
	Carbon Disulfide	NS	NS	2,500 U	2,500 U	5.0 U	10 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	10 U	100 U	100 U
	Carbon Tetrachloride	2	5,000	500 U	500 U	1.0 U	2.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Chlorobenzene	200	1,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Chlorodibromomethane	20	50,000	250 U	250 U	0.50 U	5.0 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	10 U	10 U
	Chloroethane	NS	NS	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	Chloroform	50	20,000	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	Chloromethane	NS	NS	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	2-Chlorotoluene	NS	NS	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	4-Chlorotoluene	NS	NS	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,2-Dibromo-3-chloropropane (DBCP	NS	NS	1,000 U	1,000 U	2.0 U	5.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	1,2-Dibromoethane (EDB)	2	50,000	250 U	250 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	10 U	10 U
	Dibromomethane	NS	NS	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,2-Dichlorobenzene	2000	2,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,3-Dichlorobenzene	2,000	50,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,4-Dichlorobenzene	200	8,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Dichlorodifluoromethane (Freon 12)	NS	NS	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	1,1-Dichloroethane	1,000	20,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,2-Dichloroethane	5	20,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,1-Dichloroethylene	80	30,000	500 U	500 U	1.0 U	**1.5**	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	cis-1,2-Dichloroethylene	100	50,000	**8,200**	**6,500**	1.0 U	**160**	1.0 U	1.0 U	**6.3**	**1.1**	1.0 U	**56**	**61**	**50**
	trans-1,2-Dichloroethylene	90	50,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,2-Dichloropropane	3	50,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,3-Dichloropropane	NS	NS	250 U	250 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	10 U	10 U
	2,2-Dichloropropane	NS	NS	500 U	500 U	1.0 U	2.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,1-Dichloropropene	NS	NS	250 U	250 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	10 U	10 U
	cis-1,3-Dichloropropene	10(2)	200(2)	200 U	200 U	0.40 U	2.0 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.80 U	8.0 U	8.0 U
	trans-1,3-Dichloropropene	10(2)	200(2)	200 U	200 U	0.40 U	5.0 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.80 U	8.0 U	8.0 U
	Diethyl Ether	NS	NS	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	Diisopropyl Ether (DIPE)	NS	NS	250 U	250 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	10 U	10 U
	1,4-Dioxane	6,000	50,000	50,000 U	50,000 U	100 U	50 U	100 U	100 U	100 U	100 U	100 U	200 U	2,000 U	2,000 U
	Ethylbenzene	20,000	5,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Hexachlorobutadiene	1	3,000	250 U	250 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	10 U	10 U
	2-Hexanone (MBK)	NS	NS	5,000 U	5,000 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	20 U	200 U	200 U
	Isopropylbenzene (Cumene)	7,000(1)	50,000(1)	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	p-Isopropyltoluene (p-Cymene)	7,000(1)	50,000(1)	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Methyl tert-Butyl Ether (MTBE)	50,000	50,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Methylene Chloride	10,000	50,000	2,500 U	2,500 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	10 U	100 U	100 U
	4-Methyl-2-pentanone (MIBK)	50,000	50,000	5,000 U	5,000 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	20 U	200 U	200 U
	Naphthalene	1,000	20,000	2,500 U	2,500 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	10 U	100 U	100 U
	n-Propylbenzene	7,000(1)	50,000(1)	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Styrene	100	6,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,1,1,2-Tetrachloroethane	10	50,000	500 U	500 U	1.0 U	5.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,1,2,2-Tetrachloroethane	9	50,000	250 U	250 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	1.0 U	10 U	10 U
	Tetrachloroethylene	50	30,000	**740**	**750**	1.0 U	**2.5**	1.0 U	1.0 U	**1.9**	1.0 U	1.0 U	**18**	**68**	**20**
	Tetrahydrofuran	NS	NS	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	Toluene	50,000	40,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,2,3-Trichlorobenzene	NS	NS	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	1,2,4-Trichlorobenzene	2,000	50,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,1,1-Trichloroethane	4,000	20,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,1,2-Trichloroethane	900	50,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Trichloroethylene	30	5,000	**42,000**	**44,000**	1.0 U	**1,500**	**1.3**	**3.5**	**20**	**11**	**15**	**240**	**1,100**	**1,800**
	Trichlorofluoromethane (Freon 11)	NS	NS	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	1,2,3-Trichloropropane	NS	NS	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	1,2,4-Trimethylbenzene	7,000(1)	50,000(1)	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	1,3,5-Trimethylbenzene	7,000(1)	50,000(1)	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U
	Vinyl Chloride	2	50,000	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	m+p Xylene	9,000	5,000	1,000 U	1,000 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	40 U	40 U
	o-Xylene	9,000	5,000	500 U	500 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	2.0 U	20 U	20 U

Table C-3: Summary of for Groundwater Analytical Results -- April 2012
Payne Cutlery
New Bedford, Massachusetts

Analysis	Analyte		Sample ID:	CGW-8		CGW-10	CGW-11	CGW-14	CGW-15	CGW-16	CGW-17	TRC-1	TRC-2	TRC-3	TRC-4
			Sample Date:	4/5/2012	4/5/2012	4/5/2012	4/11/2012	4/5/2012	4/5/2012	4/5/2012	4/5/2012	4/4/2012	4/4/2012	4/4/2012	4/4/2012
		GW-2	GW-3		Field Dup										
VPH															
(ug/L)	C5-C8 Aliphatics	3,000	50,000	**15,000**	**14,000**	100 U	**1,200**	NA	NA	NA	100 U	100 U	**130**	NA	**800**
	C9-C12 Aliphatics	5,000	50,000	1,000 U	1,000 U	100 U	100 U	NA	NA	NA	100 U	100 U	100 U	NA	100 U
	C9-C10 Aromatics	7,000	50,000	1,000 U	1,000 U	100 U	100 U	NA	NA	NA	100 U	100 U	100 U	NA	100 U
	Benzene	2,000	10,000	10 U	10 U	1.0 U	1.0 U	NA	NA	NA	1.0 U	1.0 U	1.0 U	NA	1.0 U
	Ethylbenzene	20,000	5,000	10 U	10 U	1.0 U	1.0 U	NA	NA	NA	1.0 U	1.0 U	1.0 U	NA	1.0 U
	Methyl tert-Butyl Ether (MTBE)	50,000	50,000	10 U	10 U	1.0 U	1.0 U	NA	NA	NA	1.0 U	1.0 U	1.0 U	NA	1.0 U
	Naphthalene	1,000	20,000	50 U	50 U	5.0 U	5.0 U	NA	NA	NA	5.0 U	5.0 U	5.0 U	NA	5.0 U
	Toluene	50,000	40,000	10 U	10 U	1.0 U	1.0 U	NA	NA	NA	1.0 U	1.0 U	1.0 U	NA	1.0 U
	m+p Xylene	9,000	5,000	20 U	20 U	2.0 U	2.0 U	NA	NA	NA	2.0 U	2.0 U	2.0 U	NA	2.0 U
	o-Xylene	9,000	5,000	10 U	10 U	1.0 U	1.0 U	NA	NA	NA	1.0 U	1.0 U	1.0 U	NA	1.0 U
EPH															
(ug/L)	C9-C18 Aliphatics	5,000	50,000	100 U	100 U	NA	100 U	NA	NA	NA	NA	100 U	100 U	NA	100 U
	C19-C36 Aliphatics	NS	50,000	100 U	100 U	NA	100 U	NA	NA	NA	NA	100 U	100 U	NA	100 U
	C11-C22 Aromatics	50,000	5,000	100 U	100 U	NA	100 U	NA	NA	NA	NA	100 U	100 U	NA	100 U
	Acenaphthene	NS	6,000	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Acenaphthylene	10,000	40	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Anthracene	NS	30	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Benzo(a)anthracene	NS	1,000	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Benzo(a)pyrene	NS	500	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Benzo(b)fluoranthene	NS	400	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Benzo(g,h,i)perylene	NS	20	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Benzo(k)fluoranthene	NS	100	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Chrysene	NS	70	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Dibenz(a,h)anthracene	NS	40	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Fluoranthene	NS	200	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Fluorene	NS	40	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Indeno(1,2,3-cd)pyrene	NS	100	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	2-Methylnaphthalene	2,000	20,000	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Naphthalene	1,000	20,000	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Phenanthrene	NS	10,000	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U
	Pyrene	NS	20	2.0 U	2.0 U	NA	2.0 U	NA	NA	NA	NA	2.0 U	2.0 U	NA	2.0 U

Notes:

ug/L - micrograms per liter.

NA - Sample not analyzed for the listed analyte.

NS - No MassDEP standards exist for this analyte.

U - Compound was not detected at specified quantitation limit.

Values in **Bold** indicate the compound was detected.

Values shown in Bold and shaded type exceed one or more of the listed MassDEP Method 1 standards.

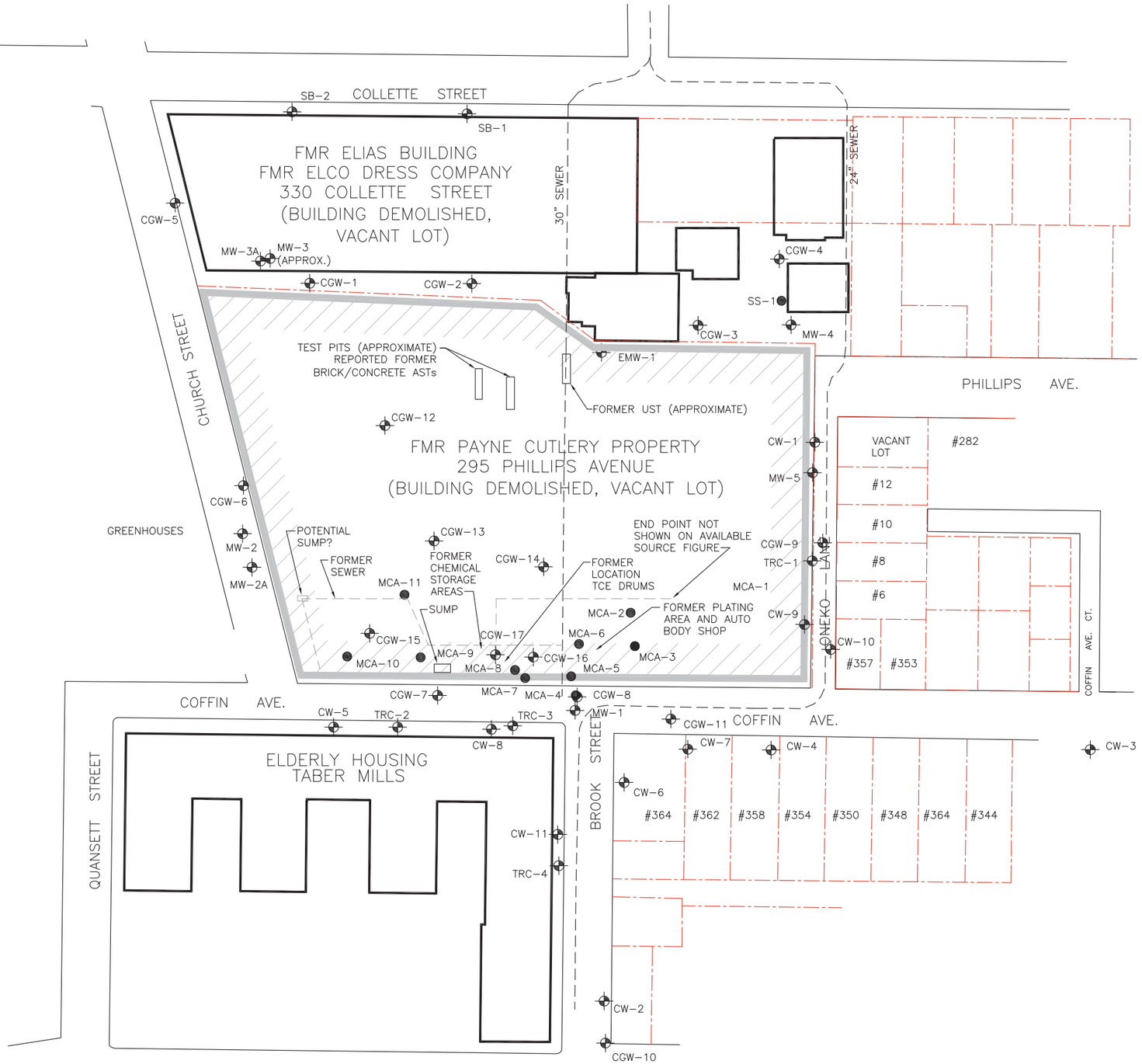
VOCs - Volatile Organic Compounds.

VPH - Volatile Petroleum Hydrocarbons.

EPH - Extractable Petroleum Hydrocarbons.

(1) - MassDEP Method 1 standards for C9-C10 aromatic hydrocarbons used.

(2) - MassDEP Method 1 standards for 1,3-Dichloropropene used.



LEGEND:

- MCA-2 SOIL BORINGS BY OTHERS
- CW-4 GROUNDWATER MONITORING WELLS
- DELINEATES APPROXIMATE BOUNDARY OF FORMER PAYNE CUTLERY PROPERTY.

APPROXIMATE GRAPHIC SCALE

0' 50' 100' 200'

FORMER PAYNE CUTLERY
295 PHILLIPS AVENUE
NEW BEDFORD, MA.

