EXHIBIT E

FUSS & O'NEILL

Exhibit L

SAILER
Environmental, Inc.
environmental consultants

December 31, 2018

Attorney – Client Privileged

Chris Carpentieri, Esq.
Chris Carpentieri & Associates, LLC
109 Centre Street
City Island, NY 10464

Re: 171 Lombardy Street
Brooklyn, NY
SEI Project No. 795.03

Dear Chris:

Sailer Environmental, Inc. (SEI) is pleased to provide you with this report setting forth the results of its preliminary evaluation of available options to remediate the impacted soils that have been identified at 171 Lombardy Street in the Borough of Brooklyn, Kings County, New York (the Site). The site consists of one lot of land identified in the Borough of Brooklyn land records as Block 2821, Lot 1.

Background

The New York State Department of Environmental Conservation (NYSDEC) has investigated soil and ground water at, and in the vicinity of, the Site as a result of work performed during its Meeker Avenue Plume Trackdown investigation. Specifically, the NYSDEC found tetrachloroethene (PCE) in shallow ground water at concentrations up to 8,400 parts per billion (ppb), and in deep ground water up to 20,000 ppb. PCE was also detected at a concentration of 23,000 parts per million (ppm) in a soil sample collected from 1' to 1.5' below grade adjacent to the Site sanitary system cesspool located on the west side of the building in the sidewalk on Varick Avenue. Based on those investigations NYSDEC alleged that the Site is one of several sources of PCE, trichloroethene (TCE), and other daughter compounds formed by the reductive dechlorination of PCE and TCE (hereinafter referred to as Halogenated Volatile Organic Compounds "HVOCs"), found in the ground water in the area. SEI was retained to investigate NYSDEC's allegations and develop a plan to determine the aerial extent and degree of the HVOC impacted soil at the Site.

Initially, SEI filed a request under the New York State Freedom of Information Law (FOIL) for documents related to the NYSDEC Meeker Avenue Plume Trackdown investigation. SEI was provided with an electronic copy of the NYSDEC public files containing over 32,000 pages of reports including the November 2013 Phase VII Site Characterization report prepared by URS Corporation. Based upon a review of the data, SEI developed a scope of work to collect soil samples at the Site in an effort to determine the extent and degree of the HVOCs in the soils and to determine whether the Site is contributing to the ground water plume beneath the Site.

Soil Sampling Conducted in October and November 2015

In October and November 2015, SEI conducted soil sampling at the Site to attempt to delineate the horizontal and vertical extent of the HVOCs impact previously identified along Varick Avenue by NYSDEC and to determine whether potential areas of concern at the Site (floor drains, cesspools and loading docks) were sources of the HVOCs. This investigation is documented in SEI's December 21, 2015 letter report to Chris Carpentieri.

In summary, SEI's investigation found that the cesspools did not contain detectable concentrations of the HVOCs, that there were some impacted soils in the vicinity of the floor drains and determined that vertical extent of the HVOCs impact was limited to a depth of approximately 22 feet below ground surface (bgs) along Varick Avenue. These results were consistent with the vertical distribution of the VOCs identified by NYSDEC. The horizontal limits of the VOCs impact were found to extend beyond the soil samples collected and required additional soil sampling to complete the delineation.

Compound-Specific Isotope Analysis

During the October and November 2015 sampling event, SEI also collected soil samples for Compound-Specific Isotope Analysis (CSIA). The CSIA was performed in an effort to determine if the HVOCs detected in the soils at the site were a contributing source to the ground water contamination associated with the Meeker Avenue Plume Trackdown investigation. Different spills of PCE may have different isotopic "signatures" that can be used to associate a plume of contamination in ground water with a particular spill. CSIA has been used successfully at a variety of sites to distinguish between contaminant releases which occurred at different times and places at complex spill sites. The findings of the CSIA samples were used to compare the characteristics of the HVOCs detected in the soil at the site to the HVOCs detected in ground water samples collected by the NYSDEC.

The CSIA was performed on shallow soil samples collected by SEI during the October and November 2015 sampling event. SEI subcontracted GZA GeoEnvironmental, Inc. to compare the CSIA results of the three soil samples to the NYSDEC's CSIA analysis of ground water samples collected from monitoring wells located adjacent to the Site building along Varick Avenue. The findings of the CSIA analysis of the shallow soil samples and the CSIA analysis of the ground water samples disclosed that there are different carbon isotope signatures between the PCE detected in the shallow soil samples as compared to the PCE detected in the ground water at the subject site. The different carbon isotope signatures suggest that PCE in the soil at the subject site may be from a different source than PCE detected in the ground water, within a 90%

confidence interval. A copy of GZS GeoEnvironmental, Inc. May 12, 2016 letter report in attached as Appendix A.

Soil Vapor Investigation and Soil Sampling Conducted in July and August 2016

Based upon the results of the soil sampling and analysis described above SEI conducted a Soil Vapor Investigation beneath the floor of the building and conducted additional soil sampling to continue to delineate the horizontal and vertical extent of PCE and TCE Impact in accordance with SEI Proposal 16-010/NY.

Soil Vapor Investigation

The soil samples that were collected from beneath the floor of the building during the October and November 2015 site assessment were collected along the western perimeter of the building closest to Varick Avenue. In July 2016, SEI conducted a soil vapor survey of the soils beneath the concrete floor of the northern portion of the building. The soil vapor survey was conducted within the interior portions of the building using a portable photoionization detector (PID). A hammer drill was used to bore holes through the concrete floor and into the soil below to a depth of approximately 2.5-feet below the floor surface. SEI then utilized the PID and a sampling probe to sample the soil for HVOC vapors at each location. The soil vapor screening was performed to aid SEI in determining the areas beneath the concrete floor that may be impacted by elevated concentrations of HVOCs and to determine the areas from which soil samples would be collected from soil borings for laboratory analysis.

The soil vapor survey detected HVOC vapors in the shallow soils beneath the northern portion of the building at concentrations ranging from 10 parts per million (ppm) to 650 ppm. The soil vapor survey indicated widespread impact of the HVOCs in the shallow soil beneath the northern portion of the building. The soil vapor survey sampling locations and the concentrations of HVOC vapors detected at each respective location are shown on the attached Figure 1, Soil Vapor Survey Map.

Soil Sampling Conducted in August 2016

In August 2016, SEI collected soil samples from soil borings advanced through the concrete floor in that the northern portion of the building to delineate the vertical and horizontal extent of the impacted soil. SEI collected twenty-seven soil samples from fourteen soil borings. The soil cores from each soil boring were screened for the HVOC vapors using a PID. One soil sample was collected from near the surface of each sampling location to delineate the horizontal extent of the impacted soil. An additional soil sample was collected from each sampling location (except one location) at depth to delineate the vertical extent of the impacted soil. The samples collected at depth were selected based on indications of the HVOC vapors using the PID.

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The analytical results of the soil samples showed that the shallow soil from beneath the floor is impacted by the VOCs at concentrations above the applicable NYSDEC soil criteria. The VOC impacted soil was detected in the shallow soils throughout the northern portion of the building. Elevated concentrations of the VOCs were also detected is two soil samples collected at a depth of 10-feet below surface grade. The locations of the soil samples and a summary of the analytical results are shown on the attached Figure 2, August 2016 Soil Sample Location Map.

Discussion

SEI's Proposal 16-010/NY and subsequent discussions with the tenant in the building called for the additional sampling to be conducted in phases. This approach would allow interpretation of data in phases and accommodate the tenant's needs to operate their business while the investigation was taking place. The soil vapor survey and soil sampling described above were the first phase of work to be conducted. Additional sampling within the building and along Varick Avenue was anticipated after the August 2016 of sampling was completed.

Based upon the results of the August 2016 sampling, the horizontal extent of the HVOCs impacted soil was far more wide spread than anticipated. In fact the data suggests that approximately 24,000 tons of soil under the building would require remediation to meet the NYSDEC standards. Traditional excavation and disposal of the soil beneath the building would almost certainly require that most, if not all, of the building be demolished before work could begin and the excavation and disposal of the soil would likely exceed $8.5 million dollars. See Appendix B-1 and B-2 for the basis of this estimate). Additional horizontal delineation in and around the building (including delineation of the soils known to be impacted along Varick Avenue and the central and southern portions of the building) will increase the volume of soil to be remediated.

Rather than continue the horizontal delineation of the impacted soil SEI, in consultation with you and the Site owner, decided that a preliminary evaluation of remedial alternatives to excavation and disposal of soils was warranted to determine whether there was a more practical and cost effective method. The results of that evaluation are discussed below.

SEI evaluated several alternatives to remediate the soils including, Soil Vapor Extraction and Air Sparging (SVE/AS), In Situ Chemical Oxidation (ISCO), In Situ Chemical Reduction (ISCR), Enhanced Anaerobic Bioremediation, Bioaugmentation and In Situ Thermal Treatment. Each of these technologies are described in Appendices C-1 through C-5 and Appendix D. A summary of SEI evaluation these alternatives is provided in the table below:

Preliminary Evaluation of Remedial Alternatives			
Technology	**Description of Technology**	**Applicability of Technology to the Site**	**Cost**
SVE/AS	Injection of air into the ground water to volatilize the HVOCs. The vapors are then extracted from the soils above the water table for treatment. (See Appendix C-1)	There appear to be two different sources of HVOCs beneath the site: the HVOCs in the ground water and the HVOCs in the soils above the ground water. They appear to have not comingled and the Site may not be contributing to the HVOCs in the ground water. Use of this technology would comingle these two sources and negate any argument that the Site is not responsible for the HVOCs in the ground water. Not recommended for this Site.	N/A
ISCO	Injection of chemical oxidants into the soil and/ or ground water to rapidly oxidize and destroy the HVOCs that are contacted by them. (See Appendix C-2)	There appear to be two different sources of HVOCs beneath the site: the HVOCs in the ground water and the HVOCs in the soils above the ground water. They appear to have not comingled and the Site may not be contributing to the HVOCs in the ground water. Use of this technology would involve injection of the liquid oxidants which will likely move the HVOCs in the soils downward to the ground water and negate any argument that the Site is not responsible for the HVOCs in the ground water. Not recommended for this Site.	N/A

ISCR	Biogeochemical reduction utilizing iron particles or iron salts that are injected into the soils to enhance biodegradation of the HVOCs. (See Appendix C-3)	There appear to be two different sources of HVOCs beneath the site: the HVOCs in the ground water and the HVOCs in the soils above the ground water. They appear to have not comingled and the Site may not be contributing to the HVOCs in the ground water. Use of this technology would involve injection of the liquid oxidants which will likely move the HVOCs in the soils downward to the ground water and negate any argument that the Site is not responsible for the HVOCs in the ground water. Not recommended for this Site.	N/A
Enhanced Anaerobic Bioremediation	This technology injects hydrogen to enhance the biodegradation of HVOCs in soil and ground water. (See Appendix C-4)	This technology only works in the saturated zone. The HVOCs in the soil at the Site are well above the Saturated zone. This technology will not work.	N/A
Bioaugmentation	This technology injects cultured microorganisms for bioaugmentation of HVOCs in soil and ground water. (See Appendix C-5)	This technology only works in the saturated zone. The HVOCs in the soil at the Site are well above the Saturated zone. This technology will not work.	N/A
In Situ Thermal Conduction Heating	This technology utilizes heater rods installed through the floor of the building to heat the soils to a temperature of ± 200^0 F. The HVOCs are then extracted by vertical extraction wells grouped with each heater. The HVOC vapors are then treated. (See Appendix D)	This technology appears to be suitable for treatment of the HVOCs in the soils beneath the building. According to studies provided to SEI, the technology does not cause the HVOCs to migrate downward toward the ground water during treatment. (See Appendix E)	$3 million

Based upon the above analysis of remedial alternatives it appears that In Situ Thermal Conduction Heating may be a viable alternative to excavation and disposal of the soils beneath the building. Please remember that in addition to the remediation of the soils beneath the building some soil excavation will still be necessary in the vicinity of the side walk along Varick Avenue and possibly in other areas that have not yet been fully delineated.

Should you have any questions or require additional information please contact us.

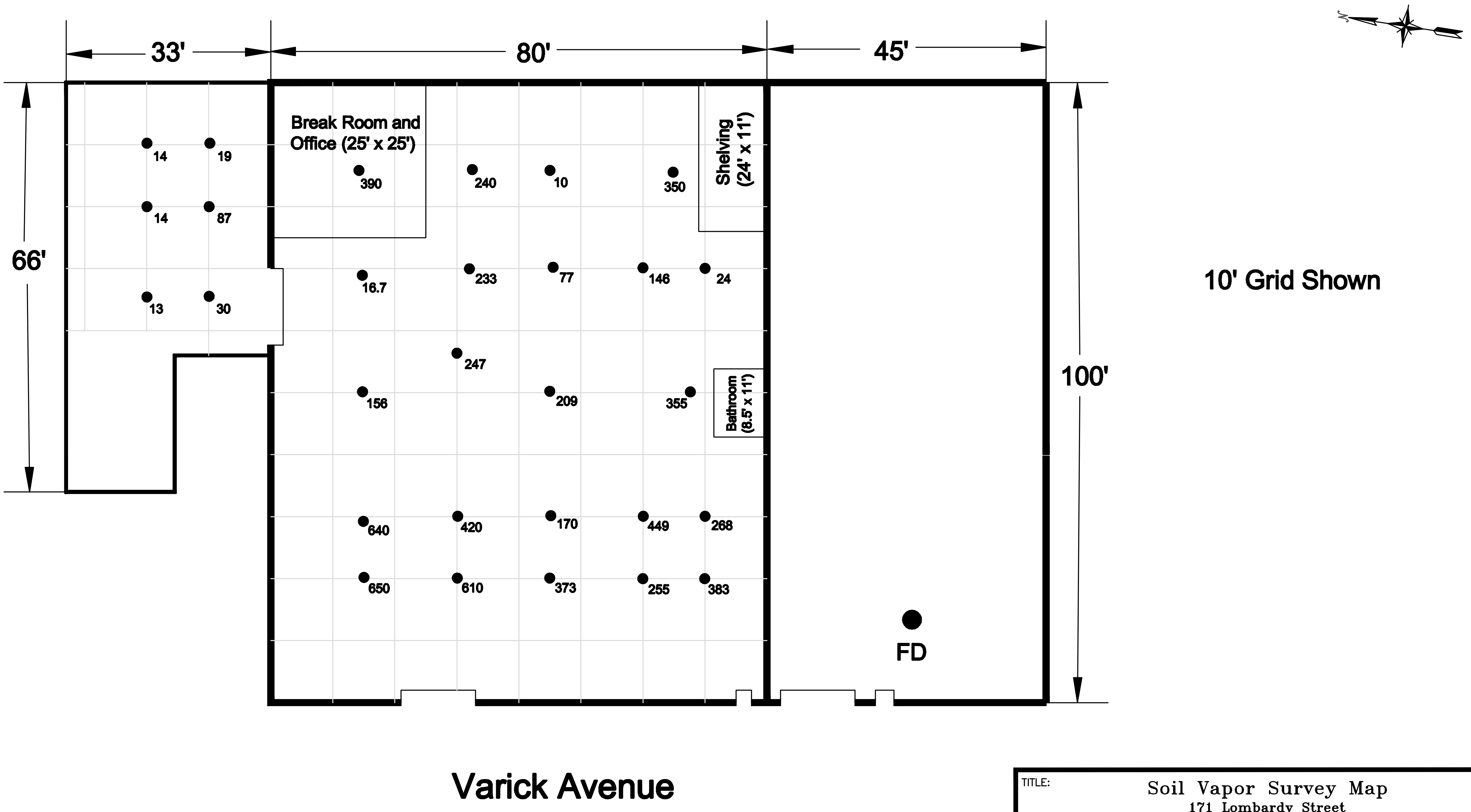
Sincerely,

SAILER ENVIRONMENTAL, INC.