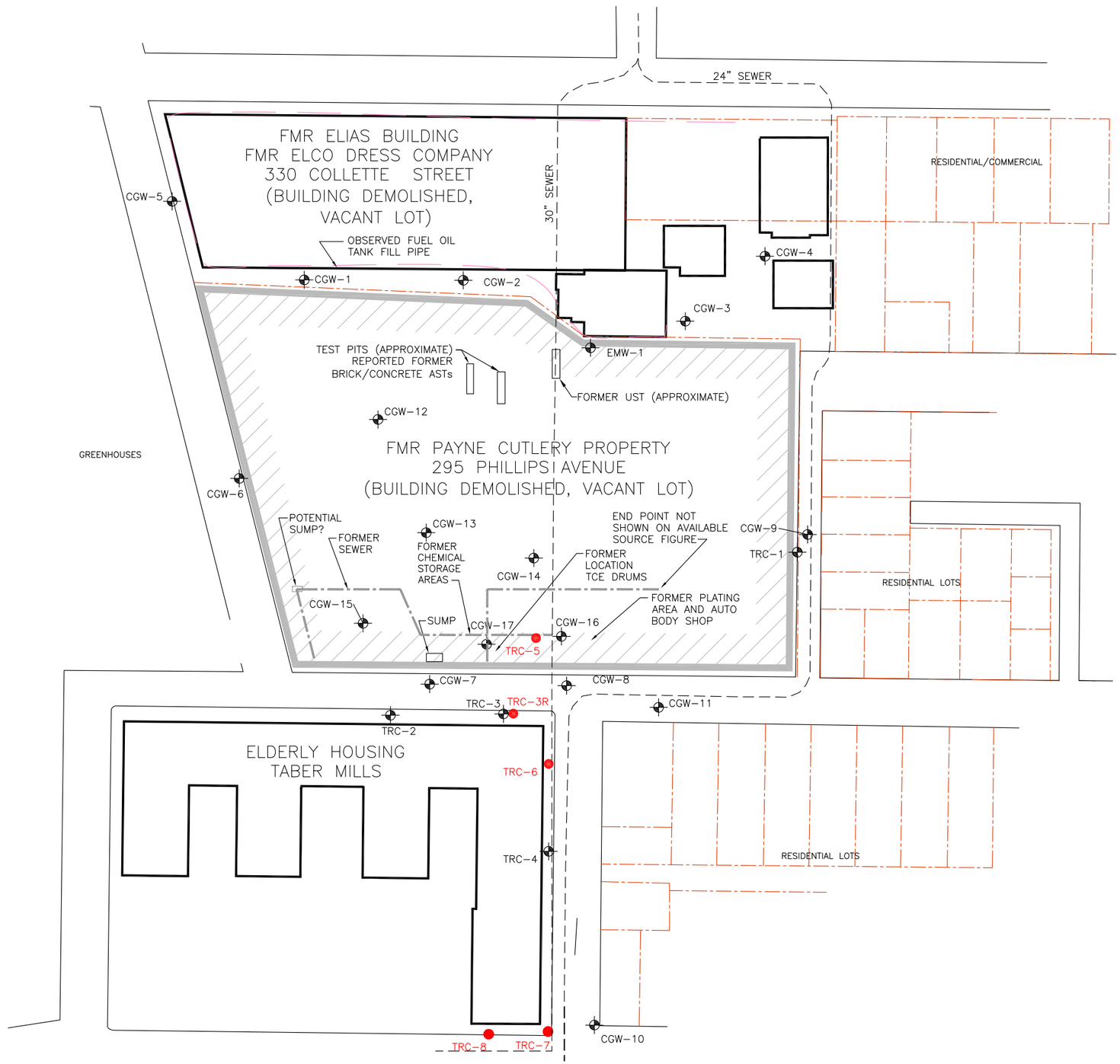
HISTORICAL SOIL BORING AND MONITORING WELL LOCATIONS

TRC
Wannalancit Mills
650 Suffolk Street
Lowell, MA 01854
(978) 970-5600

FIGURE
C-1

DRAWN BY: HWB
CHECKED BY: ACL
DATE: JAN 2013

FILE: T:\E_CAD\172744\HIST SOIL BORING & MW LOCS.dwg



LEGEND:

- EXISTING GROUNDWATER MONITORING WELL
- PROPOSED SOIL BORING AND MONITORING WELL LOCATION
- APPROX. LOCATION OF SEWER LINE
- APPROX. LOCATION OF FORMER SEWER LINE

NOTES:
1. BASE MAP WAS DIGITIZED FROM A COPY OF AN UNDATED PLAN ENTITLED "SITE PLAN" PREPARED BY CYGNUS GROUP OF SOUTHBOROUGH MA. FIG 2 ORIGINAL SCALE 1"=50'.

APPROXIMATE GRAPHIC SCALE
0' 50' 100' 200'

FORMER PAYNE CUTLERY
295 PHILLIPS AVENUE
NEW BEDFORD, MA

PROPOSED SOIL BORING AND MONITORING WELL LOCATIONS

TRC
Wannalancit Mills
650 Suffolk Street
Lowell, MA 01854
(978) 970-5600

FIGURE
C-2

DRAWN BY: HWB
CHECKED BY: ACL
DATE: JAN 2013

FILE: T:\E_CAD\172744\WELL_LOCATIONS_2013_01_17.dwg

4.0 FORM D – PROJECT OBJECTIVES AND SCHEDULE

4.1 Project Objectives

Preparation of a Site-Specific Health and Safety Plan

Prior to initiating subsurface assessment fieldwork, TRC will prepare a site-specific Health and Safety Plan (HASP) to ensure the safety of TRC employees performing environmental investigation activities on-Site. The HASP will be developed in accordance with the requirements set forth in 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response*. Specifically, the HASP will identify and detail potential site hazards, appropriate action limits for each hazard, required task-specific personal protective equipment, decontamination procedures, and proper protocols for emergency events if encountered. The HASP will be provided to project personnel and will be adhered to during on-Site investigation activities. A copy of the HASP will be on-Site at all times during investigation activities.

Soil Boring Advancement and Soil Samples

Five (5) soil borings (TRC-3R and TRC-5 through TRC-8) will be installed using hollow stem auger drilling techniques. The locations of the soil borings may be adjusted based upon the results of utility locations, drilling refusal, or other field constraints. The soil borings are estimated to be installed to a maximum depth of 20 feet below ground surface (bgs). Proposed soil borings locations are depicted on Figure C-2. Soil borings TRC-3R, TRC-6, TRC-7, and TRC-8 are being advanced only for the purpose of installing monitoring wells. Soil boring TRC-5 is being installed in order to evaluate remedial options in the presumed source area and for the purpose of installing a monitoring well.

Two subsurface soil samples will be collected from TRC-5 for treatability analyses. One soil sample may be collected from borings TRC-6, TRC-7 or TRC-8 for VOC analysis if jar headspace readings exceed 20 parts per million by volume (ppmv). It should be noted that if jar headspace readings are significantly elevated in TRC-6, one sample for treatability analyses may be collected here instead of two samples at TRC-5. Samples will not be collected from TRC-3R as this boring is being installed to replace a damaged well. Refer to Table E-1 for the proposed soil samples to be collected including proposed chemical analyses.

Monitoring Well Installation and Groundwater Samples

Five of the soil borings will be completed as two-inch diameter poly-vinyl chloride (PVC) monitoring wells. Following well development, one groundwater sample will be collected from four of the monitoring wells for laboratory analysis of VOCs. Refer to Table E-1 for the proposed groundwater samples to be collected.

Groundwater Elevation Survey and Non-Aqueous Phase Liquid (NAPL) Measurement

After groundwater monitoring well installation and development, TRC will conduct a relative elevation survey of the newly-installed wells. Top of well riser elevations will be surveyed to an arbitrary benchmark. Depth to groundwater from the top of the well riser will be measured using an oil/water interface probe to concurrently monitor for the presence of NAPL. The elevation survey information, in conjunction with the depth to groundwater measurements, will be used to further assess the shallow groundwater flow across the Site.

4.2 Project Deliverables

An Interim Phase II Comprehensive Site Assessment report and Tier Classification submittal will be prepared that will include a summary of the work conducted, Site history, and Site testing results based on the above-described work and other recently completed work. An IRA Status Report (or IRA Completion Report) will also be prepared.

4.3 Project Timeline

Activities	Project Start	Project End
QAPP Addendum Submission	1/21/13	1/25/13
EPA Approval	1/25/13	2/8/13
Field Work	2/8/13	5/15/13
Regulatory Reports	4/22/13	6/15/13

4.4 Regulatory Standards/Criteria

Groundwater sample results will be compared to the applicable MCP Method 1 GW-2/GW-3 cleanup standards in an effort to evaluate contaminant conditions and provide a current basis for determining future investigation needs.

Results of soil sampling will be used by the selected permanganate injection vendor to determine the volume and concentration of permanganate solution to inject into the shallow aquifer system. Results of VOCs in soil samples will also be compared to the applicable MCP Method 1 cleanup standards (S-1/GW-2).

5.0 FORM E – SAMPLING DESIGN AND SITE FIGURES

5.1 Proposed Activities

The proposed sample locations, analyses to be performed, and rationale for sample locations are summarized in Table E-1. Proposed soil and groundwater sampling locations are depicted on Figure C-2. The locations of the proposed soil borings and monitoring wells may be adjusted based upon access limitations, utility locations, drilling refusal, or other field constraints.

Soil Boring Advancement and Soil Sampling

Four soil borings (TRC-5 through TRC-8) will be installed using hollow stem auger drilling techniques. The borings will be advanced a minimum of one foot into bedrock at each location to confirm and evaluate the depth and the nature of the bedrock beneath the Site. The locations of the soil borings may be adjusted based upon utility locations, drilling refusal, or other field constraints.

Soil samples will be collected every five feet to an anticipated maximum depth of 20 feet bgs, with the exception of soil boring TRC-5, where soil samples will be collected continuously to an anticipated maximum depth of 20 feet bgs. During the advancement of soil borings, soil samples will be visually examined and screened in the field for VOCs using the jar headspace method. Immediately upon collecting the sample, a photoionization detector (PID), or equivalent, will be passed over the surface of the sample and any organic vapor readings above background will be noted. VOC samples will be immediately and carefully placed (in a manner to minimize volatilization) in preserved vials upon collection, and then immediately placed on ice.

Soils for headspace screening will be transferred for each depth interval into glass jars (≥8oz.), filled approximately halfway, and capped with foil followed by a screw-on lid. Soil jars will be shaken prior to collecting headspace readings. Additionally, soil jars will be warmed in advance of headspace screening if the work is performed during cold temperatures. After at least 10 minutes, soil headspace readings will be obtained by removing the sample caps from each jar and inserting a PID or equivalent through the foil to measure the organic vapor concentration in the headspace. All soil headspace readings will be recorded.

Two subsurface soil samples will be collected from TRC-5 for treatability analyses, with the depth interval to be selected based on field observations (e.g., visual and/or olfactory evidence of contamination) and jar headspace screening results. Soil recovered from the depth interval chosen for sampling will be placed into stainless steel bowls using stainless steel spoons (all equipment to be decontaminated properly prior to use) and subsequently homogenized. The homogenized sample will be transferred to containers with a stainless steel spoon for total organic carbon (TOC) and Permanganate Natural Oxidant Demand (PNOD) analyses and immediately placed on ice in a cooler.

Up to one additional soil sample may be collected from boring locations TRC-6, TRC-7, or TRC-8 for VOC analysis if field observations indicate significant VOC impacts (i.e., greater than 20 ppmv jar headspace readings) at these locations. Table E-1 summarizes the target depth intervals for

sample collection which can be used as a field guide. Actual depth intervals may vary based on field observations.

Soils (excess sample volume, auger cuttings, etc.) will be returned to their place of origin (either placed inside of the boreholes or dispersed near the borehole location) at similar depths from which they were recovered. The PID and visual observations will be used to evaluate if residuals require further handling and disposal (e.g., off-site disposal as regulated wastes). Residuals screened for disposal as a regulated waste will be properly disposed of by the responsible party.

Soil Boring Advancement to Replace Destroyed Monitoring Well TRC-3

One soil boring (TRC-3R) will be installed using hollow stem auger drilling techniques. It will be located as close as possible to the previous location of TRC-3. The boring will be advanced a depth of 15 feet, matching the depth of destroyed well TRC-3. No soil samples will be collected during drilling, since soil characterization was previously performed for boring TRC-3.

Soils (excess sample volume, auger cuttings, etc.) will be returned to their place of origin (either placed inside of the boreholes or dispersed near the borehole location) at similar depths from which they were recovered. The PID and visual observations will be used to evaluate if residuals require further handling and disposal (e.g., off-site disposal as regulated wastes). Residuals screened for disposal as a regulated waste will be properly disposed of by the responsible party.

Monitoring Well Installation

The five soil borings (TRC-3R and TRC-5 through TRC-8) will be completed as groundwater monitoring wells to help refine the nature and extent of the chlorinated solvent plume beneath the Site and neighboring properties.

Each well will be constructed of two-inch diameter Schedule 40 PVC to a maximum anticipated depth of 20 feet. The pipe sections will be threaded screw type, eliminating the need for solvent-based glue. Each well will have 10 feet of 10-slot (0.010-inch machine slotted) screen placed so as to extend above and below the upper surface of the water table. A sand pack will be placed around the screen extending to a level approximately one foot above the top of the screen. A bentonite seal approximately two feet thick will be placed above the sand pack in order to seal off the screened portion of the well from the overlying strata. The remainder of the well annulus will be filled with a cement/bentonite grout to ground surface. A protective road box cover will be installed over the top of the wells and the cap will be flush with the ground surface for any wells located in paved or landscaped areas.

Well Development

Monitoring well development will be performed in the new monitoring wells by removing at least three well volumes by purging with a submersible or peristaltic pump. Any non-dedicated submersible equipment that is put down a well will be decontaminated between locations. Furthermore, well development activities will proceed from the least contaminated location to the most contaminated location. Headspace measurement of VOCs will be made on purged groundwater using the field

screening equipment. If the headspace VOC reading exceeds 10 ppmv, the purge water will be drummed or containerized until the groundwater sample test results are obtained to evaluate disposal options. If the headspace VOC readings are less than 10 ppmv, the well development water will be returned to the ground surface in the source area.

Groundwater Sampling

After development, the monitoring wells will be allowed to stabilize for a period of at least seven days prior to sampling. After stabilizing, depth to groundwater and thickness of light-NAPL (LNAPL; if present) will be gauged within each groundwater well on the Site within a 24-hour period. TRC will conduct a relative elevation survey of the top of the riser at each new well location and measure distances to field-determined reference points to accurately show monitoring well locations on future Site plans. Together the depth to water data, the elevation data, and the well location information will be used to assess groundwater flow beneath the Site.

Groundwater samples will be collected from the four new monitoring wells and existing wells CGW-8 and TRC-4. After purging and prior to sample collection, groundwater from each well will be examined for visual evidence or residual permanganate (a purple tint) and screened for residual permanganate using a spectrophotometer. If permanganate is found to be present in the groundwater collected from a monitoring well, granular sodium thiosulfate will be gradually added to the groundwater sample collected from that well until the permanganate has been neutralized and the water is clear. The addition of sodium thiosulfate to neutralize residual permanganate was recommended in a 2006 EPA report on In-Situ Chemical Oxidation authored by Scott Huling and Bruce Pivetz (EPA/600/R-06/072, August 2006).

Samples will be obtained using low-flow sampling techniques with adjustable rate submersible pumps. Any non-dedicated submersible equipment that is put down a well will be decontaminated between locations. Furthermore, gauging and sampling activities will proceed from the least contaminated location to the most contaminated location. Refer to Table E-1 for an overview of the proposed groundwater samples to be collected, which includes the proposed chemical analyses for each sample. The locations of the proposed and existing monitoring well locations are illustrated on Figure C-2.

5.2 Completeness

Field completeness, which measures the amount of 1) valid measurements obtained from all the measurements taken in the project and 2) valid samples collected, will have an objective of 100 percent. Laboratory completeness, which measures the amount of valid measurements obtained from all valid samples submitted to the laboratory, will have an objective of greater than 95 percent.

Table E-1: Proposed Soil and Groundwater Sampling Program
Former Payne Cutlery, New Bedford, MA

Sample ID[1]	Description	Target Sample Depth Interval	Analyses	Rationale / Notes
Proposed Treatability Soil Sampling				
TRC-5-1	Proposed soil sample for analysis of treatability parameters	TBD[2]	VOCs, TOC, and PNOD	▪ To evaluate the effectiveness and feasibility of chemical injection as a remedial option at the Site.
TRC-5-2*	Proposed soil sample for analysis of treatability parameters	TBD[2]	VOCs, TOC, and PNOD	▪ To evaluate the effectiveness and feasibility of chemical injection as a remedial option at the Site.
Proposed/Potential VOC Soil Sampling[3]				
TRC-6	Proposed/potential soil sample for VOC analysis if headspace readings > 20 ppmv are measured	TBD[2]	VOCs	▪ To assess VOC soil impacts downgradient of the Former Payne Cutlery Site and evaluate the effectiveness and feasibility of chemical injection as a remedial option at the Site.
TRC-7	Proposed/potential soil sample for VOC analysis if headspace readings > 20 ppmv are measured	TBD[2]	VOCs	▪ To assess VOC soil impacts downgradient of the Former Payne Cutlery Site and evaluate the effectiveness and feasibility of chemical injection as a remedial option at the Site.
TRC-8	Proposed/potential soil sample for VOC analysis if headspace readings > 20 ppmv are measured	TBD[2]	VOCs	▪ To assess VOC soil impacts downgradient of the Former Payne Cutlery Site and evaluate the effectiveness and feasibility of chemical injection as a remedial option at the Site.
Proposed Groundwater Sampling				
CGW-8	Existing monitoring well location	Screen interval 5 to 15 ft.	VOCs and Permanganate[4]	▪ To determine the presence or absence of residual permanganate in the groundwater. ▪ To help define the nature and extent of the chlorinated solvent plume originating at the Former Payne Cutlery Site.
TRC-4	Existing monitoring well location	Screen interval 4 to 14 ft.	VOCs and Permanganate[4]	▪ To determine the presence or absence of residual permanganate in the groundwater. ▪ To help define the nature and extent of the chlorinated solvent plume originating at the Former Payne Cutlery Site.
TRC-5	Proposed monitoring well location	TBD[2]	VOCs and Permanganate[4]	▪ To determine the presence or absence of residual permanganate in the groundwater. ▪ To help define the nature and extent of the chlorinated solvent plume originating at the Former Payne Cutlery Site.

Table E-1: Proposed Soil and Groundwater Sampling Program
Former Payne Cutlery, New Bedford, MA

Sample ID[1]	Description	Target Sample Depth Interval	Analyses	Rationale / Notes
TRC-6	Proposed monitoring well location	TBD[2]	VOCs and Permanganate[4]	▪ To determine the presence or absence of residual permanganate in the groundwater. ▪ To help define the nature and extent of the chlorinated solvent plume originating at the Former Payne Cutlery Site.
TRC-7	Proposed monitoring well location	TBD[2]	VOCs and Permanganate[4]	▪ To determine the presence or absence of residual permanganate in the groundwater. ▪ To help define the nature and extent of the chlorinated solvent plume originating at the Former Payne Cutlery Site.
TRC-8	Proposed monitoring well location	TBD[2]	VOCs and Permanganate[4]	▪ To determine the presence or absence of residual permanganate in the groundwater. ▪ To help define the nature and extent of the chlorinated solvent plume originating at the Former Payne Cutlery Site.

Notes:
TOC – total organic carbon
TBD – to be determined
VOCs – volatile organic compounds
PNOD – permanganate natural oxidant demand
PPMV – parts per million by volume
[1]– Actual soil boring and/or monitoring well locations may be adjusted based upon field observations.
[2]– Sample depth may vary based on field screening, visual observations and/or physical constraints at each location.
[3]– If soil headspace readings above 20 ppm are measured during the installation of wells TRC-6 through TRC-8, one soil sample would be submitted for VOC analysis from the boring/depth interval that exhibited the highest headspace reading.
[4]–Permanganate will be screened in the field using a spectrophotometer.

*If any TRC-6 soil sample has higher PID concentrations than any TRC-5 sample, then the highest PID concentration sample from TRC-6 will be analyzed instead of a second TRC-5 sample.

6.0 FORM F – SAMPLING AND ANALYTICAL METHODS REQUIREMENTS

Table F-1: Sampling and QA Summary
Former Payne Cutlery, New Bedford, MA

Field Sample Matrix	Parameter	Sample Type[A]	Estimated Number of Samples	Preparation /Analytical Method References	SOP Reference No.[B]	MassDEP CAM No.	Sample Preservation	Holding Time from Collection	Container
Soil									
Soil	PNOD	Field Sample	Up to 2 samples	ASTM D 7262-07	NA (Lab: Ursus)	NA	Cool to 4°C	Not specified	1-4 oz amber glass jar w/Teflon lined cap
Soil	TOC	Field Sample	Up to 2 samples	SW-846 Method 9060	See Section 7.2 (Lab: Alpha Analytical)	NA	Cool to 4°C	28 days to extraction	1-4 oz amber glass jar w/Teflon lined cap
Soil	VOCs	Field Sample, Field Duplicate and Trip Blank	Up to 3 samples, 1 FD	SW-846 Method 5035A/8260B	prep: 1a analysis: 3a (Lab: Alpha Analytical)	WSC-CAM-IIA	Methanol - preserved in the field and Cool to 4°C (high-level); and water-preserved in the field and Cool to 4°C (low-level) (soil/preservative ratio: 1:1)	High level. 14 days to analysis Low-Level: 48 hours to freezing at <-7°C; 14 days to analysis	2-40 ml Methanol preserved VOA vials (high-level); or 2-40 mL vials with lab reagent water and magnetic stir bar (low-level) (D)
Groundwater									
Groundwater	VOCs	Field Sample, Field Duplicate and Trip Blank	6 Samples, 1 FD, and 1 Trip Blank	SW-846 5030B/8260B	Prep: 2a analysis: 3a (Lab: Con-Test Analytical)	WSC-CAM-IIA	HCl to pH <2[C] and Cool to 4°C	14 days to analysis	2-40 mL VOA vials
Groundwater	Permanganate	Field Sample, Instrument Blank, Field Replicate, Duplicate Reading[E]	6 Samples, , 1 Instrument Blank, 1 Field Replicate, and 1 Duplicate Reading	See Section 7.1 of QAPP Addendum	NA	NA	Cool to 4°C	Not specified	1L amber glass w/Teflon lined cap

Notes:
CAM – compendium of analytical methods
TOC – total organic carbon
VOCs – volatile organic compounds

PNOD – permanganate natural oxidant demand
(A) FD = field duplicate samples
(B) SOP Reference No. from Section 7.2 of TRC's Generic QAPP
(C) If samples show evidence of permangarate, granular sodium thiosulfate will be added until water is clear. Refer to Section 5.1 of the QAPP Addendum.
(D) A separate 2-oz container will be collected for percent moisture analysis.
(E) Refer to Section 12.1 for a description of the field QC samples.

7.0 FORM G – METHOD AND SOP REFERENCE TABLES

7.1 Field SOP References

Attachment A of the Generic QAPP (EPA RFA# 13028; November 2012) contains copies of all field SOPs. SOPs which will be used during this investigation are as follows:

SOP #	SOP Title	Revision #	Date of SOP
TRC SOP-001	Groundwater Sampling	0	October 2012
TRC SOP-004	Equipment Decontamination Procedures	0	August 2003
TRC SOP-005	Visual-Manual Procedure for Soil Description and Identification	0	August 2006
TRC SOP-009	Groundwater Monitoring Well Installation	2	October 1999
TRC SOP-010	Groundwater Monitoring Well Development	2	October 1999
TRC SOP-012	Water Level and Product Measurement	0	August 2003
TRC SOP-014	Packaging and Shipping of Environmental Samples	1	November 2003
TRC SOP-016	Headspace Field Screening Procedure	0	August 2003
TRC SOP-018	Sample Chain of Custody	0	May 2003
TRC SOP-021	Field Activity Documentation	0	April 2003
TRC SOP-024	Calibration of Field Instruments for Water Quality Parameters	0	December 2003

Procedures for the field analysis of potassium permanganate in groundwater are provided below.

Low Concentration Samples (samples with no color or light purple color)

1. For most accurate results, pass the groundwater through a 0.22 micron Millipore GSWP or equivalent filter. This is solution "A".

2. Turn on the Hach DR890 and enter User Method 101. It should read mg/L KMnO4.

3. Zero the DR890 with lab grade or dilution water.

4. Read the concentration of solution "A" in mg/L.

High Concentration Samples (Samples with dark purple color)

1. Prepare a 1 mL to 1000 mL (1L) dilution of the groundwater in lab grade or demand free water and then mix well. For most accurate results, pass this solution through a 0.22 micron Millipore GSWP or equivalent filter. This is solution "A".

2. Turn on the Hach DR890 and enter User Method 102. It should read mg/L KMnO4.

3. Zero the DR890 with lab grade or dilution water.

4. Read the concentration of solution "A" in mg/L.

7.2 Laboratory Method and SOP References

With the exception of TOC analysis, refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a list of the methods and SOPs used by Con-Test and Alpha. A full copy of the laboratory SOPs is included as Attachment C of TRC's Generic QAPP. A copy of the laboratory's SOP for the analysis of TOC is provided as Attachment A of this QAPP Addendum. Table F-1 clarifies which SOPs and which laboratories are being used for this program. These methods and SOPs are also summarized below.

Preparatory and Analytical Method References:	Prep	Analysis	Alpha Analytical SOP	Con-Test Analytical SOP	Preparatory Method Associated with
1a. USEPA. Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples. SW846 Method 5035A, Draft Revision 1. July 2002.	X		*Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)*, 7/3/2012, Rev. No. 4 (SOP 2108)	*Volatile Organics by GC/MS (Method EPA 8260)*, 5/29/12, Revision 7 (Appendix B, revised 8/25/10)	3a
2a. USEPA. Purge-and-Trap for Aqueous Samples. SW846 Method 5030B, Revision 2. December 1996.	X				3a
3a. USEPA. Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry. SW846 Method 8260B, Revision 2. December 1996.		X			NA

In addition, the following SOP will be used by Alpha for the analysis of TOC in soil:

Total Organic Carbon and Soot in Soil, Sediment, 1/3/2013, Revision 7 (SOP 2182)

This SOP is provided in Attachment A of this QAPP Addendum.