Edward N Sailer

Edward N. Sailer, CHMM, LEP
President

Attachments



10' Grid Shown

Legend:

●383 - Soil vapor sample location with soil vapor result shown in ppm

TITLE: Soil Vapor Survey Map 171 Lombardy Street Brooklyn, New York		
PREPARED FOR: Chris Carpentieri & Associates		
SAILER ENVIRONMENTAL, INC. environmental consultants Madison, Connecticut Lebanon, New Jersey	DRAWN BY DT	DATE 7/28/16
	CHECKED BY ENS	SCALE (Approximate) As Shown
	PROJECT NO. 795.03	DRAWING NO. Fig. 1

SS25	SS26
2 feet	14 feet
PCE = 14.2	PCE = 0.0514
TCE = 0.0732	TCE = ND
ACE = 0.0561	ACE = 0.0190

SS23	SS24
2 feet	14 feet
PCE = 22.4	PCE = 0.210
TCE = 0.0398	TCE = 0.0052
ACE = 0.0686	ACE = 0.0102

SS21	SS22
2 feet	12 feet
PCE = 3.47	PCE = 0.061
TCE = 0.0233	TCE = ND
ACE = 0.0958	ACE = 0.0156

SS15	SS16
2 feet	10 feet
PCE = 49.0	PCE = 0.108
TCE = 0.112	TCE = ND
DCE = 0.265	DCE = 0.0069

SS13	SS14
2 feet	15 feet
PCE = 65.1	PCE = 0.132
TCE = 0.113	TCE = ND
ACE = 0.0555	ACE = ND

SS11	SS12
2 feet	14 feet
PCE = 65.0	PCE = 1.30
TCE = 0.082	TCE = 0.0188

SS9	SS10
2 feet	19 feet
PCE = 80.1	PCE = 0.287
TCE = 0.132	TCE = 0.0052
BEN = 0.0696	BEN = ND

SS7	SS8
2 feet	18 feet
PCE = 51.1	PCE = 0.229
TCE = 0.110	TCE = ND

SS3	SS4
2 feet	19 feet
PCE = 164	PCE = 0.260
TCE = 0.229	TCE = ND
DCE = 0.254	DCE = 0.0184
ACE = 0.0887	ACE = ND

SS1	SS2
2 feet	20 feet
PCE = 4.06	PCE = 0.970
TCE = 0.0748	TCE = 0.012

SS5	SS6
2 feet	10 feet
PCE = 181	**PCE = 2.65**
TCE = 0.0594	TCE = 0.0223

SS19	SS20
1.5 feet	10 feet
PCE = 74.1	**PCE = 97.7**
TCE = 6.64	**TCE = 1.13**
DCE = 0.0280	**DCE = 2.42**
ACE = 0.0698	**ACE = 0.130**

SS17	SS18
1.5 feet	17 feet
PCE = 78.4	PCE = 0.959
TCE = 1.36	TCE = 0.009
DCE = 3.24	DCE = 0.0330

SS27
1.5 feet
PCE = 305
TCE = 0.0081
ACE = 0.146

S3-T	S3-B
1 - 2 feet	19 - 20 feet
PCE = ND	PCE = 0.0064
TCE = ND	TCE = ND

S2-T	S2-B
1 - 2 feet	14 - 15 feet
PCE = ND	PCE = 0.0078
TCE = ND	TCE = ND

S1-T	S1-B
1 - 2 feet	19 - 20 feet
PCE = ND	PCE = ND
TCE = ND	TCE = ND

S4-T	S4-B
5 - 6 feet	19 - 20 feet
PCE = ND	PCE = 0.0037
TCE = ND	TCE = ND

B2
1 foot
PCE = 37.3
TCE = 1.09

B1-T	B1-B
1 foot	5 feet
PCE = 0.53	**PCE = 2.55**
TCE = ND	TCE = ND

Floor Drain	Floor Drain
1 foot	5 feet
PCE = 20.0	**PCE = 43.5**
TCE = 0.142	TCE = 0.302
DCE = 0.138	**DCE = 0.377**
ACE = 0.413	**ACE = 0.188**

IN7-T	IN7-B
2 feet	20 feet
PCE = 6,840	**PCE = 7.51**
TCE = 5.15	TCE = 0.185
DCE = ND	**DCE = 2.85**

IN6-T	IN6-B
1.5 feet	20 feet
PCE = 8,770	**PCE = 169**
TCE = 8.55	TCE = 0.454
DCE = ND	**DCE = 4.61**

VS6-T	VS6-B
1 foot	20 feet
PCE = 269	PCE = 0.779
TCE = 0.300	TCE = 0.0183
ACE = 0.0955	ACE = 0.0209

VS5-T	VS5 (8)	VS5-B
1 foot	8 feet	20 feet
PCE = 146	PCE = ND	PCE = 0.709
TCE = 0.253	TCE = ND	TCE = 0.0117
ACE = 0.0614	**ACE = 0.149**	ACE = 0.0206

VS7-T	VS7 (8)	VS7-B
0.5 feet	8 feet	12 feet
PCE = 415	PCE = 0.392	PCE = 0.221
TCE = 14.1	TCE = 0.0127	TCE = 0.0071
DCE = 23.6	DCE = 0.0556	DCE = 0.0161
ACE = ND	**ACE = 0.0519**	**ACE = 0.0621**

NYS DEC Sample DEC-094D		
0.5 feet	3 feet	6.5 feet
PCE = 150	**PCE = 790**	**PCE = 22**
TCE = 2.5	TCE = 0.24	TCE = 0.24

IN1-T	IN1-8	IN1-B
1.5 feet	6-8 feet	20 feet
PCE = 134	**PCE = 318**	**PCE = 3.2**
TCE = 0.132	**TCE = 3.21**	TCE = 0.0059
ACE = 0.176	ACE = ND	ACE = ND

NYS DEC Sample DEC-080D	
0.5 - 2 feet	5 - 6 feet
PCE = 11,000	**PCE = 1,100**

IN2-T	IN2 (10-12)	IN2-B
1.5 feet	10-12 feet	20 feet
PCE = 394	**PCE = 323**	PCE = 0.0544
TCE = 0.166	**TCE = 1.35**	TCE = ND
DCE = 0.0634	**DCE = 0.270**	DCE = 0.0017
ACE = 0.175	**ACE = 0.0921**	ACE = ND

IN3-T	IN3-B
1.5 feet	20 feet
PCE = 147	PCE = 0.924
TCE = 0.865	TCE = 0.0083
ACE = 0.136	ACE = ND

IN4-T	IN4-B
1.5 feet	20 feet
PCE = 82.2	PCE = 0.304
TCE = 0.293	TCE = 0.0065
DCE = 2.12	DCE = 0.0224
ACE = 0.0778	ACE = ND

VS3-T	VS3 (7)	VS3-B
1 foot	7 feet	20 feet
PCE = 324	PCE = 0.628	PCE = 0.453
TCE = 18.4	TCE = 0.0154	TCE = ND
DCE = 24.4	DCE = 0.0300	DCE = 0.0298
ACE = 0.145	**ACE = 0.0598**	ACE = 0.0243
BEN = 0.602	BEN = ND	BEN = ND

IN5-T	IN5-B
1.5 feet	20 feet
PCE = 36.7	PCE = 0.299
TCE = 0.0531	TCE = 0.0067
ACE = 0.0571	ACE = ND

NYS DEC Sample DEC-095D	
4 - 5 feet	6 - 7 feet
PCE = 1.5	**PCE = 34**
TCE = 0.0045	TCE = 0.15

NYS DEC Sample DEC-095DA	
4 - 5 feet	
PCE = 3,200	**TCE = 10**

NYS DEC Sample DEC-095		
1 - 1.5 feet	2 - 2.5 feet	4 - 4.5 feet
PCE = 23,000	**PCE = 1,800**	PCE = 1.0
TCE = 10	TCE = 0.47	TCE = 0.0080

VS2-T	VS2 (7)	VS2 (12)	VS2-B
1 foot	7 feet	12 feet	20 feet
PCE = 1.81	**PCE = 1.84**	PCE = 0.505	PCE = 0.716
TCE = 0.0547	TCE = 0.0545	TCE = 0.010	TCE = 0.017
ACE = 0.0702	**ACE = 0.0858**	**ACE = 0.144**	ACE = 0.047

VS1-T	VS1 (6)	VS1 (15)	VS1-B
1 foot	6 feet	15 feet	20 feet
PCE = 5.65	PCE = 0.146	PCE = 0.177	PCE = 0.394
TCE = 0.058	TCE = 0.0045	TCE = ND	TCE = 0.0069
ACE = 0.0969	ACE = 0.0214	ACE = 0.027	ACE = 0.0216

Legend:

● - Soil boring location with analytical results summary

PCE = Tetrachloroethene

TCE = Trichloroethene

DCE = cis-1,2-Dichloroethene

ACE = Acetone

BEN = Benzene

ND = Not Detected

◎ - Cesspool

Analytical results are in milligrams per kilogram (mg/kg). Bold/highlighted analytical results exceed their respective NYS DEC criteria.

TITLE:
Soil Sample Results Map
171 Lombardy Street
Brooklyn, New York

PREPARED FOR:
Chris Carpentieri & Associates

SAILER
ENVIRONMENTAL, INC.
environmental consultants
Madison, Connecticut
Lebanon, New Jersey

DRAWN BY DT	DATE 9/14/16
CHECKED BY ENS	SCALE (Approximate) As Shown
PROJECT NO. 795.03	DRAWING NO. Fig. 2

171 Lombardy Street
Brooklyn, NY
December 31, 2018

Appendix A

SAILER
Environmental, Inc.
environmental consultants

GZA
Proactive by Design

Geotechnical
Environmental
Ecological
Water
Construction Management

655 Winding Brook Drive
Suite 402
Glastonbury, CT 06033
T: 860.286.8900
F: 860.652.8590
www.gza.com

VIA EMAIL

May 12, 2016
File No. 05.0045803.00

Edward N. Sailer
Sailer Environmental, Inc.
One Orchard Park Road
P.O. Box 21
Madison, CT 06443

Re: Interpretation of CSIA Data
171 Lombardy Street
Brooklyn, New York
Reference no. 795.02

Dear Ted:

GZA GeoEnvironmental, Inc. (GZA) is pleased to provide Sailer Environmental, Inc. (Sailer) this interpretation of compound specific isotope analysis (CSIA) data collected at 171 Lombardy Street, Brooklyn, New York (Site). CSIA was performed on samples collected from groundwater adjacent to the Site which contains chlorinated ethenes (tetrachloroethene (PCE) and trichloroethene (TCE)). Site specific CSIA data is also available for soil samples collected on the Site. This memorandum:

1. Provides an interpretation of the Site CSIA data;
2. Provides suggestions for further Site investigation; and
3. Recommends an expert consultant who is willing to work with Sailer to design the additional site investigation, analyze samples, and interpret data.

BACKGROUND

GZA understands that unsaturated soil at the Site is contaminated with PCE and TCE to approximately 22 feet below ground surface (bgs). Groundwater is approximately 47 feet bgs. PCE concentrations in Site soil have been reported up to 8,770 milligrams per kilogram (mg/kg). 2013 samples of groundwater in shallow and deep New York State Department of Environmental Conservation (NYSDEC) monitoring wells DEC-080 and DEC-080D (located adjacent to the Site) contained 1,100 (DEC-080) and 9,400 (DEC-080D) micrograms per liter (µg/L) of PCE. A CSIA report provided to NYSDEC identifies DEC-080 and DEC-080D as impacted by PCE Source 7.

Sailer collected three shallow (4 and 1.5 feet bgs) soil samples (B2, IN2-T, and IN6-T) in October and November 2015 and sent them to Pace Analytical (Pittsburgh, Pennsylvania) for two-dimensional (2D-) CSIA of carbon and chlorine in PCE. GZA has compared these Site soil data to CSIA groundwater data from Meeker Avenue Plume PCE Source 7, located adjacent to the Site on the western border. The Meeker Avenue

Plume data were provided to NYSDEC by ZymaX Forensics (formerly in Escondido, California[1]) on 29 April 2013.

In industrial and urban areas, multiple sources of the same contaminant frequently occur. This is particularly true for releases of chlorinated solvents. The ratio of stable isotopes in PCE varies, depending on the isotope ratio in the feed stock used for PCE synthesis and on the particular chemical process used to manufacture the material. The isotopic fractionation values of carbon ($^{13}C/^{12}C$) and chlorine ($^{37}Cl/^{35}Cl$) for PCE can vary from one manufacturer to another and also between different production batches produced by the same manufacturer. Different spills of PCE may have different isotopic "signatures" that can be used to associate a plume of contamination in ground water with a particular spill. CSIA has been used successfully at a variety of sites to distinguish between contaminant releases which occurred at different times and places at complex spill sites. This knowledge can be used to identify the parties that were responsible for the contamination, and CSIA has been accepted as one line of evidence in litigation[2].

SITE DATA COMPARED TO NYSDEC PCE SOURCE 7

This section provides GZA's opinion regarding the Site CSIA data compared to NYSDEC PCE Source 7, based on our review of these reports:

1. 171 Lombardy St. - Phase II Site Investigation;
2. Sailer 17730 (Site CSIA laboratory report); and
3. ZymaX Forensic Report (CSIA forensic evaluation of the Meeker Ave. Plume, which includes data from PCE Source 7).

The Site soil has detections of PCE down to 20 feet bgs (maximum of 7.8 µg/kg at boring S1-B), but the highest concentrations are in shallow soil (maximum of 8,700 mg/kg at 1.5 feet bgs, boring IN6-T). Groundwater is approximately 47 feet bgs. Samples from shallow and deep NYSDEC monitoring wells adjacent to the Site (February and March 2013) contained PCE groundwater concentrations of 1,100 µg/L (DEC-080) and 9,400 µg/L (DEC-080D). Soil samples collected by NYSDEC during construction of monitoring well DEC-080D were analyzed for volatile organic compounds and results indicated that shallow soil contained 11,000 mg/kg PCE from 0.5 to 2 feet bgs, and 1,100 mg/kg PCE from 5 to 6 feet bgs. Deeper soil data were not available, but PID (photoionization detector) readings in the boring for DEC-080D were non-detect at 25 feet bgs.

Three Site soil samples, with PCE concentrations of 37, 394, and 8,700 mg/kg, had $\delta^{13}C$ of -30.19, -30.62, and -28.55‰; and $\delta^{37}Cl$ of -2.51, -2.43, and -2.33‰. $\delta^{13}C$ and $\delta^{37}Cl$ are the carbon and chlorine stable isotope ratios, respectively, in units of parts per thousand or "per mill" (‰). "δ" is delta, or "del".

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[1] ZymaX Forensics is now part of Pace Analytical.

[2] Hunkeler, Daniel, Rainer U. Meckenstock, Barbara Sherwood-Lollar, Torsten C. Schmidt, and John T. Wilson. 2008. A guide for assessing biodegradation and source identification of organic ground water contaminants using compound specific isotope analysis (CSIA). Ada, Oklahoma: USEPA Office of Research and Development, National Risk Management Research Laboratory.