8.0 FORM H – FIELD EQUIPMENT CALIBRATION AND CORRECTIVE ACTION

Calibration procedures, frequency of calibration, calibration acceptance criteria, and corrective actions are provided in TRC SOPs which were included in Attachment A of TRC's Generic QAPP (EPA RFA #13028; November 2012). The following field equipment will be used for this site investigation:

- **Photoionization detector:** Refer to TRC SOP-016.
- **GPS Unit:** Refer to Section 8.0 of TRC's Generic QAPP.
- **Water-level meter and product interface probe:** Refer to TRC SOP-012.
- **Turbidimeter:** Refer to TRC SOP-024.
- **YSI (or equivalent) water quality probe** (includes pH, dissolved oxygen, oxidation-reduction potential, temperature, and specific conductance): Refer to TRC SOP-024.
- **Hach DR 890 Spectrophotometer (or equivalent):** See calibration procedures below.

8.1 Spectrophotometer Calibration Procedures for Potassium Permanganate

The Hach DR 890 spectrophotometer, or equivalent, will be used for this site investigation. The DR 890 allows storage of up to five user-entered programs (101-105). User **Method 101** has been selected for reading "**Low** Range Potassium Permanganate Concentrations" in mg/L $KMnO_4$. User **Method 102** has been selected for reading "**High** Range Potassium Permanganate Concentrations" in mg/L $KMnO_4$. The procedure uses a low range potassium standard of 5 mg/L and a high range standard of 10 mg/L. Each standard will be analyzed prior to sample analysis and must show recovery within 80-120% of the true value. If outside of this range, the manufacturer will be contacted for resolution.

9.0 FORM I – LABORATORY EQUIPMENT CALIBRATION AND CORRECTIVE ACTION

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a list of the calibration requirements for the VOC methods being used by Con-Test and Alpha laboratories during this investigation.

Calibration requirements associated with the TOC analyses are summarized below.

Instrument	Activity	Frequency	Acceptance Criteria	Corrective Action	Parameter	SOP Ref.*
TOC Analyzer	Initial calibration – 5 levels and a blank	Prior to sample analysis	r $\geq$ 0.995	Run new calibration curve and/or service instrument	TOC	See Section 7.2
	Continuing calibration – mid-level standard	Once every 10 samples and at end of analytical run	80-120%	Reanalyze continuing calibration standard. If still outside limits, recalibrate and reanalyze all samples since last compliant calibration standard.		

10.0 FORM J – SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for routine procedures that will be followed in preparing field samples for transport to the laboratory.

11.0 FORM K – ANALYTICAL SENSITIVITY AND PROJECT CRITERIA

Analyses of soil samples for TOC and VOCs will be performed by Alpha Analytical of Westborough, Massachusetts and analyses of groundwater samples for VOCs will be performed by Con-Test Analytical of East Longmeadow, Massachusetts. Analyses of soil samples for PDOD will be performed by Ursus of Mount Horeb, Wisconsin. A copy of Con-Test Analytical and Alpha Analytical laboratory SOPs was provided as Attachment C of TRC's Generic QAPP (EPA RFA #13028; November 2012).

Tables K-1 through K-5b of TRC's Generic QAPP summarize the method detection limits (MDLs) and reporting limits (RLs) from Alpha and Con-Test laboratories for typical analyses performed for Brownfields investigations compared to the project action levels for this program. A summary of the RLs and project action levels for this program is provided in the tables below for each matrix (Table K-Groundwater and K-Soil). As of the date of this site-specific QAPP addendum, the current MassDEP Method 1 soil and groundwater standards have been incorporated into each table and the reporting limits and the stated MassDEP standards have been reviewed for accuracy.

Table K-1: Groundwater Samples: Summary of Target Analytes, RLs, and Project Action Levels

Former Payne Cutlery, New Bedford, MA

Analysis	Analyte	RLs	MCP Method 1	
			GW-2	GW-3
VOCs				
(ug/L)	Acetone	10	50,000	50,000
8260B	tert-Amylmethyl Ether	0.50	NS	NS
	Benzene	1.0	2,000	10,000
	Bromobenzene	1.0	NS	NS
	Bromochloromethane	1.0	NS	NS
	Bromodichloromethane	1.0	6	50,000
	Bromoform	1.0	700	50,000
	Bromomethane	2.0	7	800
	2-Butanone (MEK)	10	50,000	50,000
	n-Butylbenzene	1.0	7,000(1)	50,000(1)
	sec-Butylbenzene	1.0	7,000(1)	50,000(1)
	tert-Butylbenzene	1.0	7,000(1)	50,000(1)
	tert-Butylethyl Ether	0.5	NS	NS
	Carbon Disulfide	5.0	NS	NS
	Carbon Tetrachloride	1.0	2	5,000
	Chlorobenzene	1.0	200	1,000
	Chlorodibromomethane	0.50	20	50,000
	Chloroethane	2.0	NS	NS
	Chloroform	2.0	50	20,000
	Chloromethane	2.0	NS	NS
	2-Chlorotoluene	1.0	NS	NS
	4-Chlorotoluene	1.0	NS	NS
	1,2-Dibromo-3-Chloropropane	2.0	NS	NS
	1,2-Dibromoethane	0.50	2	50,000
	Dibromomethane	1.0	NS	NS
	1,2-Dichlorobenzene	1.0	2,000	2,000
	1,3-Dichlorobenzene	1.0	2,000	50,000
	1,4-Dichlorobenzene	1.0	200	8,000
	Dichlorodifluoromethane	2.0	NS	NS
	1,1-Dichloroethane	1.0	1,000	20,000
	1,2-Dichloroethane	1.0	5	20,000
	1,1-Dichloroethylene	1.0	80	30,000
	cis-1,2-Dichloroethylene	1.0	100	50,000
	trans-1,2-Dichloroethylene	1.0	90	50,000
	1,2-Dichloropropane	1.0	3	50,000
	1,3-Dichloropropane	0.5	NS	NS
	2,2-Dichloropropane	1.0	NS	NS
	1,1-Dichloropropene	2.0	NS	NS
	cis-1,3-Dichloropropene	0.40	10(2)	200(2)
	trans-1,3-Dichloropropene	0.40	10(2)	200(2)

Table K-1: Groundwater Samples: Summary of Target Analytes, RLs, and Project Action Levels

Former Payne Cutlery, New Bedford, MA

Analysis	Analyte	RLs	MCP Method 1	
			GW-2	GW-3
	Diethyl Ether	2.0	NS	NS
	Diisopropyl Ether	0.50	NS	NS
	1,4-Dioxane	50	6,000	50,000
	Ethyl Benzene	1.0	20,000	5,000
	Hexachlorobutadiene	0.50	1.0	3,000
	2-Hexanone	10	NS	NS
	Isopropylbenzene	1.0	7,000(1)	50,000(1)
	p-Isopropyltoluene	1.0	7,000(1)	50,000(1)
	MTBE	1.0	50,000	50,000
	Methylene Chloride	5.0	10,000	50,000
	MIBK	10	50,000	50,000
	Naphthalene	2.0	1,000	20,000
	n-Propylbenzene	1.0	7,000(1)	50,000(1)
	Styrene	1.0	100	6,000
	1,1,1,2-Tetrachloroethane	1.0	10	50,000
	1,1,2,2-Tetrachloroethane	0.50	9	50,000
	Tetrachloroethylene	1.0	50	30,000
	Tetrahydrofuran	2.0	NS	NS
	Toluene	1.0	50,000	40,000
	1,2,3-Trichlorobenzene	2.0	NS	NS
	1,2,4-Trichlorobenzene	1.0	2,000	50,000
	1,1,1-Trichloroethane	1.0	4,000	20,000
	1,1,2-Trichloroethane	1.0	900	50,000
	Trichloroethylene	1.0	30	5,000
	Trichlorofluoromethane	2.0	NS	NS
	1,2,3-Trichloropropane	2.0	NS	NS
	1,2,4-Trimethylbenzene	1.0	7,000(1)	50,000(1)
	1,3,5-Trimethylbenzene	1.0	7,000(1)	50,000(1)
	Vinyl Chloride	2.0	2	50,000
	m/p Xylene	2.0	9,000	5,000
	o-Xylene	1.0	9,000	5,000

Notes:
ug/L - micrograms per liter.
NS - No MassDEP standards exist for this analyte.
RLs - Reporting limits.
VOCs - Volatile Organic Compounds.
(1) - MassDEP Method 1 standards for C9-C10 aromatics used.
(2) - MassDEP Method 1 standards for 1,3-Dichloropropene used.

Table K-2: Soil Samples: Summary of Target Analytes, RLs, and Project Action Levels

Former Payne Cutlery, New Bedford, MA

Analysis	Analyte	RLs	MCP Method 1 S-1/GW-2
VOCs (mg/kg) 8260B	Acetone	0.010	50
	tert-Amylmethyl Ether	0.004	NS
	Benzene	0.001	30
	Bromobenzene	0.005	NS
	Bromochloromethane	0.004	NS
	Bromodichloromethane	0.001	0.1
	Bromoform	0.004	1
	Bromomethane	0.002	0.5
	2-Butanone (MEK)	0.010	50
	n-Butylbenzene	0.001	100(1)
	sec-Butylbenzene	0.001	100(1)
	tert-Butylbenzene	0.004	100(1)
	tert-Butylethyl Ether	0.004	NS
	Carbon Disulfide	0.004	NS
	Carbon Tetrachloride	0.001	5
	Chlorobenzene	0.001	3
	Chlorodibromomethane	0.001	0.03
	Chloroethane	0.002	NS
	Chloroform	0.0015	0.3
	Chloromethane	0.004	NS
	2-Chlorotoluene	0.004	NS
	4-Chlorotoluene	0.004	NS
	1,2-Dibromo-3-Chloropropane	0.004	NS
	1,2-Dibromoethane	0.004	0.1
	Dibromomethane	0.004	NS
	1,2-Dichlorobenzene	0.004	30
	1,3-Dichlorobenzene	0.004	40
	1,4-Dichlorobenzene	0.004	4
	Dichlorodifluoromethane	0.010	NS
	1,1-Dichloroethane	0.0015	5
	1,2-Dichloroethane	0.001	0.1
	1,1-Dichloroethylene	0.001	40
	cis-1,2-Dichloroethylene	0.001	0.4
	trans-1,2-Dichloroethylene	0.0015	1
	1,2-Dichloropropane	0.0035	0.1
	1,3-Dichloropropane	0.004	NS
	2,2-Dichloropropane	0.005	NS
	1,1-Dichloropropene	0.005	NS
	cis-1,3-Dichloropropene	0.001	0.4(2)
	trans-1,3-Dichloropropene	0.001	0.4(2)

Table K-2: Soil Samples: Summary of Target Analytes, RLs, and Project Action Levels

Former Payne Cutlery, New Bedford, MA

Analysis	Analyte	RLs	MCP Method 1 S-1/GW-2
	Diethyl Ether	0.005	NS
	Diisopropyl Ether	0.004	NS
	1,4-Dioxane	0.10	6
	Ethyl Benzene	0.001	500
	Hexachlorobutadiene	0.004	6
	2-Hexanone	0.010	NS
	Isopropylbenzene	0.001	100(1)
	p-Isopropyltoluene	0.001	100(1)
	MTBE	0.002	100
	Methylene Chloride	0.005	20
	MIBK	0.010	50
	Naphthalene	0.0040	40
	n-Propylbenzene	0.001	100(1)
	Styrene	0.002	4
	1,1,1,2-Tetrachloroethane	0.001	0.1
	1,1,2,2-Tetrachloroethane	0.001	0.02
	Tetrachloroethylene	0.001	10
	Tetrahydrofuran	0.004	NS
	Toluene	0.0015	500
	1,2,3-Trichlorobenzene	0.004	NS
	1,2,4-Trichlorobenzene	0.004	70
	1,1,1-Trichloroethane	0.001	500
	1,1,2-Trichloroethane	0.0015	2
	Trichloroethylene	0.001	2
	Trichlorofluoromethane	0.004	NS
	1,2,3-Trichloropropane	0.004	NS
	1,2,4-Trimethylbenzene	0.004	100(1)
	1,3,5-Trimethylbenzene	0.004	100(1)
	Vinyl Chloride	0.002	0.6
	m/p Xylene	0.002	300
	o-Xylene	0.002	300
TOC (mg/kg)	TOC	0.1	NA

Notes:
mg/kg – milligrams per kilogram or parts per million (ppm).
VOCs – Volatile Organic Compounds
NS – No MassDEP criteria specified
RLs – Reporting limits.
NA – Not applicable
(1) - MassDEP Method 1 standards for C9-C10 aromatics used
(2) - MassDEP Method 1 standards for 1,3-Dichloropropene used.

12.0 FORM L – FIELD QUALITY CONTROL REQUIREMENTS

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a summary of the typical field QC samples. Specific field QC samples planned for this investigation are included in Table F-1.

12.1 Spectrophotometer Field QC

The following additional QC requirements apply to the spectrophotometer analysis for permanganate.

- Instrument Blank: Place a deionized water sample in the cell holder and perform a test. Verify that permanganate is below the detection limit. If permanganate is detected above the detection limit, the instrument must be recalibrated according to the procedure described in Section 8.1.
- Duplicate Readings: Precision of spectrophotometer measurements on groundwater samples will be assessed by duplicate readings of investigative samples. Duplicate readings will be made at a frequency of one per 20 samples per day. Precision of these measurements will also be measured through the calculation of relative percent difference (RPD). The resulting information will be used to assess field analytical variability. The RPD of these readings must be $\leq$ 35 when both values are greater than 2x the detection limit. If one or both of these values are less than 2x the detection limit, the RPD is not assessed.
- Replicate Measurements: Precision of spectrophotometer measurements on groundwater will also be assessed by replicate measurements of samples. This will involve preparing each sample separately. Replicate measurements will be made at a frequency of one per 20 samples. The RPD of these measurements must be $\leq$ 35 when both values are greater than 2x the detection limit. If one or both values are less than 2x the detection limit, the RPD is not assessed.

13.0 FORM M – LABORATORY QUALITY CONTROL REQUIREMENTS

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a summary of the laboratory QC requirements for the VOC methods being used during this investigation. Laboratory QC requirements for the TOC method are summarized below.

Table M-a: Laboratory QC: TOC

Matrix	Soil				
Analytical Group	**TOC**				
Analytical Method/ SOP Reference	SW-846 9060				
Laboratory QC:	**Frequency/ Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action (CA)**	**Person(s) Responsible for CA**	**Data Quality Indicator (DQI)**
Calibration Blank	After every CCV	TOC < RL	Reclean, retest, reanalyze, and/or qualify data	Analyst and Data Validator	Accuracy/bias-Contamination
Method Blank	1/20 samples	TOC < RL	Reclean, retest, reanalyze, and/or qualify data	Analyst and Data Validator	Accuracy/bias-Contamination
Matrix Spike	1/20 samples/matrix	%Rs 75-125	Reanalyze and qualify data	Analyst and Data Validator	Accuracy/bias
Matrix Duplicates	1/20 samples/matrix	RPDs ≤25	Reanalyze and qualify data	Analyst and Data Validator	Precision
Laboratory Control Sample	1/20 samples	%Rs 75-125	Reanalyze and qualify data	Analyst and Data Validator	Accuracy/bias

RL – Reporting Limit
% Rs – Percent Recoveries
RPDs – Relative Percent Differences

14.0 FORM N – DATA MANAGEMENT AND DOCUMENTATION

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a summary of how project data and information will be documented, tracked and managed from their generation in the field to final use and storage in a manner that ensures data integrity and defensibility.

15.0 FORM O – ASSESSMENT AND RESPONSE ACTIONS

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a summary of the assessment and response actions that may be performed.

16.0 FORM P – PROJECT REPORTS

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a summary of the typical components of the final project report, the report frequency, and the report distribution.

An Interim Phase II Comprehensive Site Assessment, and Tier Classification will be prepared that will include a summary of the work conducted, Site history, and Site testing results based on the above-described work. An IRA Status (or Completion) Report will also be prepared.

17.0 FORM Q – FIELD DATA EVALUATION

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a summary of the field data evaluation procedures.

18.0 FORM R – LABORATORY DATA EVALUATION

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a summary of the laboratory data evaluation procedures.

19.0 FORM S – DATA USABILITY AND PROJECT EVALUATION

Refer to TRC's Generic QAPP (EPA RFA# 13028; November 2012) for a summary of the data usability evaluation procedure.

Attachment A
Laboratory SOP for TOC Analysis

Total Organic Carbon and Soot in Soil, Sediment

References: USEPA, "Method 9060 Total Organic Carbon," in Test Methods for Evaluating Solid Waste, SW846, Third Edition, Final Update, December 1996.

Perkin Elmer, "PE 2400 Series II CHNS/O Analyzer User's Manual," The Perkin-Elmer Corporation, April 1998.

USEPA, Region II, Lloyd Kahn, "Determination of Total Organic Carbon in Sediment", July 27, 1988.

"Quantification of the Dilute Sedimentary Soot Phase: Implications for PAH Speciation and Bioavailability" published in Environmental Science and Technology, Vol. 31, No. 1, 1997 by Gustafsson, Haghseta, Chan, McFarlane and Gschwend.

"Reinterpreting Literature Sorption Data Considering Both Absorption into Organic Carbon and Adsorption onto Black Carbon" published in Environmental Science and Technology, Vol. 37, No. 1, 2003 by Accadi-Dey and Gschwend

1. Scope and Application

Matrices: This method is applicable for solid samples (soils, sediments, sludges).

Definitions: Refer to Alpha Analytical Quality Manual.

The organic carbon in a sample consists of a variety of organic compounds in various oxidation states. Some of these compounds may be oxidized by biological or chemical processes and can be measured by the Biochemical Oxygen Demand or Chemical Oxygen Demand tests. To measure the amount of organically bound carbon, the organic carbon molecules are broken down into single carbon units, and converted into a form that can be measured quantitatively.

The PE 2400 Series II CHNS/O Analyzer can simultaneously determine carbon (C), hydrogen (H), nitrogen (N), sulfur (S), and oxygen (O) in organic material. In the CHN mode, the PE 2400 Series II CHNS/O Analyzer uses a combustion method to convert the sample elements to simple gases (CO_2, H_2O, and N_2). The resulting gases are homogenized and controlled to exact conditions of pressure, temperature, and volume. The homogenized gases are allowed to de-pressurize through a column where they are separated in a stepwise steady-state manner and detected as a function of their thermal conductivity and reported as a percentage for solid samples. Treated with phosphoric acid prior to analysis, the Total Organic Carbon (TOC) content is determined by the amount of CO_2 in the sample. If the sample is analyzed without pretreatment, the Total Carbon (TC) content is determined. Total Inorganic Carbon can be determined by subtraction of the TOC from the TC values.

This method is applicable to the measurement of TOC and Soot in solid samples $\geq$ 100mg/Kg or $\geq$ 0.01%, dry weight. According to the instrument manufacturer, a sample of up to 70% carbon can be analyzed without dilution.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the TOC Analyzer and in the interpretation of the data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the Quality Assurance Officer and/or Laboratory Director on a case-by-case basis.

2. Summary of Method

An aliquot of solid sample is homogenized, dried at 103 - 105°C, re-homogenized, and the particle size is reduced by mortar and pestle. The sample is pre-treated with phosphoric acid to convert the inorganic carbon (*i.e.,* carbonate and bicarbonate in the form of CO_2) prior to analysis. The sample is re-dried at 103 - 105°C and another aliquot is removed for analysis, by weighing on the Microbalance, which is linked to the TOC analyzer.

Organic carbon is measured using combustion and a carbonaceous analyzer. The sample, of approximately 2-5mg, is oxidized in a pure oxygen environment, introduced into a furnace by a 60-slot Autosampler, then combusted. A greater mass may be weighed if the sample observations indicate low carbon content. As much as 20-25mg may be utilized. The carrier gas (O_2) is combined with the carbon content of the combusted sample to form CO_2. Elements, such as halogens and sulfur, are removed by scrubbing reagents in the combustion zone. A thermoconductivity detector then measures the CO_2. The amount of CO_2 derived from a sample is directly proportional to the concentration of organic carbonaceous material in the sample.

For Soot, the dried sample will be reduced to a powder by grinding it with a mortar and pestle. An aliquot of sample, approximately 10-12mg, will be transferred into an aluminum tin. Again, as much as 20-25mg of sample may be utilized if observations indicate low soot content. The tins will be placed in an oven or muffle furnace for 24 hours at 375°C. After sample is in the muffle furnace for 24hrs sample is treated with phosphoric acid then re-dried and reduced to a powder with a mortar and pestle. At the end of this time they will be cooled to room temperature, and are ready for analysis on the TOC Analyzer.

2.1 Method Modifications from Reference

None.

3. Reporting Limits

The Practical Quantitation Limit (PQL) or Reporting Limit (RL) is 0.01% (or 100mg/Kg) for solid samples.

4. Interferences

4.1 To determine the TOC/Soot content, the inorganic fractions (carbonate and bicarbonate) must be removed prior to analysis by lowering the pH of the sample to $\leq$ 2. When removing the inorganic carbon, care must be taken in sample pretreatment to minimize the potential of loss of volatile organic carbon present in the sample.

4.2 Maintaining the samples at 4±2°C, and analyzing within the specified holding time minimizes bacterial decomposition and volatilization of the organic material.

4.3 Elements, such as halogens and sulfur, are removed by scrubbing reagents in the combustion zone. Large and/or complex organic molecules such as tannins, lignins, or humic acids may be oxidized slowly. If these compounds are suspected to be present, it is advisable to check the efficiency of the oxidation procedure with a selected representative sample, and adjust the analysis (sample size) as needed.

4.4 Chlorides at a concentration of greater than 0.1% may completely inhibit the oxidation of organic matter. The sample size may need to be adjusted to compensate for this interference.

4.5 Oils from skin, or contact with any organic material, such as plastic containers and rubber tubing, can contaminate samples. Handle the weighing tins with tweezers.

4.6 Sample heterogeneity can be a major source of imprecision in TOC/Soot results. Recommend to clients to perform a client-specific duplicate, to evaluate precision and representativeness of the TOC/Soot results to the site.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound must be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

The use of laboratory equipment and chemicals exposes the analyst to several potential hazards. Good laboratory techniques and safety practices shall be followed at all times. All relevant Material Safety Data Sheets (MSDSs) are kept on file.

Approved PPE, which includes Safety Glasses, Gloves and Lab Coats, must be worn at ***all*** times when handling samples, reagents, chemicals, or when in the vicinity of others handling these items, so that dermal contact is avoided. All standards, reagents and solvents shall be handled under a hood using the proper PPE. All flammable solvents must be kept in the flammable storage cabinet, and returned to the cabinet immediately after use. When transporting chemicals, use a secure transporting device and/or secondary outer container. Chemical storage is properly segregated and adequately ventilated to reduce the possibility of hazardous reactions. Chemical storage in work areas shall be kept to a minimum. Storage on bench tops or other work surfaces, except temporary, is not permitted.

All standards and reagents shall be prepared in a hood while using the proper PPE.

Analytical instrumentation poses the unique possibility of exposure to high voltages. Other than the *routine* instrument maintenance, as listed in the front of every Instrument Maintenance Logbook, at no time shall an instrument operator attempt to maintenance an instrument alone, or without the proper training, supervision or instruction. Caution must always be used in the presence of moving parts (autosamplers) and hot surfaces (injection ports).

All additional company safety practices shall be followed at all times as written in the *Chemical Hygiene Plan*.

All TOC standard solutions must be handled with caution. See pages 5-3 through 5-5 of the PE 2400 Series II CHNS/O Analyzer User's Manual for additional and specific Warnings and Precautions.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

A minimum of 5 grams of sample must be collected in a glass jar.

6.2 Sample Preservation

Soil samples must be refrigerated and maintained at 4°±2°C until drying and analysis.

Sediment samples are either processed within 28 days (or 14 days for Lloyd Kahn) or can be frozen at -15C to -20C until processing.

6.3 Sample Shipping

The *Sample Receipt & Login SOP* (1559) describes how samples are normally shipped or obtained by the laboratory, precautions to be used in opening sample shipments, and sample storage conditions.

6.4 Sample Handling

Soil samples must be refrigerated and maintained at 4°±2°C until drying and analysis.

Sediment samples are either processed within 28 days (or 14 days for Lloyd Kahn) or can be frozen at -15C to -20C until processing.

All solid samples (NOT requiring the *Lloyd Kahn* Calibration method) must be analyzed within 28 days from the date of collection. **Note:** If samples require the *Lloyd Kahn* Calibration method, the hold time is 14 days.

The *Sample Receipt & Login SOP* (1559) describes the responsibilities of sample custody including all proper documentation, verification, and tracking procedures, following Chain of Custody (COC) protocols and sample receipt procedures using the *Sample Receipt Checklist*, which includes the check for proper sample preservation and cooler temperature verification.

Internal COC procedures for sample tracking include the use of sample tracking logbooks. These procedures are also described in the *Sample Receipt & Login SOP* (1559).

7. Equipment and Supplies

7.1 Instrument: Perkin Elmer 2400 Series II CHNS/O Analyzer with computer and PE software

7.2 Detector: Thermal Conductivity

7.3 Mortar and pestle

7.4 Oven: 103° - 105°C

7.5 Dessicator

7.6 Volumetric Flasks: Class-A, various volumes

7.7 Microbalance: Perkin-Elmer, Model AD-6, linked to the instrument. See the Manufacturer User's Manual, Section 1.2, pages 3-4, for Microbalance and weighing instructions. The Microbalance calibration is verified every day using 2.0mg - 200mg weights, in the range of daily use, and be accurate within +/1%. If the balance needs to be re-calibrated, see the Manufacturer User's Manual SOP, Section 1.1, page 3, for details.

7.8 Tweezers: Anti-Magnetic

7.9 Tin Boats: Small and Large.

7.10 Glass Beads: Filter Aid 400, High-density; from Perkin Elmer or 3M. Used as the CCB/Method Blank media.

7.11 Gas-tight syringes: Various measuring sizes, including 10µL for direct sample spiking

7.12 Printer : OKIDATA Microline 320 Turbo-9 Pin

Note: All maintenance records including routine upkeep and outside service visits are maintained in the instrument maintenance logbooks. See the Manufacturers User's Manual for detailed troubleshooting instructions and routine maintenance, as needed.