Adjacent groundwater samples, with PCE concentrations of 1,100 µg/L (shallow) and 9,400 µg/L (deep), had $\delta^{13}C$ of -27.6 and -27.5‰; and $\delta^{37}Cl$ of -1.7 and -1.8‰. Analytical error for samples that are run under similar conditions typically exhibits a total uncertainty of approximately ±0.5‰ for $\delta^{13}C$ and approximately ±0.7‰ for $\delta^{37}Cl$. **Table 1** illustrates the potential variations in CSIA data due to analytical uncertainties.

It is possible that the differences in chlorine isotopic signatures between Site PCE and PCE Source 7 are due to analytical uncertainty. The different carbon isotope signatures, however, suggest that Site PCE may be from a different source than PCE Source 7, within a 90% confidence interval (Student's t-test comparison).

Generally, there is little significant isotopic fractionation caused by transport and partitioning (*e.g.*, volatilization or dissolution) processes. PCE degradation, however, does cause significant isotopic fractionation. The difference in isotopic signatures between PCE in Site soil and PCE in adjacent groundwater monitoring wells DEC-080 and DEC-080D (PCE Source 7) could be caused by fractionation due to degradation. However, we believe this is unlikely because: 1) PCE biotic and abiotic degradation are aqueous processes, and not anticipated to occur in unsaturated soil; 2) PCE $\delta^{13}C$ values for both Site and NYSDEC samples are within the range of known manufactured PCE carbon stable isotopic ratios (-23 to -38‰); and 3) PCE biodegradation intermediates TCE and *cis*-1,2-dichloroethene (cDCE) were not detected above the method reporting limit in the sample from deep monitoring well DEC-080D, while shallow monitoring well DEC-080 contained only 13 µg/L TCE and no reportable cDCE.

Table 1. Potential variations in CSIA data due to analytical uncertainties.

	DEC-080D	**DEC-080**	**B2**	**IN2-T**	**IN6-T**
Matrix	**Off-site Groundwater**	**Off-site Groundwater**	**Site Soil**	**Site Soil**	**Site Soil**
$\delta^{13}C$ (‰)	**-27.5**	**-27.6**	**-30.19**	**-30.62**	**-28.55**
$\delta^{13}C$ + 0.5‰	-27.0	-27.1	-29.69	-30.12	-28.05
$\delta^{13}C$ - 0.5‰	-28.0	-28.1	-30.69	-31.12	-29.05
	DEC-080D	**DEC-080**	**B2**	**IN2-T**	**IN6-T**
$\delta^{37}Cl$ (‰)	**-1.8**	**-1.7**	**-2.51**	**-2.43**	**-2.33**
$\delta^{37}Cl$ + 0.7‰	-1.1	-1.0	-1.81	-1.73	-1.63
$\delta^{37}Cl$ - 0.7‰	-2.5	-2.4	-3.21	-3.13	-3.03

RECOMMENDATIONS FOR ADDITIONAL SITE INVESTIGATION

GZA suggests additional site investigation based on: 1) the vertical distance between Site contaminated soil and NYSDEC contaminated groundwater; and 2) the difference in isotopic signatures between Site CSIA data and available CSIA data from NYSDEC PCE Source 7. The design of the sampling strategy should be based on a conceptual model of the Site that considers potential contaminant migration pathways in addition to evaluating PCE concentrations and isotopic signatures at different depths and locations. 2D- or 3D-CSIA[3] of several PCE samples from the Site and NYSDEC PCE Source 7 should be performed at the same laboratory to minimize analytical uncertainties and provide enough data for a robust statistical evaluation.

EXPERT CONSULTANT RECOMMENDATION

While we would be very pleased to continue working with Sailor on this important project, due to the potential financial and regulatory implications for your client, and the reputations of the experts likely to be retained by NYSDEC, you and your client may wish to consider using an internationally recognized technical expert in CSIA interpretation.

GZA has, briefly and anonymously, discussed the Site data with Dr. Orfan Shouakar-Stash of the University of Waterloo and Isotope Tracer Technologies, Inc. (IT2), Waterloo, Ontario, Canada. Dr. Shouakar-Stash is an internationally known isotope hydrogeochemist. His qualifications are available at http://www.it2isotopes.com/index-3.html. Dr. Shouakar-Stash is willing to help you design the additional site investigation, analyze samples, and interpret data. In the interest of anonymity, we did not discuss expert witness testimony; however, this role is typical for someone with his expertise. If you are interested, please contact Dr. Shouakar-Stash at orfan@it2isotopes.com, 519-886-5555.

GZA sincerely appreciates the opportunity to be of service to Sailer on this important project. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Sincerely yours,

GZA GEOENVIRONMENTAL, INC.

Karen Kinsella
Karen Kinsella, Ph.D.
Technical Specialist

Kathleen Cyr, P.G., P.E., LEP
Principal

Tanya P. Justham
Tanya Justham, M.S.
Consultant/Reviewer

---

[3] 3D-CSIA measures hydrogen stable isotope ratios as well as carbon and chlorine.

171 Lombardy Street
Brooklyn, NY
December 31, 2018

Appendix B-1

SAILER
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Edward N. Sailer

From: Robert Brown <rvb@codeenvironmental.com>
Sent: Thursday, February 16, 2017 4:51 PM
To: 'Edward N. Sailer'
Subject: RE: 171 Lombardi Street, Brooklyn, NY

Ted

Here is a budgetary estimate for your Lombary St. project.

Sheet Piling	25,245 sq. ft. @ $49.10/ft.= $1,407,250
Excavation	24,000/tons @ $18.75/ ton = $450,000
Backfill	24,000/tons @ $32.00/ton= $768,000
Disposal	24,000/tons @ $250/ton = $6,000,000 (only a guess)

Total for above: $8,625,250

Building Demo, dewatering, building demo disposal, permits, air monitoring, H&S, Mobilizations.... NOT INCLUDED!!!!!

171 Lombardy Street
Brooklyn, NY
December 31, 2018

Appendix B-2

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INNOVATIVE
RECYCLING TECHNOLOGIES

690 No. Queens Avenue
Lindenhurst, NY 11757
Phone: (631) 225-3044
Fax: (631) 225-3056

December 30, 2016

Mr. Edward Sailer
Sailer Environmental
One Orchard Park Road
Madison, CT 06443

Re: Proposal for the transportation and disposal of F-Listed soil from the 171 Lombardi Street in Brooklyn, NY.

Dear Mr. Sailer:

Innovative Recycling Technologies, Inc. (IRT) is pleased to present the following proposal for the transportation and disposal of F-Listed soil from located in Brooklyn, NY. The costs associated with this activity are as follows:

Transportation & Disposal-Hazardous F Listed Soil ***(22 ton minimum/load)***	**$233.75/ton**

Terms and Conditions:

All documentation will be prepared by IRT. No loads are $850.00per load. Loading demurrage will be one hour free loading, then $125.00/hour thereafter. Payment terms are net 30 days from the date of our invoice. Past due invoices are subject to a 1.5% service charge per month. The customer is responsible for all costs associated with the collection of all outstanding balances. This proposal must be signed and returned prior to the start of any work activity. NYC Sales Tax will be applied to the total amount of the invoice unless a tax exempt certificate is provided prior to the start of the project.

We are looking forward to working with you on this project. If you have any questions, please feel free to contact me at 631-225-3044.

Very truly yours,

John Dull
Vice President

Accepted By: ______________________

Print Name: ______________________

Date: ______________________

171 Lombardy Street
Brooklyn, NY
December 31, 2018

Appendix C-1

SAILER
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A Citizen's Guide to Soil Vapor Extraction and Air Sparging

What Are Soil Vapor Extraction And Air Sparging?

Both soil vapor extraction, or "SVE," and air sparging extract (remove) contaminant vapors from below ground for treatment above ground. Vapors are the gases that form when chemicals evaporate. SVE extracts vapors from the soil *above* the water table by applying a vacuum to pull the vapors out. Air sparging, on the other hand, pumps air underground to help extract vapors from groundwater and wet soil found *beneath* the water table. The addition of air makes the chemicals evaporate faster, which makes them easier to extract with another technology, such as SVE.

Both methods are used for chemicals that evaporate easily—like those found in solvents and gasoline. These chemicals are known as "volatile organic compounds," or "VOCs."

How Do They Work?

Extraction:

SVE involves drilling one or more *extraction* wells into the contaminated soil to a depth above the water table, which must be deeper than 3 feet below the ground surface. Attached to the wells is equipment (such as a blower or vacuum pump) that creates a vacuum. The vacuum pulls air and vapors through the soil and up the well to the ground surface for treatment.

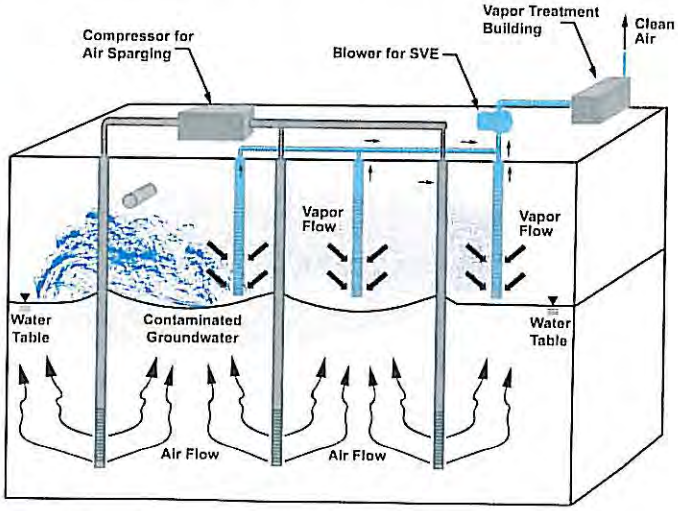

Illustration of a combined air sparging and SVE system.

Sometimes the ground must be paved or covered with a tarp to make sure that the vacuum does not pull air from above into the system. Pulling in clean air would reduce the efficiency of the cleanup. The cover also prevents any vapors from escaping from the ground to the air above.

Air sparging involves drilling one or more *injection* wells into the groundwater-soaked soil below the water table. An air compressor at the surface pumps air underground through the wells. As air bubbles through the groundwater, it carries contaminant vapors upward into the soil above the water table. The mixture of air and vapors is then pulled out of the ground for treatment using SVE.

Treatment:

Extracted air and contaminant vapors, sometimes referred to as "off-gases," are treated to remove any harmful levels of contaminants. The off-gases are first piped from the extraction wells to an air-water separator to remove moisture, which interferes with treatment. The vapors are then separated from the air, usually by pumping them through containers of activated carbon. The chemicals are captured by the carbon while clean air exits to the atmosphere. (See *A Citizen's Guide to Activated Carbon Treatment* [EPA 542-12-001.]).

Filter materials other than activated carbon may be used. In a process called "biofiltration," tiny microbes (bacteria) are added to break down the vapors into gases, such as carbon dioxide and water vapor. Another option is to destroy vapors by heating them to high temperatures.

How Long Will They Take?

Cleaning up a site using SVE or air sparging may take several years. The actual cleanup time depends on several factors. For example, cleanup may take longer where:

- Contaminant concentrations are high.
- The contaminated area is large or deep.
- The soil is dense or moist, which slows the movement of vapors.

These factors vary from site to site.

Are SVE And Air Sparging Safe?

When properly designed and operated, SVE and air sparging pose little risk to site workers or the community. Treatment of the vapors involves no harmful chemicals that must be transported to the site. Chemical vapors are contained from extraction to treatment so they cannot be accidentally inhaled by anyone nearby. Only clean air that meets air quality standards is released. The air released to the atmosphere following treatment may be sampled to make sure all harmful vapors have been removed or destroyed.

How Might It Affect Me?

Area neighborhoods may experience some increased truck traffic as the equipment for SVE or air sparging is delivered and later removed. Installation of the systems involves the use of drilling rigs and sometimes other heavy machinery to install wells, blowers, and treatment equipment. Sheds or larger buildings may be built to house the treatment systems, keeping any noise to a minimum. Workers will visit these systems regularly to ensure they are working.

Why Use Soil Vapor Extraction And Air Sparging?

SVE and air sparging are efficient ways to remove VOCs above and below the water table. Both methods can help clean up contamination under buildings, and cause little disruption to nearby activities when in full operation. SVE and air sparging are often used together. SVE and air sparging are being used or have been selected for use at approximately 285 and 80 Superfund sites, respectively.

Pipes transport vapors from the underground SVE extraction well to treatment.

Above-ground treatment system includes two tanks of activated carbon.

Example

Both SVE and air sparging are being used to clean up several acres of contaminated soil and groundwater at the Vienna PCE Superfund site in West Virginia. Two dry cleaning facilities contaminated the area with PCE (also known as perchloroethene or "perc"), a solvent used to clean clothing, forcing the shutdown of the town's drinking water wells.

In 2005, construction of the cleanup systems was completed and included 74 air sparging wells, 34 extraction wells, and four treatment buildings. The off-gases are piped to an air-water separator, followed by containers of activated carbon for treatment. By 2010, 1,618 pounds of PCE had been removed and PCE concentrations had decreased by as much as 99% in some wells. EPA will continue to operate the systems and monitor PCE levels until cleanup objectives have been reached throughout the site.

For More Information

For more information about this and other technologies in the Citizen's Guide Series, visit:

www.cluin.org/remediation
www.cluin.org/products/citguide
www.cluin.org/sve
www.cluin.org/airsparging

NOTE: This fact sheet is intended solely as general information to the public. It is not intended, nor can it be relied upon, to create any rights enforceable by any party in litigation with the United States, or to endorse the use of products or services provided by specific vendors. The Agency also reserves the right to change this fact sheet at any time without public notice.

United States
Environmental Protection
Agency

Office of Solid Waste and
Emergency Response
(5102G)

EPA 542-F-12-018
September 2012
www.epa.gov/superfund/sites
www.cluin.org

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December 31, 2018

Appendix C-2

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Home > Site Remediation Solutions Overview > *In Situ* Chemical Oxidation

In Situ Chemical Oxidation

At a Glance

Mechanism:
Chemical Destruction
Chemical reactions and free radicals destroy contaminants on contact

Treatable Contaminants:, ,
Treats wide range of contaminants

Concentrations:
Treats moderate to high concentrations

Time:
Rapid treatment time (weeks to months)

Conditions:
Saturated and unsaturated zones

Applications Frequency:
Multiple applications generally required

In Situ Chemical Oxidation Overview

In situ chemical oxidation (ISCO) involves the injection or direct mixing of reactive chemical oxidants into groundwater and soil for the primary purpose of rapid and complete contaminant destruction. ISCO is a versatile treatment technology that is most often deployed in source zones characterized by moderate to high contaminant concentrations in groundwater, significant sorbed contamination, and the potential

Featured Project

RegenOx® Technology Expedites Hollywood Brownfield Site Transaction

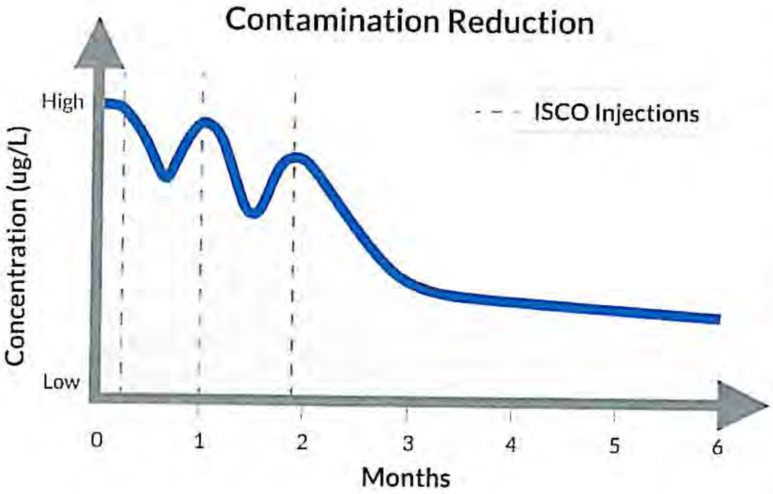
Featured Webinar

Jack Sheldon: A Tale of Two ISCO Chemistries

Video

Jeremy Birnstingl PhD Discusses *In Situ* Chemical Oxidation presence of residual, separate-phase contamination (LNAPL or DNAPL droplets or ribbons).