8. Reagents and Standards

Use reagent grade chemicals for all reagents. All reagents and standards must be stored at 4±2°C and expire 6 months from preparation, unless otherwise indicated below.

8.1 Deionized (DI) water: All references to DI water refer to ASTM Type II reagent grade water which has been boiled, cooled and capped to eliminate CO_2.

8.2 Phosphoric Acid solution: Add 200mL of H_3PO_4 to 800mL of DI water. Mix thoroughly and cool to room temperature before use. Store in a glass bottle and keep at room temperature. This solution is stable for 6 months.

8.3 Potassium Hydrogen Phthalate (KHP), Calibration Solution/CCV or K-Factor for TOC: 10,000mg/L equivalent to 10,000mg/Kg Carbon, or 1.0 % TOC. NIST SRM 185h

Dissolve 2.128g of potassium hydrogen phthalate (primary standard grade) in ASTM DI water, and dilute to 100mL in a volumetric flask. This standard is good for 6 months, stored at room temperature. Discard solution if discoloration or any signs of bacterial growth are observed.

Note: When preparing this solution for the *Lloyd Kahn* Calibration method, double the weight (4.256g) to 100mL in a volumetric flask for a 2% TOC solution. This will be the stock for the highest point of the calibration curve. Appropriate dilutions can then be made from this stock for the rest of the calibration curve outlined in Section 10.2.4.

8.4 Potassium Hydrogen Phthalate (KHP) Spiking Solution/MS: 10,000mg/L equivalent to 10,000mg/Kg Carbon, or 1.0 % TOC. From a separate source than the solution in Section 8.3, Sigma Aldrich or equivalent.

Dissolve 2.128g of potassium hydrogen phthalate (primary standard grade) in ASTM DI water, and dilute to 100mL in a volumetric flask. *Use a separate source or different lot of KHP from that used to prepare the calibration standard.*

This stock may be stored up to six months at room temperature. Discard solution if discoloration or any signs of bacterial growth are observed. Use at 1.0 % TOC concentration for solid samples, and at 10,000mg/L for aqueous samples.

8.5 Reporting Limit Standard: An appropriate dilution is made from the stock standard (Section 8.3), which is prepared and analyzed to confirm the reporting limit for the given matrix (Section 3).

8.6 Acetanilide – LCS/SRM for Total Carbon: NIST SRM 141d with certified concentration of Carbon = 71.089%.

8.7 Cystine – CCV for Total Carbon: From Perkin Elmer with value of carbon = 29.99%

8.8 Solid Laboratory Control Sample / Independent Calibration Verification (LCS/ICV): Standard Reference Material (SRM) NIST 1944, a separate source from the calibration standard that is certified at the concentration of 4.4% TOC for solid samples. SRM 1649 for Total Carbon or Soot certified at the concentration of 17.68% Total Carbon.

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

9.1.1 Method Blank: A method blank must be analyzed once per every 20 samples or per TOC/Soot batch, whichever is more frequent. The Blank consists of 30mg of Filter Aid (Section 7.10).

TOC must not be detectable in the method blank at a concentration greater than the reporting limit for the given matrix (Section 3).

Corrective Action: Analysis of the method blank and all associated samples must be performed until the blank is in control. Samples cannot be analyzed until an acceptable method blank analysis is obtained. Exceptions may be made with approval of the Department Manager, if the samples associated with the out of control method blank are non-detect for TOC/Soot, or if sample TOC/Soot concentrations are greater than 5X the blank levels. In such cases, the sample results are accepted without corrective action for the high method blank and the client is notified in a project narrative associated with the sample results.

9.1.2 Continuing Calibration Blank: A CCB must be analyzed immediately after every CCV. The CCB is 30mg of Filter Aid (Section 7.10).

The CCB concentration must not be greater than the reporting limit for the given matrix (Section 3).

Corrective Action: Repeat analysis once to see if an analytical error occurred. If the CCB still exceeds the control limits, re-calibrate and/or re-analyze a fresh blank. All samples associated with the out of control CCB must be re-analyzed (since the last acceptable CCB). Exceptions may be made with approval of the Department Manager if the samples associated with the out of control method blank are non-detect for TOC/Soot or if sample TOC/Soot concentrations are greater than 5X the blank levels. In such cases, the sample results are accepted without corrective action for the high CCB and the client is notified in a project narrative associated with the sample results.

9.1.3 Instrument Blank: An Instrument Blank must be analyzed during Calibration.run2. The Instrument Blank consists of 30mg of Filter Aid (Section 7.10).

9.2 Laboratory Control Sample (LCS)

Laboratory control sample (LCS or ICV) must be from a second source or lot number to verify the accuracy of the standard curve. The LCS/ICV is analyzed along with the samples. A LCS/ICV must be analyzed once per every 20 samples or per TOC batch, whichever is more frequent. For *solid* samples, the LCS is the NIST SRM at 4.4% TOC.

ICV/LCS consists of approximately 3.0-5.0mg of SRM 1944 with a true value of 4.4% TOC (Section 8.6). This SRM is NOT evaluated for Soot since no certified concentration for Soot is published.

The acceptable recovery QC range is 75%-125% for the LCS/ICV.

Corrective Action: Repeat analysis once to see if an analytical error has occurred. If the LCS/ICV recovery is still out of control, re-calibrate and re-analyze the LCS/ICV and all associated samples. Samples cannot be analyzed until an acceptable LCS/ICV is obtained. Exceptions may be made with approval of the Department Manager if the samples associated with the out of control LCS/ICV are also associated with a matrix spike that is in control. This is an acceptable measure of accuracy of the analytical procedures. An explanation of this out of control LCS/ICV recovery must be included in the project narrative to the client and the sample data reported with the acceptable MS results as batch QC.

9.3 Initial Calibration Verification (ICV)

Refer to Section 9.2 above.

9.4 Continuing Calibration Verification (CCV)

A CCV must be analyzed at a minimum of every 10 burns and at the close of an analytical sequence. This standard monitors instrument performance throughout the duration of the analytical run.

The **CCV** is approximately 10.0mg of Filter Aid tared to zero and spiked with 10µL of *Calibration Solution* (Section 8.3), with a 1% TOC true value. The weight recorded is the Calibration Solution only. (10µL of solution should weigh approximately 10mg).

The acceptable recovery QC range for the CCV is 80-120%.

Corrective Action: Repeat analysis once to see if an analytical error occurred. If the CCV still exceeds the control limits, re-calibrate and re-analyze all samples since last acceptable CCV.

9.5 Matrix Spike

A matrix spike must be performed once per 20 samples (5% frequency). When project specifications dictate, a Matrix Spike Duplicate (MSD) may also need to be performed at the same frequency as the MS. Prepare the MS according to Section 8.4 for the given matrix.

A **Matrix Spike** sample is spiked with 10µL of *Spiking Solution* (Section 8.4), at a 1.0 % TOC true value. The weight recorded is the sample weight prior to spiking.

The acceptable recovery QC range is 75%-125% for the MS/MSD. Calculate the %RPD as in Section 9.6 when analyzing a MS/MSD pair. The acceptable %RPD is $\leq$ 25% for solid samples.

Corrective Action: Repeat analysis once to see if an analytical error has occurred. If the % recovery or %RPD still exceeds the criteria and the LCS is compliant; include a project narrative with the results to the client noting that there may be potential matrix effects on the accuracy or precision of the TOC/Soot results as evidenced by matrix spike recovery or %RPD outside of QC limits.

9.6 Laboratory Duplicate

Duplicate analyses (matrix duplicate) must be performed once per 20 samples (5% frequency).

A Matrix Duplicate sample is weighed to represent the sample in consistency, and weight.

Acceptable relative percent difference (RPD) of duplicates is $\leq$ 25% for solid duplicates and $\leq$ 20% for aqueous duplicates. Acceptance criterion is not applicable to sample concentrations less than 5X the reporting limit. Calculate RPD as follows:

$$\%RPD = \frac{R1 - R2}{\frac{[R1 + R2]}{2}} \times 100$$

where:

R1 = highest result
R2 = lower result

Corrective Action: Repeat analysis once to see if an analytical error has occurred. If the % RPD still exceeds the control limits; include a project narrative with the results to the client noting that there may be potential matrix effects on the precision of the TOC/Soot results as evidenced by the matrix duplicate RPD exceedence.

9.7 Method-specific Quality Control Samples

None.

9.8 Method Sequence

- Calibration Curve generation
- Method Blank
- LCS/ICV

- Laboratory Duplicate
- Matrix Spike
- Samples 1 – 8
- CCV
- CCB
- Samples 9 – 18
- CCV
- CCB

10. Procedure

10.1 Equipment Set-up

Samples are prioritized by the Department Manager for analysis based on hold time and client due date. Section 15.5 outlines the steps for final TOC reporting that will contain the sample analysis final results.

The analyst initials, date, sample ID #'s, sample weights (solids), or volumes (aqueous), of all Standards, QC samples and field samples, are entered into the TOC logbook. Include the standard, LCS and MS IDs and concentrations.

10.1.1 Pretreatment for Total Organic Carbon:

This procedure is used to remove the inorganic compounds in the sample prior to the determination of Total Organic Carbon. If Total Carbon is to be determined, addition of the phosphoric acid solution is omitted.

10.1.1.1 Aliquot 2-5g of pre-dried (103°-105°C) solid sample into an aluminum weigh dish. (This aliquot may be taken from the Percent Solids Determination aliquot, assuming Percent Solids have already been performed). Note: Any sample to be analyzed for Total Organic Carbon must be dried and acidified and dried again before analysis on the TOC instrument.

10.1.1.1.1 If samples are received that do not require percent solids, the samples must be dried and then acidified and dried again.

10.1.1.1.2 Sample aliquots that have already been dried for percent solids analysis may be acidified and re-dried for TOC.

10.1.1.1.3 If Soot analysis is required, take a portion of the dried sample aliquot, approximately 2-5 gm, and place into a muffle furnace at 375°C for 24 hours. Once the sample aliquot is cooled to room temperature, proceed to the acid addition step, Section 10.1.1.2. Samples for Soot are read analytically in the same way as Routine TOC.

10.1.1.2 Add Phosphoric Acid Solution (Section 8.2) drop wise to the solid sample in the tin dish and check for effervescence. If effervescence is observed, continue adding drop wise until the effervescence stops to ensure removal of inorganic

carbon compounds (carbonate and bicarbonate). Report any excessive effervescence or change in sample consistency to the client in the project narrative.

10.1.1.3 Place the tin dish containing the treated sample into the drying oven at 103°-105°C until dry. Remove the tin and place in a dessicator to cool. The sample is considered dry when the weight change is less than 4%, or 50mg of a previous weight, whichever is less. Samples may need to dry overnight in the oven.

10.2 Initial Calibration

On the accompanying computer, or "PC", Perkin Elmer software has been loaded to collect and save sample and standard analysis data. Create a file to store the data from each day's analytical sequence by clicking on the PE 2400 icon, go to "new" and "save" the file "as" the name of the date of the analysis (*i.e.,* 060503.chn). Data from each standard or sample analysis will be automatically stored in this file for future reference

10.2.1 Follow the instrument Manufacturers User's Manual for instrument set up and see Sections below for an outline of the initial, daily calibration procedure.

See the Manufacturers User's Manual, page 5-69, for the default instrument conditions when in the CHN operating mode.

10.2.2 *Routine* TOC/Soot Calibration Method:

TOC analyses use K-Factors (3 repeat analyses of a 1.0% TOC standard, Section 8.3) and Blanks, calculated and averaged by the instrument when the calibration is being performed. Follow the instrument Manufacturer's User's Manual, page 4-67. Calibration of the instrument using K-Factors and Blanks is performed once per day of analysis.

Load the Autosampler (Section 10.3.2) for combustion to analyze Blanks and Standards in the order listed below. All "Blanks" and "K-Factors" are prepared in the same way. Analyze the standards following the procedure in Section 10.3.

- **Instrument "Primer"** (~20.0mg of SRM 1944, with true value of 4.4% TOC) only if new column.
- **Blank 1** (30.0mg of Filter Aid) only if new column
- **K-Factor 1** (10µl of *Calibration Solution*, Section 10.3,)
  The weight recorded is the Calibration Solution, only.
- **Blank 2** (30.0mg of Filter Aid)
- **K-Factor 2** (10µl of *Calibration Solution*, Section 10.3,)
  The weight recorded is the Calibration Solution, only.
- **K-Factor 3** (10µl of *Calibration Solution*, Section 10.3,)
  The weight recorded is the Calibration Solution, only.

The K-Factors must reproduce from the mean value within +/-0.15% for carbon. The calculation involves the comparison among the latest K-Factor run, the prior K-Factor run,

and the current running average K-Factor. An "out of tolerance" message will be displayed if this criterion is not met.

The ICV/LCS and Method Blank are prepared to run immediately following the third K-Factor, given the instrument is "in tolerance".

Corrective Action: If, at any time during the 6–step process of calibration, one of the K-Factors or Blanks fail, the calibration must be re-prepared and re-analyzed until the instrument accepts all factors as "in tolerance".

10.2.3 *Lloyd Kahn* Calibration Method: **Note:** The *Routine* instrument calibration procedure (Section 10.2.2) must be established before the Linear Regression method is used, otherwise, the best results will not be obtained.