Photo Gallery



Successful treatment of source zones requires a detailed understanding of the nature and distribution of contaminant mass as well as an aggressive application approach that will maximize oxidant-contaminant contact and deliver a sufficient amount of oxidant to treat the dissolved, sorbed, and separate-phase contaminants. REGENESIS offers two safe and effective oxidation technologies for soil and groundwater treatment – PersulfOx® and RegenOx®. Both of our ISCO technologies employ unique and powerful catalysts to maximize treatment longevity, ensure efficient oxidation, and promote safe chemical use in the field.

REGENESIS reviews data from dozens of sites each week where ISCO is being considered. Our highly experienced professionals work with our clients to develop technically rigorous and cost-effective solutions for ISCO treatment of a variety of contaminants at sites with diverse conditions. Our no-cost project evaluations typically take into account:

- Treatment goals
- Practitioner health and safety
- Nature and extent of contamination
- Soil characteristics and hydrogeology of the target treatment zone
- Potential combination with other remediation technologies (e.g., bioremediation, thermal treatment, excavation, etc.)
- Application approaches and methods

REGENESIS welcomes the opportunity to provide you and your team with the tools you need to successfully plan and execute your next ISCO project.

If you currently have a project and need a remediation solution now, request a design.

Have questions or want to explore some ideas? Contact Us to get in touch with a local representative.

Learn More

- Is ISCO the right solution for your contamination concern? Find out here.
- Learn more about the right REGENESIS products for ISCO:

  - PersulfOx®
  - RegenOx®
- Have a look at our track record with ISCO with these Case Studies.

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REGENESIS® offers remediation professionals a suite of innovative technologies and services to treat a wide range of contaminants, including petroleum hydrocarbons and chlorinated solvents, via enhanced bioremediation, chemical oxidation, desorption and metals immobilization.

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Home > Site Remediation Solutions Overview > In Situ Chemical Reduction (ISCR)

In Situ Chemical Reduction (ISCR)

At a Glance

Mechanism:
Biogeochemical Reduction Combines biological and chemical reduction to treat contaminants

Treatable Contaminants:, ,
Treats specific chlorinated contaminants (PCE, TCE, DCE and VC)

Concentrations:
Treats moderate to low concentrations

Time:
Rapid treatment time (weeks to months)

Conditions:
Works in saturated and unsaturated zones

Applications Frequency:
Single application effectiveness (Usually applied with an electron donor like 3-D Microemulsion)

In Situ Chemical Reduction (ISCR) Overview

ISCR combines both biological processes and metallic particle driven abiotic pathways to chemically reduce chlorinated contaminants into harmless end products. ISCR agents are typically applied in combination with an electron donor type substrate which creates a biologically induced reducing environment. The incorporation of iron as metallic

Featured Project

Combined Technologies Replace Pump and Treat System

Video

Innovative Enhanced Reductive Dechlorination Design Cleans Up Large, Fast Moving Plume particles or ferrous salts (Fe^{2+}) can enhance chlorinated contaminant remediation by enabling various chemical reduction pathways. The application of ISCR is also often used in conjunction with electron donor substrates like 3-D Microemulsion® to limit the formation of undesirable chlorinated contaminant breakdown products such as Cis-DCE and vinyl chloride.

REGENESIS welcomes the opportunity to provide you and your team with the tools you need to successfully plan and execute your next in situ chemical reduction project.

If you currently have a project and need a remediation solution now, request a design.

Have questions or want to explore some ideas? Contact Us to get in touch with a local representative.

Learn More:

- Is ISCR the right solution for your contamination concern? Find out here.
- Learn more about the right REGENESIS product for ISCR: Chemical Reducing Solution (CRS™)

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Home > Site Remediation Solutions Overview > Enhanced Anaerobic Bioremediation

Enhanced Anaerobic Bioremediation

At a Glance

Mechanism:
Biological Degradation
Microbes metabolize contaminants to survive and grow

Treatable Contaminants:, ,
Chlorinated VOCs, pesticides, explosives, hexavalent chromium

Concentrations:
Treats high to low concentrations

Time:
Longer treatment time (1-5+ years)

Conditions:
Saturated zone

Applications Frequency:
Every 1-3 years, as needed
Single application common

Enhanced Anaerobic Bioremediation Overview

Enhanced anaerobic bioremediation is the practice of adding hydrogen to soil and groundwater to increase the number and vitality of indigenous microorganisms performing anaerobic bioremediation on any anaerobically degradable compound. Anaerobic bioremediation of chlorinated solvents, a process also known as reductive dechlorination, is the biologically mediated process by which chlorinated hydrocarbons are degraded under anoxic or anaerobic conditions. During this naturally occurring

Featured Project

Former Taxi Maintenance Site Successfully Treated with Enhanced Anaerobic Biodegradation and Bioaugmentation

Featured Webinar

REGENESIS RECORDING NOW AVAILABLE

A Multi-Site Performance Review of Slow-Release Electron Donor and Bioaugmentation Co-Application Strategy

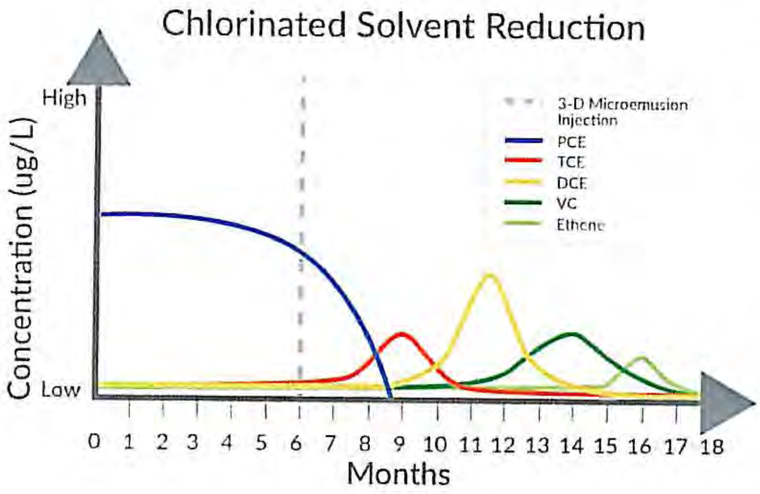
View Now

A Multi-Site Performance Review of Slow Release Electron Donor and Bioaugmentation Co-Application Strategy

Video

Jeremy Birnstingl PhD

process, anaerobic microbes substitute hydrogen for chlorine on chlorinated contaminant molecules, thus dechlorinating the compound. Complete reductive dechlorination results in the chlorinated compounds being transformed to non-toxic, dissolved gases such as ethene and ethane.



Reductive dechlorination typically proceeds at very slow, unstable rates. The use of an electron donor such as 3-D Microemulsion or Hydrogen Release Compound (HRC®) can increase the rates of reductive dechlorination up to several orders of magnitude. Under the influence of staged-release hydrogen through 3-D Microemulsion or HRC, the reductive dechlorination process can be sustained for periods of up to 2-5 years depending on subsurface conditions.

Enhanced anaerobic bioremediation is most commonly used for the treatment of chlorinated groundwater contaminants such as industrial degreasing agents like tetrachloroethylene, trichloroethylene, trichloroethane, carbon tetrachloride, certain pesticides/herbicides, nitro-aromatic explosives, hexavalent chromium, and chlorinated fluorocarbons.

REGENESIS welcomes the opportunity to provide you and your team with the tools you need to successfully plan and execute your next enhanced anaerobic bioremediation project.

If you currently have a project and need a remediation solution now, request a design.

Have questions or want to explore some ideas? Contact Us to get in touch with a local representative.

Learn More

- Is enhanced anaerobic biodegradation the right solution for your contamination concern? Find out here.
- Learn about the right REGENESIS products for enhanced anaerobic biodegradation:
  - 3-D Microemulsion
  - Hydrogen Release Compound (HRC®), Extended-Release HRC (HRC-X®) & HRC Primer®

Discusses Biological Degradation of Chlorinated Solvents and Groundwater Remediation

Innovative Enhanced Reductive Dechlorination Design Cleans Up Large, Fast Moving Plume

Photo Gallery

- Have a look at our track record with enhanced anaerobic bioremediation with Case Studies.

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Home > Site Remediation Solutions Overview > Bioaugmentation

Bioaugmentation

At a Glance

Mechanism:
Biological Degradation
Specific microbes metabolize target contaminants

Treatable Contaminants:, ,
Chlorinated VOCs

Concentrations:
Treats high to low concentrations

Time:
Longer treatment time (1-5+ years)

Conditions:
Saturated zones

Applications Frequency:
Single application common

Bioaugmentation Overview

Bioaugmentation is the practice of adding cultured microorganisms into the subsurface for the purpose of biodegrading specific soil and groundwater contaminants.

Bioaugmentation for Chlorinated Contaminants

In many cases, cultured microorganisms used for bioaugmentation are "specialists" in degrading specific target contaminants. For example, some microbes may be able to

Featured Webinar

A Multi-Site Performance Review of Slow Release Electron Donor and Bioaugmentation Co-Application Strategy

Video

Innovative Enhanced Reductive Dechlorination Design Cleans Up Large, Fast Moving Plume

Remediation of Chlorinated Solvents at an Industrial Facilty degrade the chlorinated compounds cis-1,2 dichloroethylene (cDCE) and vinyl chloride (VC) more quickly than the naturally-occurring microbial community at a particular site. As a result, the remediation community has shifted toward a more prescriptive approach with the use of bioaugmentation to accelerate the reductive dechlorination process, achieve remediation targets, and realize cost savings.

Specific strains of anaerobic microorganisms have been isolated, cultured and are commercially available for the biodegradation of the chlorinated contaminants cDCE and VC. Bio-Dechlor INOCULUM® Plus is a widely used bioaugmentation culture designed specifically for this purpose. It is typically co-applied with electron donor solutions such as 3-D Microemulsion® and HRC® to facilitate full and rapid reductive dechlorination.

Bioaugmentation for Petroleum Hydrocarbons

Relative to bioaugmentation for the degradation of petroleum hydrocarbons or any aerobically degradable contaminants in soil and groundwater, it is rare if ever that aerobic degrader augmentation is required to facilitate enhanced aerobic biodegradation.

Research has shown that aerobic microrganisms are ubiquitous and are typically limited by the availability of oxygen to sustain and grow their populations. REGENESIS recommends the use of Oxygen Release Compound (ORC®) or ORC Advanced® stimulate the existing aerobic microbial community through enhanced aerobic biodegradation.

REGENESIS welcomes the opportunity to provide you and your team with the tools you need to successfully plan and execute your next bioaugmentation project.

If you currently have a project and need a remediation solution now, request a design.

Have questions or want to explore some ideas? Contact Us to get in touch with a local representative.

Learn More

- Is bioaugmentation the right solution for your contamination concern? Find out here.
- Learn more about the right REGENESIS products for bioaugmentation:
  - Bio-Dechlor INOCULUM® Plus
- Have a look at our track record with bioaugmentation with Case Studies.

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Sitemap

171 Lombardy Street
Brooklyn, NY
December 31, 2018

Appendix D

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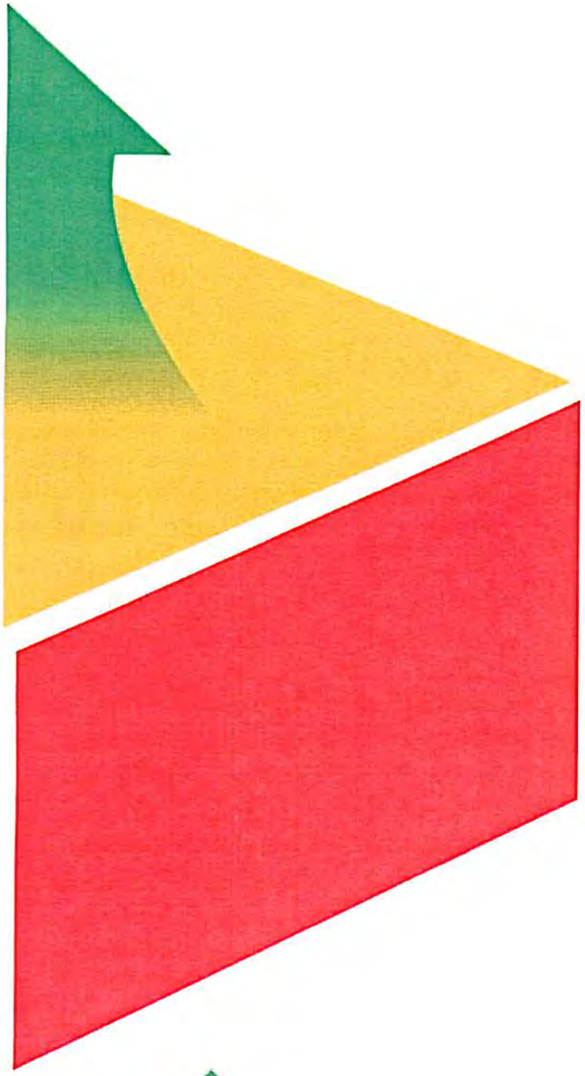

Sailer Environmental, Inc.

171 Lombardy Street Site
Brooklyn, New York

Preliminary Site Evaluation Budgetary Proposal

December 14, 2016

Attorney-Client Privileged

TERRATHERM
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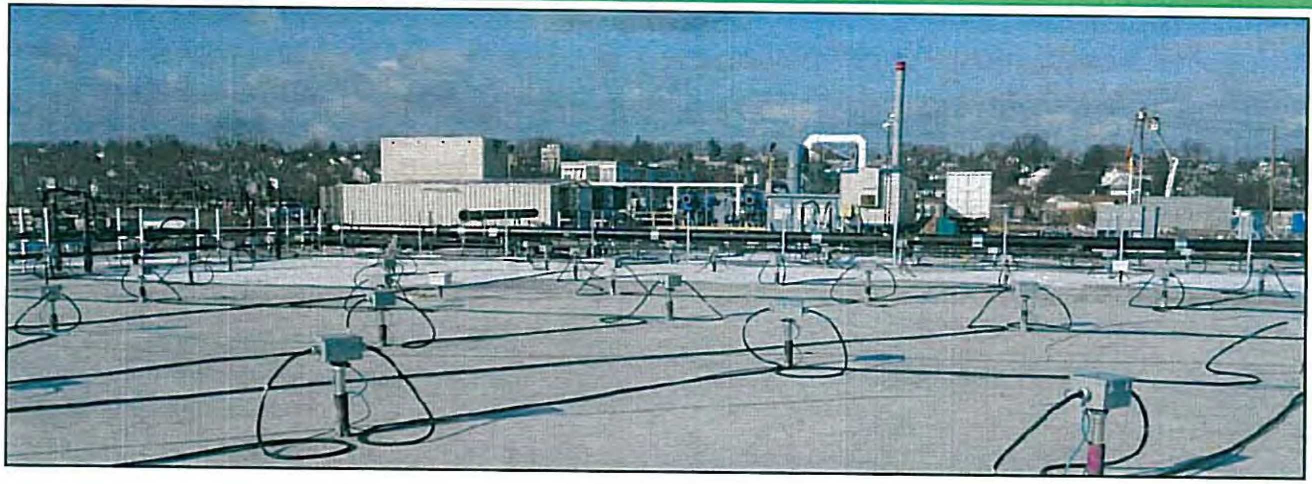
About TerraTherm



- A U.S. based company offering all major methods of subsurface heating:
  - In Situ Thermal Desorption (ISTD) via Thermal Conductive Heating (TCH)
  - Steam Enhanced Extraction (SEE)
  - Electrical Resistance Heating (ERH)
- Completed 50 thermal projects worldwide either directly or through a Licensee
- Meets treatment goals 100% of the time
- TerraTherm Experience Modification Rating (EMR) history:
  - 2015: 0.69
  - 2014: 0.91
  - 2013: 0.89
  - 2012: 0.90

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Site Background

Site Name: 171 Lombardy Street Site

Site Location: Brooklyn, New York

Site/Environmental Consultant: Sailer Environmental, Inc.

Objective: Obtain a conceptual cost to implement thermal remediation at the site

Contaminants of Concern: Tetrachloroethene (PCE), Trichloroethene (TCE), Cis-1,2-Dichloroethene, and Benzene

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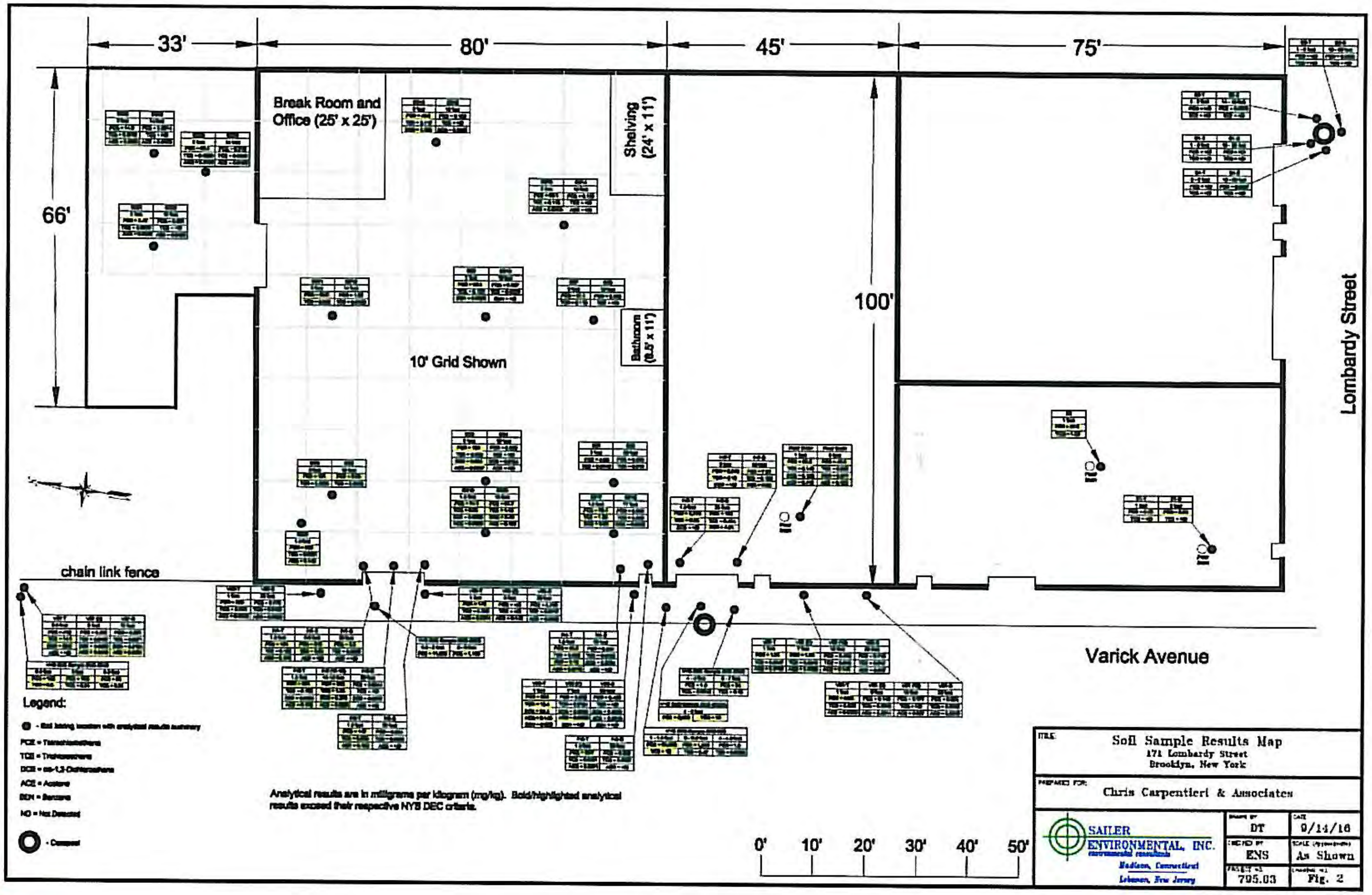
Treatment Area Map



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Geology and Hydrogeology

Geology:

- 0 to 100 ft bgs: Fine Sand with some Fill and Silty Sand

Hydrogeology: Water surface elevation is found at 50 ft bgs.

Hydraulic conductivity value ranges between 0.075 ft/day and 0.15 ft/day. An average hydraulic conductivity value of $3.88\text{x}10^{-5}$ cm/sec (0.11 ft/day) was used for this evaluation.

Hydraulic gradient: A hydraulic gradient value of 0.003 ft/ft was provided and used for this evaluation, but will not affect the heat balance, since the site is entirely above the water table.

Conceptual Treatment Scenarios

Treatment Area	Target Area (ft^2)	Target Depth (ft bgs)	Target Volume (CY)
Area 1	14,326 (L: 158 ft – W: 91 ft)	0.0 – 20.0	10,612

Contaminants of Concern, Mass Estimate, and Remediation Goals

Contaminants of Concern: Tetrachloroethene (PCE), Trichloroethene (TCE), Cis-1,2-Dichloroethene, and Benzene

Mass Estimate: The calculated mass is approximately 8,700 lbs. This is based on a treatment volume of 10,612 CY and an assumed average concentration of approximately 284 mg/kg.

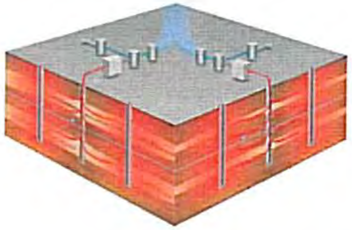
The calculated average concentration based on all data is 649 mg/kg, but is governed by two very high hits of PCE at 23,000 mg/kg and 11,000 mg/kg.

Remediation Goals:

Chemical Name	Soil (mg/kg)	
	Max Level Detected	Target Level
Tetrachloroethene (PCE)	23,000	<1.3
Trichloroethene (TCE)	18.4	<0.47
Cis-1,2-Dichloroethene	24.4	<0.25
Benzene	0.0695	<0.06

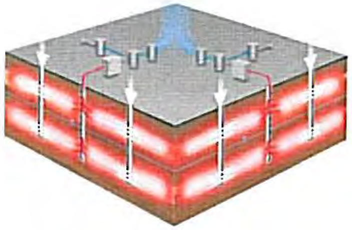
Thermal Technologies Evaluated

Thermal Conduction Heating
(TCH / ISTD)



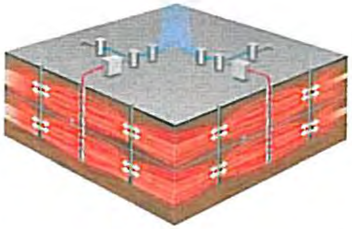
For all sites with low to moderate groundwater flow rates and either Volatile Organic Compounds (VOCs) or Semi-Volatile Organic Compounds (SVOCs).

Steam Enhanced Extraction
(SEE)

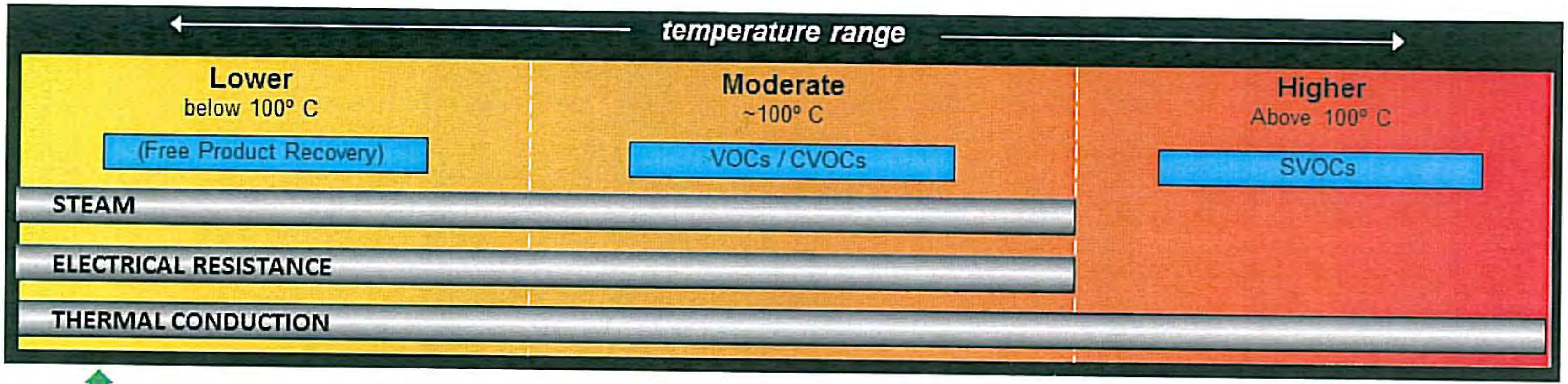


For permeable sites with significant groundwater flow rates and for sites with either volatile or moderately volatile contaminants.

Electrical Resistance Heating
(ERH)



For all sites with low to moderate groundwater flow rates and either volatile or moderately volatile contaminants.



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Thermal Technologies Evaluated

Characteristics	TCH	SEE	ERH
Heating Method	Conduction	Steam injection, convection	Resistance
Factors Governing Heating	Thermal conductivity Groundwater flow	Permeability injection rates and pressure	Electrical resistivity Groundwater flow
Maximum Temperature	325-400°C (once dewatered)	100°C (boiling point)	100°C (boiling point)
Sensitivity to Water Content and Flow	Works in wet and dry conditions Water flow can remove heat faster than is added	Not Sensitive	Does not work in dry conditions Water flow can remove heat faster than it is added
Sensitivity to Contrasts between Layers	Differences in water content and flow may affect heating rate	Aquitards not heated directly	Resistivity contrasts may lead to uneven and incomplete heating – long electrodes may be inefficient
Sensitivity to Buried Objects	Not sensitive	Low-permeable layers may interfere with stream migration	Metal debris and pipes may prevent uniform heating
Heat Input Governed By	Soil thermal conductivity (varies by a factor of 1 to 3 between most common geologies)	Hydraulic conductivity	Soil resistivity (varies by a factor of more than 200 for most common geologies)
Fluids Added to Ground	None	Steam	Water

Note: *Thermal conductive heating was selected for this preliminary evaluation, since TerraTherm has previous success implementing TCH below buildings. Additionally SEE and ERH will require the addition of liquids in the vadose zone, which will potentially spread the contamination downwards towards the water table. TCH will be implemented using a robust extraction strategy, where vapors are removed at every single TCH heater.*

Conceptual Treatment Approach/Methodology

Conceptual Treatment Approach:

- TCH using a heater spacing of up to 15 feet to target the boiling point of water.
- Soil vapor and steam extraction from vertical extraction wells co-located to the heaters used to extract the vaporized contaminants and steam and to maintain pneumatic control.

Vapor and Liquid Treatment Approach:

- Extracted vapor and liquid (condensate) treated using Granular Activated Carbon (GAC).

Monitoring:

- Temperature and pressure monitoring to track subsurface heating, pneumatic, and hydraulic control.
- Vapor and liquid treatment system monitoring for mass removal and discharge compliance.

Treatment Approach – Equipment

TerraTherm is proposing to utilize our *Tier-One* containerized equipment for this site since it meets the following conditions:

- Smaller treatment zones
- Simple geology
- Modest chemical mass
- Expedited regulatory process
- Well-defined objectives
- Volatile contaminants (such as CVOCs)

TIER ONE 1 PRICING

TerraTherm Tier-One equipment container

Optimal, efficient, cost-effective solution:

- Simplified design process
- Expedited permitting
- Simple heater borings
- Standard heating systems
- Pre-engineered treatment systems
- Duration optimized based on monitoring
- Simplified reporting

TerraTherm site with Tier-One equipment installed

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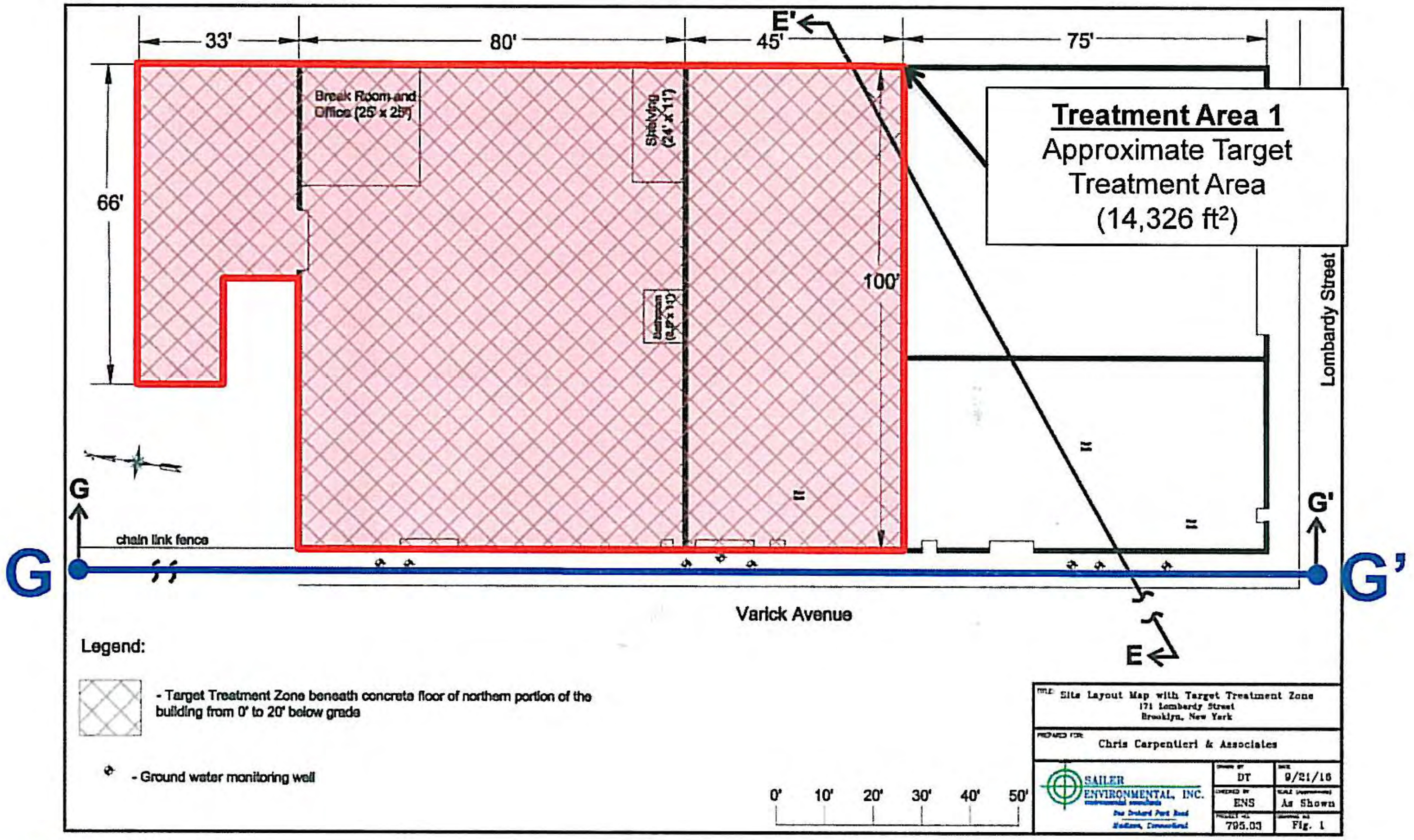
Treatment Area and Cross Sections