Prepare a curve for *Lloyd Kahn* calibration as outlined below. Additionally, see page 5-82 and 5-83 of the Manufacturers User's Manual for proper set-up of this calibration method.

Analyze each point of the calibration curve following Section 10.3. On an Excel spreadsheet, plot *Carbon (mg*) vs. *Instrument Response*, using five standards and a blank covering the analytical range of interest. See Section 8.3 for Calibration Standard preparation.

Blank = 10 ul of DI water from Barnstead

Point 1 = 0.1% (1,000mg/Kg) Standard

Point 2 = 0.5% (5,000mg/Kg) Standard Point 3 = 1.0% (10,000mg/Kg) Standard Point 4 = 2.0% (20,000mg/Kg) Standard

Point 5 = 4.0% (40,000 mg/Kg) Standard added to 30mg Filter Aid

This is the calibration curve for Linear Regression analysis.

The correlation coefficient (r) of the initial calibration curve must be ≥0.995. The slope of the line must be ± 10% of historical curves.

Corrective Action: If the correlation coefficient or slope QC criteria are not met, the standard curve must be re-prepared and re-analyzed until the correlation coefficient and/or slope are acceptable.

10.3 Equipment Operation and Sample Processing

Prepare a Calibration Curve per Section 10.2.

An ICV/LCS and Method Blank are analyzed immediately following the third K-Factor of the Routine Calibration, provided the instrument is "in tolerance".

Remove all pretreated samples from the oven, and allow to cool in a dessicator. Confirm that a constant weight has been achieved as in Sections 10.1.1.1 and 10.1.1.2. Record the weights in the TOC logbook.

10.3.1 Soil Samples: The solid samples must be ground using a mortar and pestle into a fine powder, without grinding shells, rocks or other large non-representative material. Carefully pick these materials from the sample with tweezers. Transfer the ground, pre-treated solid sample to a 5.0mL glass vial labeled with the sample ID. Fill the vial to approximately 2/3 full and discard the remainder.

Weigh approximately 2-5mg of sample into a tin boat using the Perkin-Elmer Microbalance, Model AD-6, which is linked to the instrument. Samples that are known to be high in TOC may use a lesser sample aliquot. Samples where it is observed that the TOC may be low, weight as much as 20-25mg. Each sample must be weighed in duplicate. (**NOTE:** *Check the paperwork carefully as often 3 replicate analyses are specified by the client.)* Record the weights in the TOC/Soot logbook. Matrix Duplicate and Matrix Spike samples are weighed as separate samples, with their own replicates or triplicates.

Any observations regarding the sample composition must be noted in the TOC/Soot logbook such as: sandy, contains shells or rocks, contains grass or roots, is light/white in coloration, etc.

Analyze a CCV/CCB (Section 9.4 and 9.1.3) after every 10 “burns”, and at the end of the analytical sequence.

If following the *Lloyd Kahn* Calibration method, analyze the first set of batch QC samples, the ICV/LCS and Method Blank, followed by field samples with a CCV/CCB analyzed every 10 “burns”, and at the end of the analytical sequence.

10.3.2 Multiple Sample Instrument Loading:

10.3.2.1 Each tin boat is carefully folded with anti-magnetic tweezers, and placed into its respective holding tray position. (See the Manufacturer User’s Manual SOP, Section 1.2, page 4, for tin boat folding details.) Weights, sample tray position and Autosampler location are recorded in the TOC/Soot logbook. The analyst must be very careful when transferring samples. Documentation of sample consistency is very important. See Figure 1 for an example logbook page.

10.3.2.2 Adjust the Autosampler tray to begin sampling at auto-slot #1 and carefully transfer the folded tins containing the samples to the correct auto-slot, using tweezers. All Instrument Calibration Standards (Blanks, K-Factors and/or *Lloyd Kahn* Calibration Standards) are loaded first. Immediately following will be the first batch QC samples, the ICV/LCS and Method Blank for the run, followed by field samples. Rotate the Autosampler in a *counter clockwise* manner.

10.3.2.3 A maximum of 60 tins can be held on the Autosampler at one time. The instrument only allows for 100 total samples (including calibration/blank samples) to be programmed for any given run.

10.3.3 Sample Analysis

10.3.3.1 Select the *Auto Run* option on the keypad on the instrument. The following menu appears:

AUTO RUN NO. 1
1B 2K 3S

where: B = Blank
K = K-Factor
S = Sample

Assuming the *Instrument Standardization* occupies auto-slots 1-6, Enter "3" for Sample, then select "Enter". Enter the weight of the "Primer" Standard (position 1) and select "Enter".

10.3.3.2 You will be prompted for AUTO RUN NO. 2 as in Section 10.3.3.1, except now there is a function "4NP" which allows the analyst to stop/erase everything by selecting this feature.

- Enter "1" for the Blank. The weight will not be asked for.
- Enter "2" for the first K-Factor, then select "Enter". Enter the weight of your K-Factor (the standard weight should be ~ 10mg). Select "Enter".
- Enter "1" for the second Blank, then "Enter".
- Enter "2" for the second K-Factor, then "Enter". Enter the weight, then "Enter".
- Enter "2" for the third K-Factor, then "Enter". Enter the weight, then "Enter".

10.3.3.3 All remaining sample weights are added by entering "3" for Sample, and then by entering the sample weight. Continue adding all information to the run sequence, using the keypad. When entering sample identifications, and letters are necessary, refer to the Manufacturer's User's Manual, page 3-4, for instructions for converting numbers to letters.

10.3.3.4 When all sequence information is entered and complete, select "Start". The analyses will begin. The computer will continue to display the "AUTO RUN" menu during sample analysis.

10.3.3.5 The Standard and Sample data prints out as it is collected on the line printer, and is also collected on the linked computer using the PE 2400 software. The data on the computer is saved in a file named as the date of the analysis (*i.e.,* 060503.chn) for future reference, as noted in 10.2.

10.3.3.6 When all analyses are complete, refer to the Manufacturers User's Manual SOP, Section 3.1, page 7, for instructions to "Shut Down" the instrument.

10.3.3.7 Evaluate all batch QC samples first, to confirm or exclude the need for re-analyses. The ICV/LCS, Method Blank, CCB/CCV samples must meet the acceptance criteria in Section 9. Follow the corrective action for any QC failures.

10.3.3.8 Evaluate the field samples, LCS/SRM, and MS/Duplicates next. If duplicate or triplicate "burns" of the same sample appear inconsistent, or vary by more than 30%, re-weigh two additional aliquots (or three for triplicate analyses) similar to the initial weights used, and re-analyze the sample. For a 2-replicate analysis, this give a total of four burns/sample, and for a 3-replicate analysis, this gives a total of six burns/sample. Compare the first two burns to the second two burns for the evaluation of RPD (or the first three burns to the second three burns for the

evaluation of RSD). If inconsistencies persist greater than 30%, report the lowest RPD or RSD achieved for the sample, and discuss this observation in the project narrative to the client.

10.4 Continuing Calibration

A CCV must be analyzed as outlined in Section 10.3.3 at a minimum of every 10 burns and at the close of an analytical sequence.

10.5 Preventive Maintenance

The column is changed after every 100-200 runs. Other maintenance is performed by a service provider.

11. Data Evaluation, Calculations and Reporting

11.1 Procedures for data and record management for TOC/Soot analysis must adhere to the Quality Systems Manual, other subordinate documents covering record keeping, and the *Document Control* SOP, 08-01. All records are stored in such a manner as to be safe and accessible for at least 10 years.

11.2 The relevant TOC/Soot laboratory notebooks must follow the specifications in the *Laboratory Notebook Usage* Work Instruction 1556, and all record keeping and document control practices.

11.3 Sample results for TOC/Soot are directly reported from the instrument printout.

11.4 Calculations: The following calculations are applied by the instrument when determining the percentage of Total Organic Carbon or Soot:

Carbon Blank (CB): Used to make all other determinations, namely, K-Factor and weight percent calculations. When run alternately with samples, the instrument averages the blank values.

Carbon Blank (CB) = Carbon Read – Nitrogen Read

Carbon K-Factor (C KF): K-Factor, or detector calibration factor, is determined when a known standard is analyzed to calibrate the analyzer in terms of micrograms of carbon. This calibration factor is then used to determine unknowns.

C KF = ((CR – NR) – CB x 100) / (SW x C Theory Wt. %)

where: CR = Carbon Read
NR = Nitrogen Read
CB = Carbon Blank
SW= Sample Weight (mg)
C Theory Wt % = 1% (based on the concentration of the K-Factor standard)

Carbon Weight Percent:

Carbon Weight Percent = (((CR – NR) – CB) x 100) / (SW x C KF)

where: CR = Carbon Read
NR = Nitrogen Read
CB = Carbon Blank
SW = Sample Weight (mg)
C KF = Carbon K-Factor

Example Calculation of Percent TOC/Soot from the instrument, converted to mg of TOC/Soot:

If the result from the instrument is 1.083% and the sample weight is 10.76mg:

1.083% = 100 x [**X** / 10.76mg] (to solve for **X,** divide each side by 100)
0.01083 = **X** / 10.76mg (multiply each side by 10.76mg)
0.116mg = **X**

11.5 Reporting Results

The following procedures must be followed for reporting of TOC/Soot results:

Go to the next page in the bound TOC/Soot logbook.

Retain all computer printouts for the standard and sample analyses of this sequence.

Print the sequence from the computer and review it to make sure that no weight or sample ID transcription errors were made.

Calculate the recoveries for the QC samples (IVC/LCS, CCV, MS and RPD between the duplicate samples) and ensure the Method Blank and CCB meet the criteria. Remember any “QC Failures” require corrective action. See Section 9.0 or 12.0.

After reviewing the final logbook entries, make a copy of the logbook page for secondary review.

Go to the LIMS and “batch” and “associate” the set of QC samples and field samples that were just analyzed.

Enter the Final Results into the LIMS report sheet and check for transcription errors.

Transfer all associated sample paperwork to the Department Manager for the second level review and approval.

All TOC/Soot results are reportable without qualification if analytical holding times are met, preservation (including pH and cooler temperatures) are met, all QC criteria defined in the table below are met, and matrix interference was not suspected during analysis of the TOC/Soot samples. If any of the below QC parameters are not met, all associated samples must be evaluated for re-analysis.

QC Parameter	Acceptance Criteria
Initial Calibration Curve, *Lloyd Kahn*	r ≥ 0.995 and slope ± 10% the historical curves
Initial Standardization (K-Factor)	±0.15% from average of previous K-Factors
Method Blank	< reporting limit for matrix
Laboratory Control Sample	75-125% R
Matrix Duplicate	25%RPD for results <5x reporting limit
Matrix Spike	75-125% R
Matrix Spike Duplicate if requested	75-125%R/25%RPD
Continuing Calibration Verification	80-120% of True Value
Continuing Calibration Blank	< reporting limit for matrix

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

Section 9 outlines sample batch QC acceptance criteria. If non-compliant TOC/Soot results are to be reported, the Department Manager and/or the Laboratory Director, and the QA Manager must approve the reporting of these results. The laboratory Project Manager is notified, and may chose to relay the non-compliance to the client, for approval, or other corrective action, such as re-sampling and re-analysis. The analyst or Department Manager performing the secondary review initiates the project narrative, and the narrative must clearly document the non-compliance and provide a reason for acceptance of these results.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Alpha SOP/1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP/1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

The *Hazardous Waste and Sample Disposal* SOP (1797) must be referenced for disposal of used standards, solvents, acids, reagents or other chemicals.

Once satisfactory TOC results have been generated, the sample containers must be scanned back into LIMS and returned to the appropriate sample refrigerator and held for 30 days.

All waste generated must be transferred to the waste disposal area. Dispose all solid samples in solid waste container. Aqueous samples must be poured into a 55-gallon drum marked acidic/non-chlorinated waste.

Refer to the *Chemical Hygiene Plan* and the *Hazardous Waste & Sample Disposal SOP* (1797) for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

PE 2400 Series II CHNS/O Analyzer User's Manual

Sample Receipt & Login SOP (1559)

Perkin-Elmer, Model AD-6 Manufacturer User's Manual

Document Control SOP 1729

Laboratory Notebook Usage Work Instruction (WI 1556)

SOP/1732 MDL Generation

SOP/1739 IDC Generation

Hazardous Waste & Sample Disposal SOP (1797)

16. Attachments

None.

Attachment B
ASTM Method for Measuring PNOD

Designation: D 7262 – 07

Standard Test Method for Estimating the Permanganate Natural Oxidant Demand of Soil and Aquifer Solids[1]

This standard is issued under the fixed designation D 7262; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the estimation of the permanganate natural oxidant demand (PNOD) through the determination of the quantity of potassium permanganate ($KMnO_4$) that organic matter and other naturally occurring oxidizable species present in soil or aquifer solids will consume under specified conditions as a function of time. Oxidizable species may include organic constituents and oxidizable inorganic ions, such as ferrous iron and sulfides. The following test methods are included:

Test Method A—48-hour Permanganate Natural Oxidant Demand

Test Method B—Permanganate Natural Oxidant Demand Kinetics

1.2 This test method is limited by the reagents employed to a permanganate natural oxidant demand (PNOD) of 60 g KMnO4 per kg soil or aquifer solids after a period of 48 hours (Method A) or two weeks (Method B).

1.3 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026.