Treatment Area 1
Approximate Target
Treatment Area
(14,326 ft^2)

Legend:

▨ - Target Treatment Zone beneath concrete floor of northern portion of the building from 0' to 20' below grade

⊕ - Ground water monitoring well

TITLE: Site Layout Map with Target Treatment Zone
171 Lombardy Street
Brooklyn, New York

PREPARED FOR: Chris Carpentieri & Associates

SAILER ENVIRONMENTAL, INC.

DRAWN BY DT	DATE 9/21/16
CHECKED BY ENS	SCALE As Shown
PROJECT NO. 795.03	DRAWING NO. Fig. 1

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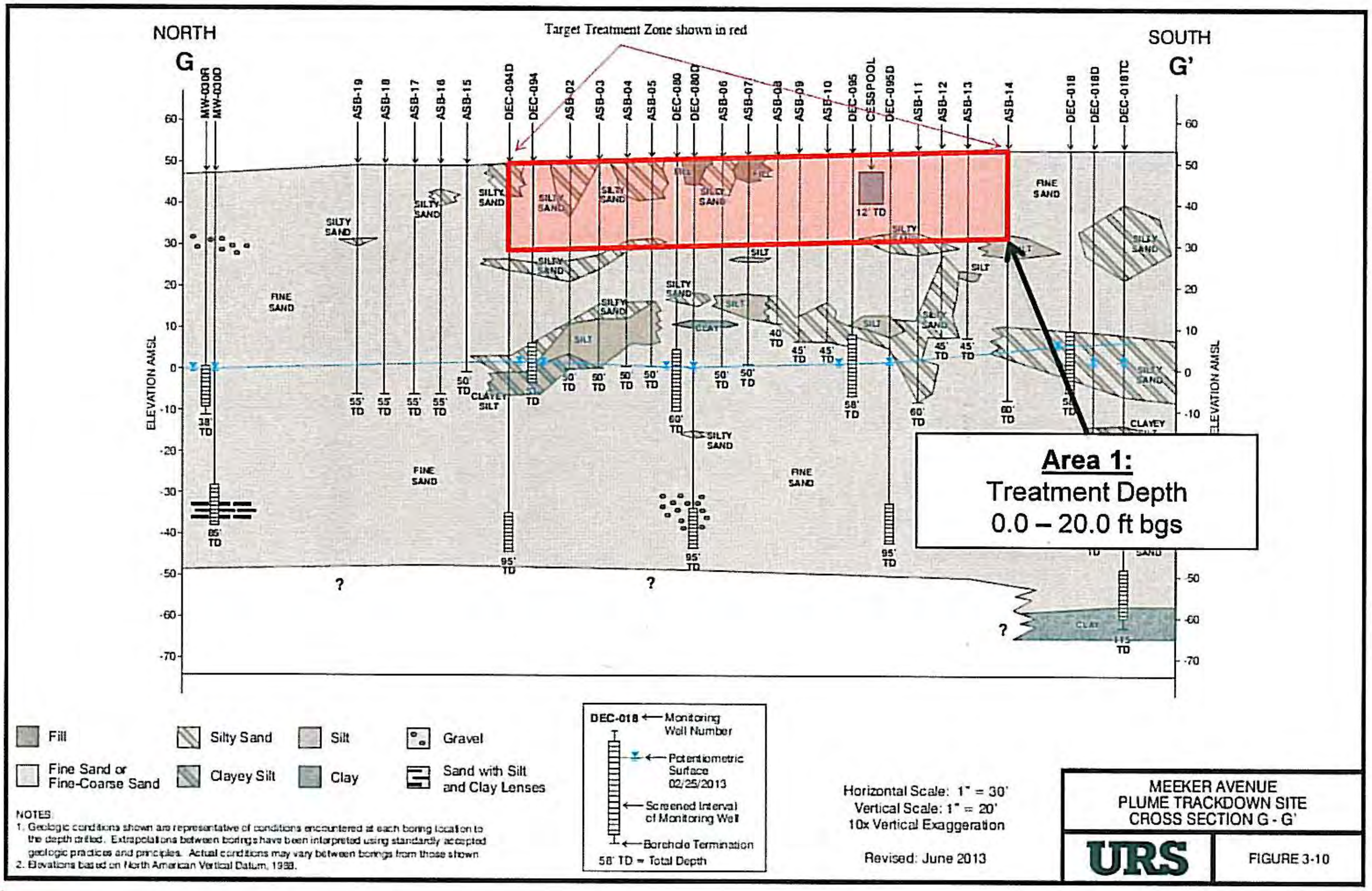
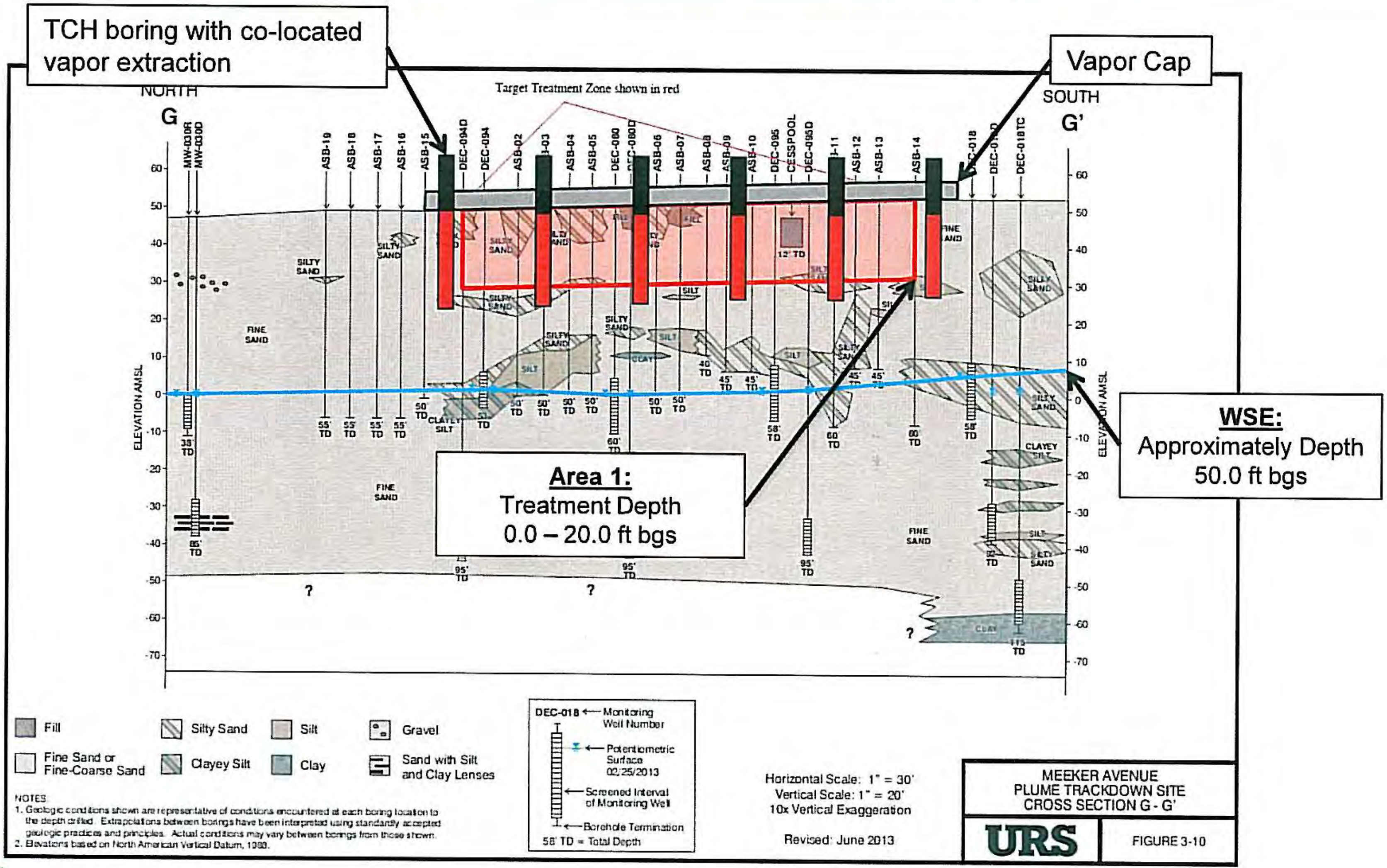
Cross Section (G – G')



NOTES:
1. Geologic conditions shown are representative of conditions encountered at each boring location to the depth drilled. Extrapolations between borings have been interpreted using standardly accepted geologic practices and principles. Actual conditions may vary between borings from those shown
2. Elevations based on North American Vertical Datum, 1988.

Area 1:
Treatment Depth
0.0 – 20.0 ft bgs

Conceptual Cross Section (G – G')



TCH boring with co-located vapor extraction

Vapor Cap

Area 1:
Treatment Depth
0.0 – 20.0 ft bgs

WSE:
Approximately Depth
50.0 ft bgs

NOTES
1. Geologic conditions shown are representative of conditions encountered at each boring location to the depth drilled. Extrapolations between borings have been interpreted using standardly accepted geologic practices and principles. Actual conditions may vary between borings from those shown.
2. Elevations based on North American Vertical Datum, 1988.

Horizontal Scale: 1" = 30'
Vertical Scale: 1" = 20'
10x Vertical Exaggeration

Revised: June 2013

MEEKER AVENUE
PLUME TRACKDOWN SITE
CROSS SECTION G - G'

URS

FIGURE 3-10

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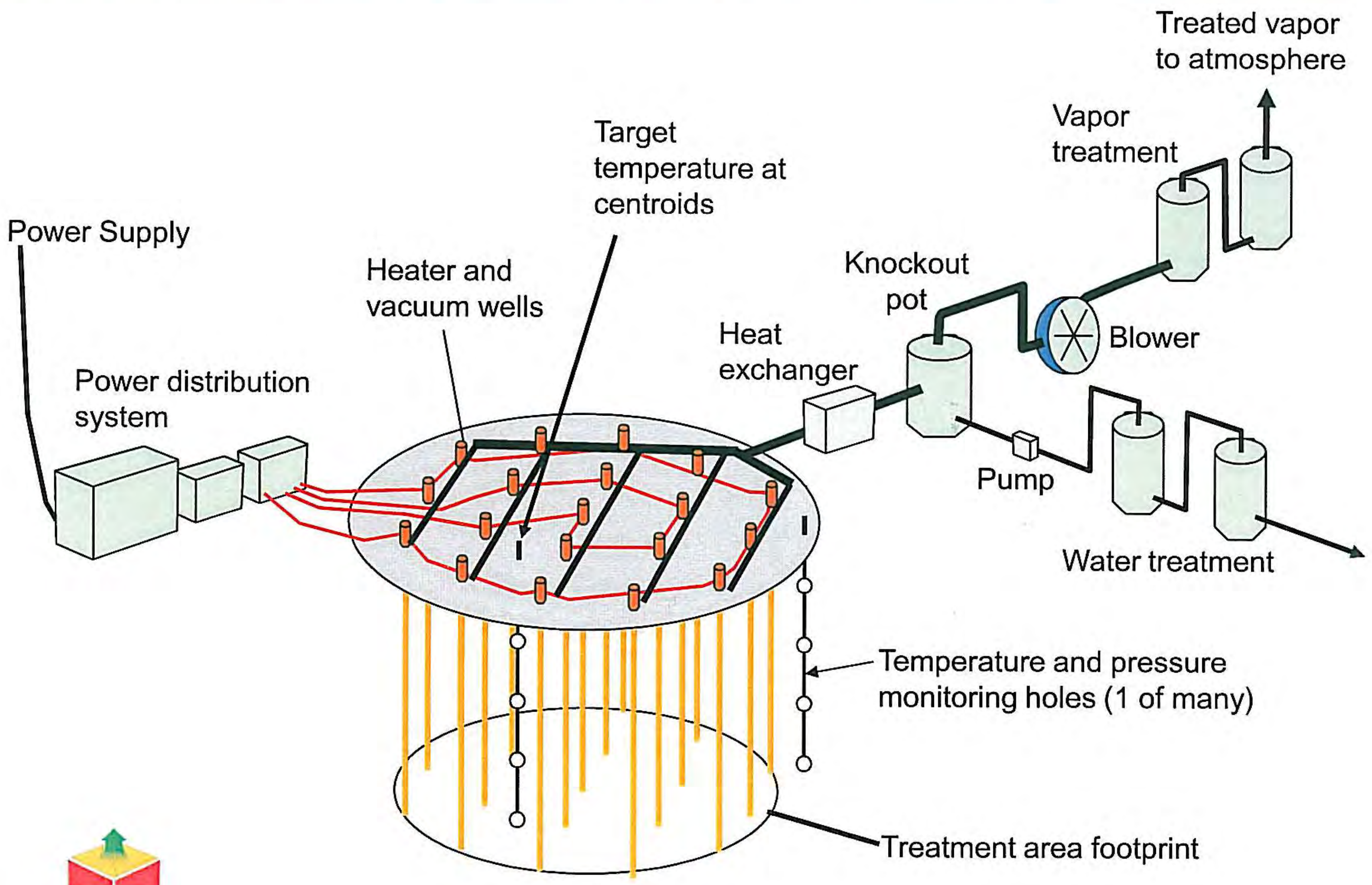
Schematic of Typical TCH Site



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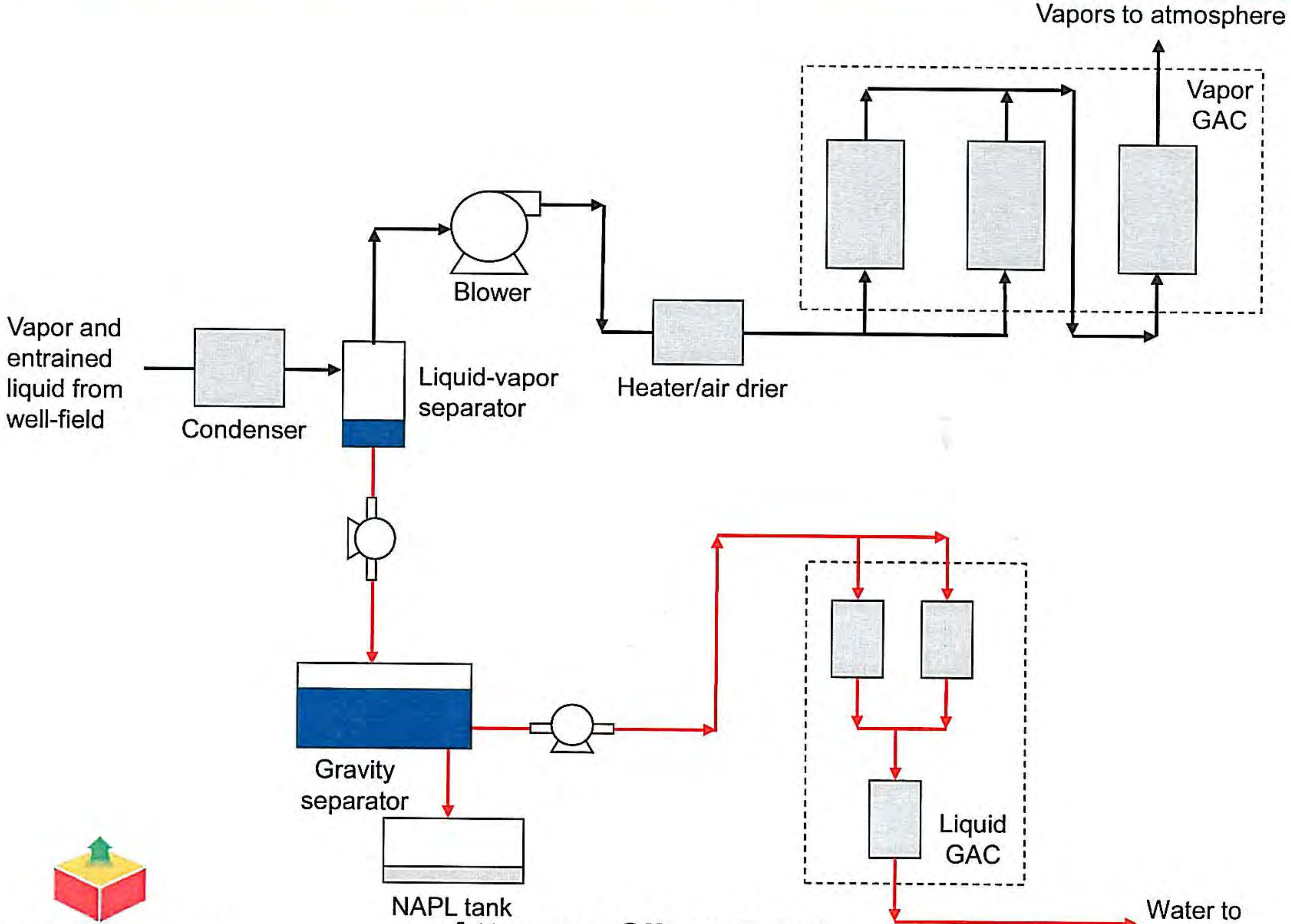
Conceptual Process Flow Diagram: Vapor and Liquid Treatment System



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Conceptual Design Parameters/Treatment Outputs

171 Lombardy Street Site	**Sailer Environmental, Inc.**	
Volume and heat capacity	***Area 1***	***Unit***
Treatment area	14,326	ft^2
Upper depth of treatment	-	ft bgs
Lower depth of treatment	20	ft bgs
Volume, TTZ	10,612	yd^3
Solids volume	6,898	yd^3
Porosity	0.35	-
Porosity volume	3,714	yd^3
Initial saturation	60	percent
Soil weight	30,800,374	lbs soil
Water weight	3,760,260	lbs water
Soil heat capacity	7,700,094	BTU/F
Water heat capacity	3,760,260	BTU/F
Total heat capacity, whole TTZ	11,460,354	BTU/F

Conceptual Design Parameters/Treatment Outputs (Continued)

171 Lombardy Street Site	**Sailer Environmental, Inc.**	
Energy balance	***Area 1***	***Unit***
TCH power input rate	633	kW
Average extracted water temperature	190	F
Percent of injected energy extracted as steam	30	%
Steam extracted, average	667	lbs/hr
Energy flux into treatment volume	2,157,719	BTU/hr
Energy flux in extracted groundwater	-	BTU/hr
Energy flux in extracted steam	647,316	BTU/hr
Net energy flux into treatment volume	1,510,403	BTU/hr
Heating per day	3.2	F/day
Start temperature	50	F
Target temperature	213	F
Estimated heat loss, worst case	57	%
Operating time		
Shake-down	5	days
Heating to boiling point	80	days
Boiling and drying	65	days
Sampling/analysis phase	5	days
Post treatment vapor extraction	14	days
Total operating time	170	days

Conceptual Design Parameters/Treatment Outputs (Continued)

171 Lombardy Street Site	
Numbers of wells	***Area 1***
Heater borings, regular application	92
Vapor extraction screen, co-located to the heater	92
Temperature monitoring holes	9

171 Lombardy Street Site	Sailer Environmental, Inc.	
Process equipment	***Value***	***Unit***
ISTD power supply	630	kW
Treatment system power supply	120	kW
Total power need to site	940	kW
Estimated total electric load	1,200	kVA
Vapor extraction rate, total	880	scfm
Non-condensable vapor	640	scfm
Estimated steam extraction	240	scfm
Liquid extraction rate	0.0	gpm
Condensed liquid rate	1.3	gpm
Water treatment rate	1.3	gpm
Vapor treatment type	GAC w/ gas conditioning	-
Dominant contaminant of concern	Tetrachloroethene (PCE)	-
Estimated COC mass	8,638	lbs
Estimated COC mass treated by vapor system	8,465	lbs
Estimated COC mass treated by water system	173	lbs
Estimated max mass removal rate, vapor system	110	lbs/day

Conceptual Utility Requirements & Budgetary Costs

171 Lombardy Street Site	**Sailer Environmental, Inc.**	
Utility estimates	***Value***	***Unit***
Power usage, in ground	2,316,000	kWh
Power usage, treatment system	487,000	kWh
Power usage, total	2,803,000	kWh
Discharge water, total	226,000	gallons
Discharge vapor, total	158	mill scf

Sailer Environmental, Inc. 171 Lombardy Street Site	
Design and Procurement	$170,000
Construction and Operation	$2,480,000
Utilities, paid by client	$310,000
Total	**$2,960,000**

Notes & Assumptions

Assumptions:

- Price:
  - +/- 30% price accuracy based on current understanding of preliminary Conceptual Site Model (CSM) as stated in this treatment concept
  - Unit power cost assumed: $0.11/kWh
  - Free access assumed to the treatment areas in the building
  - Geotechnical parameters should be further evaluated prior to implementation
- Turn-Key services:
  - Design/procurement/permitting (permitting managed by Sailer Environmental, Inc., TerraTherm supports the process)
  - Construction
  - Operations (site and office support)
  - Demobilization
  - Reporting
- Construction:
  - 80 ft/day drilling production assumed in the building.
  - Electrical and mechanical connections above grade
- Operations
  - Standard:
    - Field Crew (1 person on average) housed within 30 minute drive to the site
    - Office support: Project Management and Engineering
- Demobilization
  - Bringing site back to as near to starting conditions as possible:
    - Grouting up wells
    - Removal of all equipment
    - Overdrilling of wells is excluded

Possible Next Step

Basis of Design Report (BODR):

TerraTherm would be pleased to provide a proposal for preparation of the BODR (or alternatively for preparation of the detailed design effort as described below) for the project.

The BODR includes the following:

- Site visit and meeting
- Thermal modeling and refinement of thermal treatment concept(s)
- Evaluation of data gaps
- Risk/uncertainty evaluation
- Define exact scope of work for key project tasks (responsibility matrix)
- Comparison of multiple treatment scenarios (if applicable)
- Firm price cost estimate

The price for this deliverable can range from \$20,000 to \$25,000.

For further information, please contact John Haas at (978) 730-1200, Ext. 2648.

171 Lombardy Street
Brooklyn, NY
December 31, 2018

Appendix E

SAILER
Environmental, Inc.
environmental consultants

Edward N. Sailer

From:	John Haas <jhaas@terratherm.com>
Sent:	Wednesday, December 14, 2016 4:56 PM
To:	esailer@sailerenv.com; 'Chris Carpentieri' (chris@chriscarpentieri.com)
Cc:	Steffen Griepke; Alejandro Daza
Subject:	John Haas TerraTherm - Thank You, 171 Lombardy Street, Brooklyn NY
Attachments:	50-Does Field Data Show Downward Mobilization of DNAPL During Thermal Treatment.pdf; DNAPL mobilization White Paper.pdf

Hello Gentlemen:

It was nice speaking with you today – thank you for participating in our webinar and for your interest in TerraTherm for this exciting project.

As we discussed, please see below and attached for information:

(a) Mobilization of Contaminants:

- Please see the attached information that shows why the contaminants will not be mobilized in a downward fashion.
- Essentially, the temperature effects on the physical properties of liquid VOCs do not enhance their ability to move vertically downward as the temperature increases.

(b) Water Generation:

- After recalculating the water removal, we are conservatively estimating the pore water removal at the site to be on the order of 226,000 gallons.

171 Lombardy Street Site	**Sailer Environmental, Inc.**	
Utility estimates	***Value***	***Unit***
Power usage, in ground	2,316,000	kWh
Power usage, treatment system	487,000	kWh
Power usage, total	2,803,000	kWh
Discharge water, total	226,000	gallons

- The proposed treatment system does not discharge any other water.
- Cooling capacity will be provided from a closed loop chiller, and the rest of the treatment system will not generate any waste water.
- A small amount of water for cleaning purposes will need to be added, and that should be it.
- NOTE --- Please let me know if our design should remain with LGAC included so that the water can be treated before it's hauled away, or if we should remove the LGAC from our design such that the water is hauled away without treatment.
- We will then finish our budgetary proposal, and send it over to you for additional review and discussion.

Please review this information and let me know if you have any questions and/or if you need additional information.

Thank you again – enjoy the remainder of the week.

TERRATHERM
a Cascade Company

JOHN HAAS TECHNICAL SALES SPECIALIST

TerraTherm, Inc. | 151 Suffolk Lane, Gardner, MA 01440
P 978.730.1200 x2648 C 781.733.6042

THINK THERMAL

DISCUSSION OF DNAPL POOL BEHAVIOR DURING THERMAL REMEDIATION-SPECIFICALLY IN-SITU THERMAL DESORPTION/ THERMAL CONDUCTION HEATING

Authors: G. Heron and J. LaChance, TerraTherm

This memo describes DNAPL behavior and thermal changes occurring during in-situ thermal remediation, specifically In-Situ Thermal Desorption (ISTD)/Thermal Conduction Heating (TCH), with focus on the possibility of DNAPL pool removal and spreading. ISTD involves the heating of the subsurface primarily via thermal conduction. A network of heaters (thermal wells) are installed in the subsurface and heat moves outward by thermal conduction from the heaters towards the cooler interwell regions (i.e., heat transfer from grain to grain and through the fluids present in the subsurface). A common question, and the focus of this memo, is what happens to DNAPL (pooled and residual) as it is heated? Exploration of this question would not be possible without the simple DNAPL science regarding DNAPL penetration of capillary barriers, or data on DNAPL property changes with temperature. Therefore, the most relevant properties and mechanisms are reviewed first, using TCE and PCE as example DNAPL constituents.

Eutectic point: The lower boiling point of a DNAPL-water mixture

Areas with significant DNAPL will have lowered boiling points, due to the well-known eutectic point effects. The vapor pressures of two liquid phases located together equals the sum of the pure liquid vapor pressures, as illustrated in Figure 1 below. This means that boiling will occur where water and DNAPL touch at temperatures below 100 C (73 C for TCE, 87 C for PCE; Davis 1997; Heron et al. 1998, DeVoe and Udell 1998). When the DNAPL has been fully vaporized, the temperature can increase to the boiling point of water. This mechanism is important for understanding what happens during subsurface heating where DNAPL is present either as residual or pools.

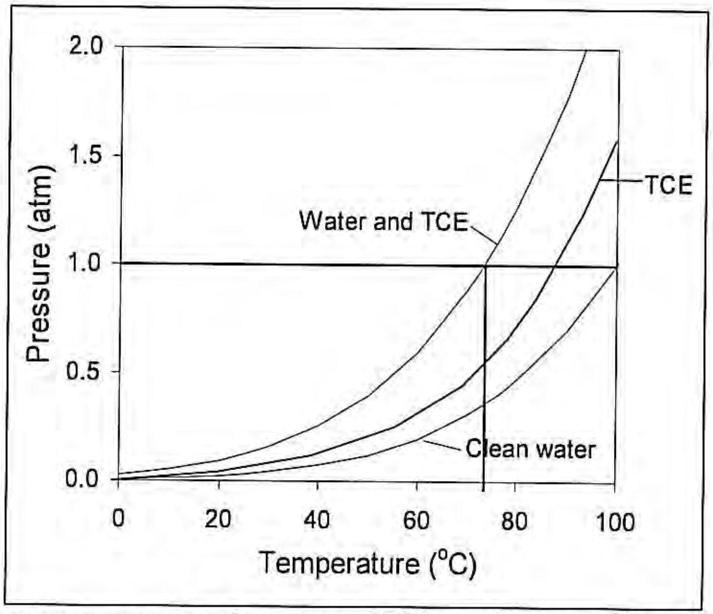

Figure 1. Vapor pressure curves for water, TCE, and a zone where both are present.

Vertical Mobilization: Critical pool height and DNAPL entry through capillary barriers

Laboratory research has shown that heating can lead to decreases in interfacial tension and capillary entry pressures for PCE DNAPL (Sleep and Ma 1997). Therefore, the potential for heating and field-scale ISTD to mobilize DNAPL needs to be addressed. To this effect, an analysis of the worst-case situation, where a significant thickness of DNAPL is prevented from migrating vertically by a capillary barrier, is in order.

Following migration below the water table, DNAPL will tend to accumulate on top of low-permeability layers or lenses. The thickness of continuous DNAPL required to penetrate a barrier below the water table, also named the critical pool height or ganglia length, can be estimated by the following equation [Hunt et al. 1988; Mercer and Cohen 1990; Pankow and Cherry 1996]:

$$z_n = \frac{2 \cdot \sigma \cdot \cos(\phi)}{r_{\text{finer}} \cdot g \cdot (\rho_n - \rho_w)}$$

where

σ:	Interfacial tension (IFT) between the DNAPL and water [N/m]
ϕ:	Wetting contact angle [°]
r_{finer}:	Pore radii in the capillary barrier [m]
g:	Gravitational acceleration [m/s^2]
ρ_w:	Density of water [kg/m^3]
ρ_n:	Density of DNAPL [kg/m^3]

Note that the viscosity of the DNAPL or the water does not enter into this equation. Factors that may affect DNAPL mobility (i.e., ability to penetrate a capillary barrier) include changes in interfacial tension (IFT), contact angle, or density. Also note that decreases in IFT or contact angle will result in a decrease in the critical pool height that a capillary barrier can support. Thus, for a DNAPL pool with a thickness right at the critical height of the underlying capillary barrier, decreases in IFT or contact angle could result in the DNAPL pool penetrating the barrier and downward migration of the DNAPL. On the other hand, if the density of the DNAPL decreases (i.e., an increase in the buoyancy of the DNAPL), then the downward driving force decreases [$g * (\rho_n - \rho_w$] and the critical pool height increases, leading to increased stabilization of the DNAPL pool.