1.4 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 This standard does not purport to interpret the results of the data. It is the responsibility of the user of this standard to interpret the results obtained and to determine the applicability of these results prior to use.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 1193 Specification for Reagent Water

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6051 Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6282 Guide for Direct Push Soil Sampling for Environmental Site Characterizations

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

2.2 *Other Standards:*[3]

Method 4500—$KMnO_4$ Standard Methods for the Examination of Water and Wastewater, 20th Ed. 1998

ANSI/AWWA B603-03. Standard for Permanganates

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *permanganate natural oxidant demand ($PNOD_t$)*—the mass of potassium permanganate consumed per mass of soil or aquifer solids as a function of time.

3.1.2 *maximum permanganate natural oxidant demand ($PNOD_{max}$)*—the maximum mass of potassium permanganate consumed per mass of soil or aquifer solids over time.

3.1.3 *permanganate natural oxidant demand kinetics*—the rate at which potassium permanganate is consumed by soil or aquifer solids.

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigations.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

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4. Summary of Test Method

4.1 Many organic and reduced inorganic substances present in soil and aquifer solids can be oxidized by permanganate. A standard potassium permanganate solution is added to a specific amount of soil or aquifer solids and allowed to react for a period of 48 hours (Method A) or two weeks (Method B). The residual permanganate concentration is measured at prescribed sampling times and the difference in concentration is used to calculate the $PNOD_t$ at that time.

4.2 Many organic and reduced inorganic substances present in soil and aquifer solids can be oxidized by permanganate. However, some organic compounds react slowly and may not be completely oxidized within the test period while others may resist oxidation altogether.

5. Significance and Use

5.1 The test method is used to estimate the permanganate natural oxidant demand exerted by the soil or aquifer solids by determining the quantity of potassium permanganate that is consumed by naturally occurring species as a function of time. Typically the measurement of PNOD is used to screen potential sites for in situ chemical oxidation (ISCO) with permanganate (Test Method A) and provide information to aid in the design of remediation systems (Test Method B).

5.2 While some oxidizable species react relatively quickly (that is, days to weeks), others react more slower (weeks to months). Consequently, the $PNOD_t$ is expected to be some fraction of the $PNOD_{max}$.

5.3 Due to mass transport related issues at the field-scale it is reasonable to assume that the $PNOD_t$ measured using the test method may overestimate the demand exerted during ISCO applications.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing/sampling/inspection/and so forth.

6. Interferences

6.1 Manganese oxides produced as a result of permanganate reduction may interfere with the analysis of permanganate (Method 4500-$KMnO_4$).

7. Apparatus

7.1 *Reactor Apparatus*—A 250 mL glass vial (Pyrex or equivalent) with an oxidant resistant screw cap is recommended. Zero headspace is not required.

7.2 *Apparatus for Drying Samples*—A laboratory oven capable of delivering sufficient controlled heat to maintain a temperature of 105°C.

7.3 *Balance Scales*—A balance having a minimum capacity of 100g and meeting the requirements of Guide D 4753, readable (with no estimation) to 0.1 % of the test mass or better.

8. Hazards

8.1 When performing laboratory analysis and handling chemicals, safety is a critical component. For this procedure, contact lenses may not be worn. Recommended personal protective equipment (PPE) for this procedure includes rubber gloves, safety glasses or goggles and a lab coat or rubber apron.

8.2 In the event of any chemical spill, refer to the specific MSDS for a proper clean-up procedure. In the case of solid potassium permanganate, sweep the solid into a clean container and dispose according to state and local regulations. A potassium permanganate spill should be diluted with water to less than 4 % strength, collected and disposed of in an approved manner. Paper or cloth towels should not be used to clean any permanganate spill.

8.3 Excess permanganate solutions can also be neutralized by sodium thiosulfate, citric acid, or other reducing agents. Solution concentrations must be less than 4 % prior to addition of any reducing agent. Excess heat can be generated and there is a potential for an unwanted reaction.[4]

9. Sampling

9.1 Collect the sample(s) in accordance with Practices D 6051, D 6169, D 6282, or D 6286. A minimum of 600 grams of soil or aquifer solids is required from each sampling location.

9.2 Samples can be preserved at 4°C for up to 28 days. However, it is the responsibility of the users of the test method to ensure the maximum holding time for their samples.

[4] Additional references on general laboratory safety and procedures can be found at: http://www.ceet.niu.edu/labs/safety.html, http://keats.admin.virginia.edu/lsm/home.html, and http://www.ehs.iupui.edu/ehs/prog_chemlabsafety.asp.

TEST METHOD A—48-HOUR PERMANGANATE NATURAL OXIDANT DEMAND

10. Scope

10.1 The test method is appropriate for the determination of the 48-hour permanganate natural oxidant demand of soil and aquifer solids. The test is designed to be used for site screening purposes only. Research has shown that a large percentage of the total permanganate natural oxidant demand can be expressed after a period of 48 hours. Consequently, this test method should not be used to determine the mass of oxidant required for the treatment of hazardous waste sites being considered for ISCO with permanganate.

11. Summary of Test Method

11.1 The sample and permanganate solutions are analyzed for permanganate after a 48-hour reaction period.

12. Reagents and Materials

12.1 *Purity of Reagents*—Reagent grade chemicals shall be used.

12.2 *Purity of Water*—Reference to water shall be understood to mean reagent grade water that meets the purity specifications of Type I or Type II water according to Specification D 1193.

12.3 *Potassium Permanganate Stock Solution (20 000 mg/L)*—Dissolve 20.0 g of potassium permanganate ($KMnO_4$) in water and dilute to 1 L. Mix the stock solution for a minimum of 2 hours to make certain the $KMnO_4$ crystals have completely dissolved.

NOTE 2—In place of potassium permanganate, sodium permanganate can be used. However, since the concentration of a commercially available NaMnO4 solution may vary, standardization is required. This may be accomplished using ANSI/AWWA B603-03.

13. Procedure

13.1 Dry each sample in the laboratory oven at 105°C for a period of 24 hours.

13.2 Homogenize the dried sample by gently mixing by hand. If large stones or rocks are present they should be removed prior to analysis using a No. 10 U.S. standard mesh sieve (2.00 mm).

13.3 Place 100 ml of 20 000 mg/l $KMnO_4$ stock solution in a 250 ml glass vial for the blank determination.

13.4 Place 50 g of dried sample in each of three 250 ml glass vials (each experiment is run in triplicate).

13.5 Place 100 ml of 20 000 mg/l KMnO4 stock solution in each of the three 250 ml glass vials containing the dried sample. Seal each of the vials and invert once to mix the reagents. Store vials at room temperature (20–22°C).

13.6 Sample each vial at 48 hours by removing a 1 ml sample aliquot. A centrifuge or oxidant resistant filter (20 µm) should be used to remove manganese oxides from the sample prior to analysis using Method 4500—$KMnO_4$.

14. Calculations

14.1 $PNOD_t$ values are expressed in units of mass of potassium permanganate per mass of dry aquifer solids using the following equation:

$$PNOD_t = \frac{V([KMnO_4]_0 - [KMnO_4]_t)}{m_{soil}} \quad (1)$$

where:

$PNOD_t$ = permanganate natural oxidant demand at time = t (g $KMnO_4$/kg soil or aquifer solids),
V = volume of the aqueous phase (l),
$[KMnO_4]_0$ = initial potassium permanganate concentration (g/l),
$[KMnO_4]_t$ = potassium permanganate concentration (g/l) at time = t, and
m_{soil} = mass of dry soil or aquifer solids (kg).

15. Precision and Bias

15.1 *Precision*—Test data on precision is not presented due to the nature of the soil and aquifer solids used by this test method. It is either not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program. Also, it is either not feasible or too costly to produce multiple specimens that have uniform physical properties. Any variation observed in the data is just as likely to be due to specimen variation as to operator or laboratory testing variation.

15.2 The Subcommittee D18.21 is seeking any data from the users of this test method that might be used to make a limited statement on precision.

15.3 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

TEST METHOD B—PERMANGANATE NATURAL OXIDANT DEMAND KINETICS

16. Scope

16.1 The test method is appropriate for the determination of the permanganate natural oxidant demand kinetics for soil and aquifer solids. A curve fitting software package can be used to determine best-fit curves and kinetic parameters for each data set using the independent first-order model described below. The curve fitting software can also be used to predict the $PNOD_{max}$ of the soil or aquifer solids based on the kinetic data.

17. Summary of Test Method

17.1 The sample and permanganate solutions are analyzed for permanganate after reaction periods of 1, 3, 7, 24, 48, 168, and 336 hours.

18. Apparatus

18.1 *Reactor Apparatus*—A 250 mL glass vial (Pyrex or equivalent) with an oxidant resistant screw cap is recommended. Zero headspace is not required.

18.2 *Apparatus for Drying Sample*—A laboratory oven capable of delivering sufficient controlled heat to maintain a temperature of 105°C.

18.3 *Balances/Scales*—A balance having a minimum capacity of 100g and meeting the requirements of Guide D 4573, readable (with no estimation) to 0.1% of the test mass or better.

19. Reagents and Materials

19.1 *Purity of Reagents*—Reagent grade chemicals shall be used.

19.2 *Purity of Water*—Reference to water shall be understood to mean reagent grade water that meets the purity specifications of Type I or Type II water according to Specification D 1193.

19.3 *Potassium Permanganate Stock Solution (30 000 mg/L)*—Dissolve 30.0 g of potassium permanganate ($KMnO_4$) in water and dilute to 1 L. Mix the stock solution for a minimum of 2 hours to make certain the $KMnO_4$ crystals have completely dissolved.

19.4 *Potassium Permanganate Stock Solution (20 000 mg/L)*—Dilute 333.3 ml of 30 000 mg/L potassium permanganate stock solution to 500 ml.

19.5 *Potassium Permanganate Stock Solution (10 000 mg/L)*—P – Dilute 166.7 ml of 30 000 mg/L potassium permanganate stock solution to 500 ml.

20. Procedure

20.1 Dry each sample in the laboratory oven at 105°C for a period of 24 hours.

20.2 Homogenize the dried sample by gently mixing by hand. If large stones or rocks are present they should be removed prior to analysis using a No. 10 U.S. standard mesh sieve (2.00 mm).

20.3 Place 100 ml of 30 000 mg/l $KMnO_4$ stock solution in a 250 ml glass vial for the blank determination.

20.4 Place 50 g of dried sample in each of three 250 ml glass vials (each experiment is run in triplicate).

20.5 Place 100 ml of 30 000 mg/l KMnO4 stock solution in each of the three 250 ml glass vials containing the dried sample. Seal each of the vials and invert once to mix the reagents. Store vials at room temperature (20 - 22°C).

20.6 Sample each vial at 48 hours by removing a 1 ml sample aliquot. A centrifuge or oxidant resistant filter (20 µm) should be used to remove manganese oxides from the sample prior to analysis using Method 4500—$KMnO_4$.

20.7 Repeat 20.3 through 20.6 using the 20 000 and 10 000 mg/l $KMnO_4$ stock solutions.

21. Calculations

21.1 PNOD values are expressed in units of mass of potassium permanganate per mass of dry aquifer solids using the following equation:

$$PNOD_t = \frac{V([KMnO_4]_0 - [KMnO_4]_t)}{m_{soil}} \quad (2)$$

where:

$PNOD_t$	=	permanganate natural oxidant demand at time = t (g $KMnO_4$/kg soil or aquifer solids),
V	=	volume of the aqueous phase (l),
$[KMnO_4]_0$	=	initial potassium permanganate concentration (g/l),
$[KMnO_4]_t$	=	potassium permanganate concentration (g/l) at time = t, and
m_{soil}	=	mass of dry soil or aquifer solids (kg).

21.2 Permanganate concentration tends to decrease rapidly within the first 48 hours and more slowly thereafter. The independent first-order kinetic rate expression shown in Eq 3, with fast and slow reaction rate constants, can be used to model permanganate decay over time.

$$\frac{d[KMnO_4]}{dt} = -k_f a[KMnO_{4f}] - k_s b[KMnO_{4s}] \quad (3)$$

where:

$[KMnO_{4f}]$	=	the concentration of $KMnO_4$ involved in the fast reactions,
$[KMnO_{4s}]$	=	the concentration of $KMnO_4$ involved in the slow reactions,
k_f	=	the first-order reaction rate constant representing the fast reactions (s^{-1}),
k_s	=	the first-order reaction rate constant representing the slow reactions (s^{-1}),
a	=	the fraction of $KMnO_4$ involved in the fast reactions, and
b	=	the fraction of the $KMnO_4$ involved in the slow reactions.

A curve fitting software package should be used to determine best-fit curves and kinetic parameters for each data set using the independent first-order model. The curve fitting software can also be used to predict the $PNOD_{max}$ based on the kinetic data.

22. Precision and Bias

22.1 *Precision*—Test data on precision is not presented due to the nature of the soil and aquifer solids used by this test method. It is either not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program. Also, it is either not feasible or too costly to produce multiple specimens that have uniform physical properties. Any variation observed in the data is just as likely to be due to specimen variation as to operator or laboratory testing variation.

22.2 The Subcommittee D18.21 is seeking any data from the users of this test method that might be used to make a limited statement on precision.

22.3 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

23. Keywords

23.1 Permanganate natural oxidant demand;*in situ* chemical oxidation; potassium permanganate

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