Sleep and Ma (1997) measured the interfacial tension of PCE-water as a function of temperature (Figure 2). The change is less than 10% between 10 and 87 C, where PCE would boil.

As shown by Heron et al (1998) and in Figure 2, DNAPL swelling (i.e., thermal expansion) during heating will tend to reduce the density difference between DNAPL and water, and therefore stabilize the situation by increasing the critical pool height. Figure 2 also contains the calculated critical pool height based on the IFT and density data, assuming that the contact angle stays the same. This shows that the critical pool height may increase with temperature, leading to a more stable condition (as much as 12% increase from 10 to 100 degrees C). No data exists for the contact angle change with temperature, but observation in laboratory setups do not indicate a significant change (PCE behavior has been observed to be stable in porous media during heating, until the eutectic point is reached, at which it will boil; Udell 2004).

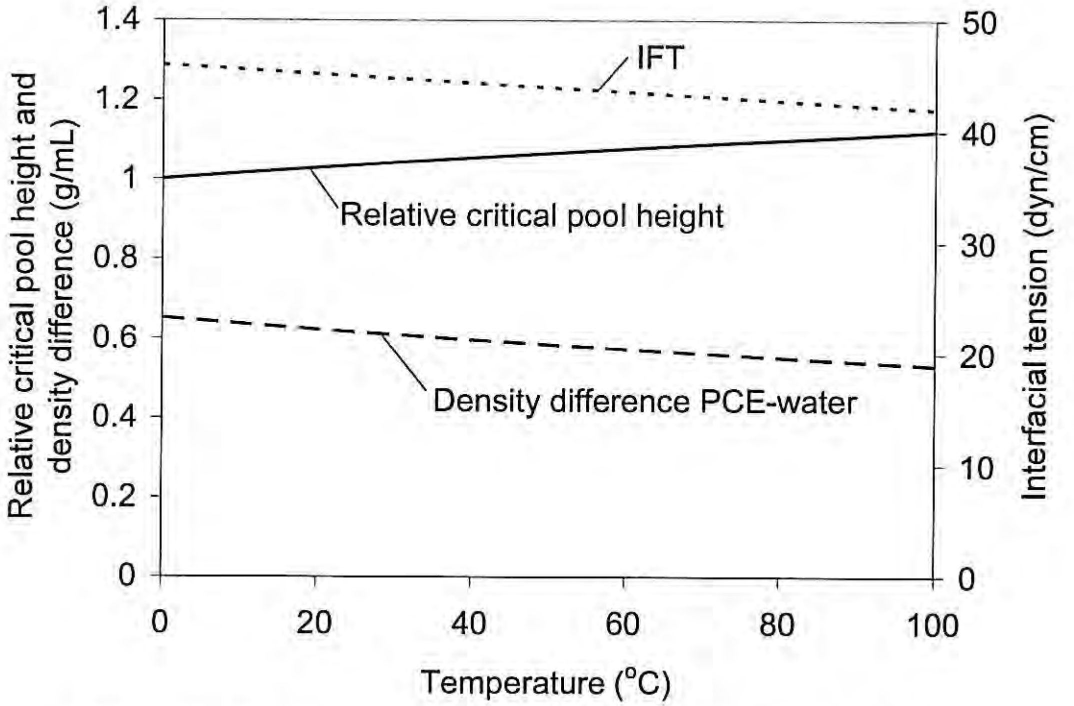

Figure 2. Temperature dependency of interfacial tension for a PCE-water system (Sleep and Ma, 1997) and the difference in density between PCE DNAPL and water (modified from Heron et al. 1998), and the calculated critical pool height relative to ambient temperature (assuming constant contact angle).

In conclusion, the analysis shows that the changes in chemical properties for a typical DNAPL constituent do not significantly affect the critical pool height that a capillary barrier can support and thus do not result in an appreciable increase in the risk of vertical mobilization of a pool. In fact, if the contact angle is unaffected, a raise in temperature will increase the critical pool height, leading to a more stable condition. These concepts are summarized in Figure 3.

Does a DNAPL pool heat up as fast as the surrounding material?

The heating rate is dependent on thermal conduction from the heater wells and convection of steam. A DNAPL-saturated porous medium will have an overall thermal conductivity and heat capacity which is similar to a water-saturated medium (K between 1.5 and 2.5 W/m/K and C in the range of 700-1,000 J/kg/K). The thermal properties of common DNAPL constituents (chlorinated solvents, coal tar, PCB) are not dramatically different than those of water.

If the volume of DNAPL is substantial, it will be vaporized and removed at temperatures close to the eutectic point, which are lower than the boiling point of water. Therefore, temperature gradients will be higher towards such areas, allowing heat conduction to occur at least as fast as it does in the surrounding water-filled medium. While this boiling leads to lower temperatures in areas containing DNAPL, the time is used to vaporize the bulk of the contaminant mass (i.e., the DNAPL), therefore it is not a hindrance to the effectiveness of the remedy but a critical component ensuring attainment of the remedial goals (Figure 3).

In consequence, there is no reason to believe that heating will be significantly slower or inhibited in subsurface zones containing high DNAPL saturations, or pools.

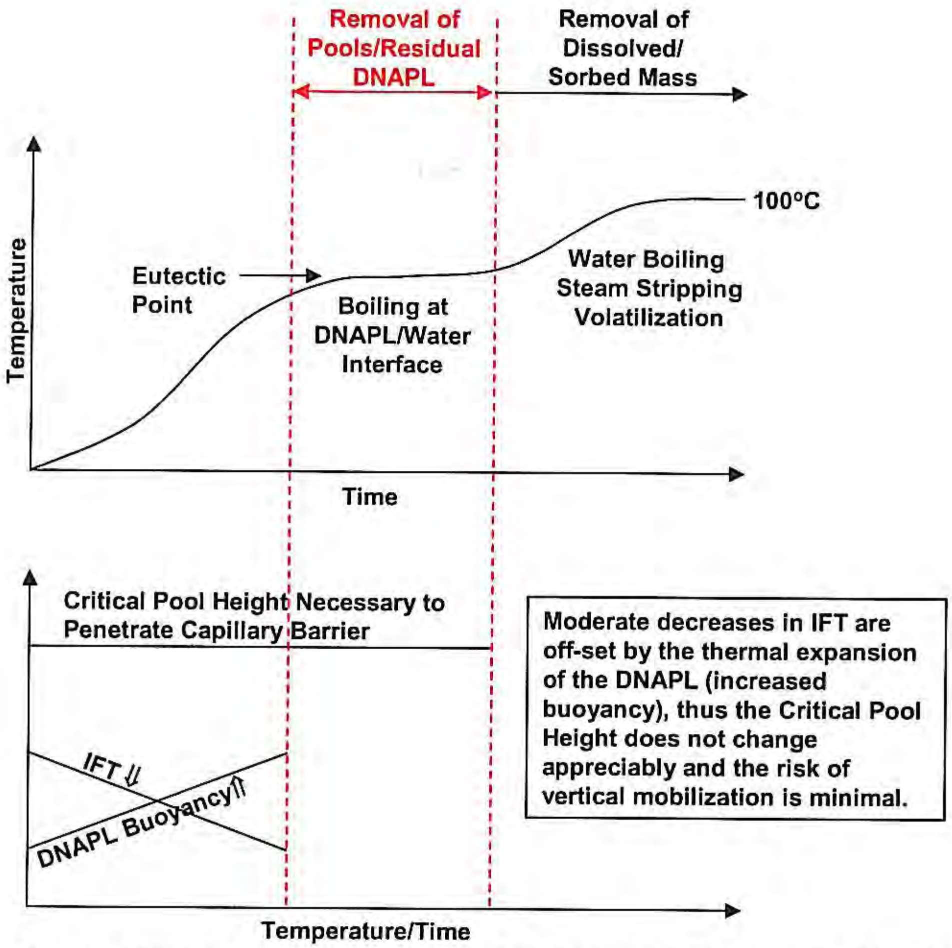

Figure 3. DNAPL behavior as a function of time and temperature at the edge of a DNAPL pool nearest a thermal conduction heater.

How will ISTD/TCH remove a pool of DNAPL, and could it make the DNAPL migrate down?

The fundamental physical/chemical changes and behaviors of DNAPL during heating were discussed above. What follows is a discussion of the approaches used with ISTD/TCH to ensure efficient and effective removal of DNAPL pools and to minimize the risk of vertical mobilization.

Low to Moderate Pool Mobilization Risk: Low permeability settings, significant capillary barrier beneath treatment zone, and/or little evidence of significant pools

In these types of geologic/contaminant settings, additional precautions are not typically required to ensure that DNAPL does not migrate vertically. For the case of a low permeability material (e.g., silt or clay), this is because: 1) the thickness and volumes of the pools are limited due to the geology and 2) the capillary resistance or entry pressure of the soil is high. As the DNAPL is heated, eventually volatizing and boiling, modest decreases in IFT are not enough to result in vertical pool mobilization. Furthermore, because the entire treatment zone is kept under a vacuum and the steam and contaminant vapors are extracted from the subsurface simultaneously with the heating, condensation of the steam and contaminants is minimized. This prevents the formation of significant DNAPL condensation banks, thus reducing the potential for vertical mobilization.

If a significant capillary barrier exists beneath the treatment zone, then the risk of mobilization during heating diminishes as all of the DNAPL will eventually be removed during the heating/treatment process.

High Pool Mobilization Risk: High permeable units interbedded with thin layers of low permeability soils, no capillary barrier beneath the treatment zone, and/or strong evidence of significant pools

In these types of geologic/contaminant settings, additional precautions may be required to ensure that DNAPL does not migrate vertically due to the possible presence of DNAPL pools at the critical pool height and the absence of a significant capillary barrier beneath the treatment zone. One approach to treating this type of site using ISTD/TCH is to heat the DNAPL pools from the sides and below after creating a hot floor below it. This approach involves extending the heater wells below the bottom of the treatment zone and boosting the power output of the bottom portion of the heaters. This will result in the creation of a hot lower zone (i.e., a hot floor") before the treatment zone and DNAPL pools are heated. By heating the material below the treatment zone to the boiling point of water, it is ensured that DNAPL cannot penetrate the heated bottom. If DNAPL were to migrate downwards, it would heat up and vaporize above the hot floor once it reached the eutectic point of the water-DNAPL mixture. As described above, DNAPL present in the treatment zone will eventually be vaporized and removed from the subsurface via the heater-vacuum wells as the pools are heated from the sides, and vapors are generated and travel towards low-pressure locations.

If a site with significant DNAPL is underlain by bedrock, then the heater wells with boosted lower sections can be extended into the rock to create a hot floor. This approach is especially effective as the thermal conductivity of bedrock is typically higher than soil due to the relatively lower porosity of the rock. Typical soil porosities range between 25 and 50% while typical crystalline bedrock porosities range between 0.1 and 10% (Freeze and Cherry, 1979). Therefore, the increased power delivery and thermal conductivity in the bedrock will result in the creation of a hot floor beneath the treatment zone before the DNAPL pools are heated and prevent migration of DNAPL into the bedrock system.

It should be noted that some sedimentary bedrock formations can have matrix porosities as high as the overlying soils (e.g., fractured sandstones and limestones). Boosting the lower portions of the heaters will still be effective in these formations at creating a hot floor beneath the treatment zone prior to heating the DNAPL pools. In addition, the potential risk of DNAPL entering these types of formations and migrating long distances is greatly reduced as compared with the risk of DNAPL entering a fractured crystalline rock. This is because of the significant potential for diffusion of the DNAPL from the fractures into the porous matrix.

It is difficult to imagine a physical situation where the risk of downward migration is increased significantly due to the modest changes in DNAPL characteristics during heating as compared to naturally occurring historical perturbations such as severe storm events with rapid infiltration or significant changes in horizontal and vertical hydraulic gradients. For example, air entrapment beneath an infiltration front can result in significant pressure increases (10 to 20 inches of water) below the water table and hydraulic gradients can fluctuate by several feet or more due to seasonal variation and anthropogenic causes (Freeze and Cherry, 1979). Vertical mobilization of a pool would require that the height of the pool be just at the critical pool height of the underlying capillary barrier and that the modest decrease in IFT as the pool is heated at the capillary barrier is not offset by thermal expansion of the DNAPL (i.e., there is not increase in buoyancy). Where a hot floor is used, the zone below such an entry point would be heated to above the eutectic point, so DNAPL migration through the floor would immediately be arrested by the tip of the DNAPL being boiled, and the vapors pushing up.

Will the concentrated VOC vapors from a boiling DNAPL pool condense in unwanted locations and make the problem worse?

When DNAPL pools are vaporized, the vapors (steam and COCs mixed) can migrate into cooler zones and condense. Since vapors have significant buoyancy compared to the groundwater, they will tend to migrate upwards or directly towards low pressure points such as the extraction wells. However, situations exist where the vapors travel to zones cooler than the eutectic temperature, in which they can condense. This is accounted for in the ISTD design by the following:

1. Horizontally around the treatment zone: Heating of a clean zone around the perimeter surrounds the treatment zone with heated soils that are too hot to allow DNAPL migration or condensation outside the target zone.
2. Vertically at bottom of treatment zone: Heating using the hot floor approach, creating conditions that cannot allow the condensate to penetrate deeper.
3. Vertically at top of treatment zone: In most projects, heating progresses to the land surface, and a vapor barrier and insulation layer ensures that no cold zones are allowed in the vadose zone. If treatment does not extend to the surface, a significant thickness of the clean zone above the target zone will be heated, creating a barrier to DNAPL condensation.

In conclusion, while zones of DNAPL condensate can form in locations that are below the eutectic temperature, these zones are inside the target treatment zone, and eventually the entire zone will be heated to temperatures too high for the condensate to stay. This has been confirmed by all drill-back sampling results into the target zones, and the prevention of spreading has been supported by low post-remediation concentrations in samples from outside the treatment zones.

Do we need to know if pools exist to design the system for removal of the pools?

Due to the stabilizing mechanisms discussed above, an unknown pool of DNAPL located inside the treatment zone will not create a spreading or removal efficiency problem. Generally, the subsurface heating scheme is designed in a robust and conservative manner, allowing for heterogeneities and variances in COC locations without compromising the remedial effectiveness.

However, the sheer mass of COCs that may be present in a pool can lead to higher than estimated mass removal rates, and potentially overwhelm the off-gas treatment system. This is one of the reasons for TerraTherm's use of robust and flexible treatment systems such as Thermal Oxidizers, which are less sensitive to contaminants load than systems relying on catalytic oxidation, activated charcoal filtration, or biological treatment.

Summary

This analysis shows that there is a very low risk of mobilizing DNAPL pools when a site is heated. Small changes in interfacial tension and density with temperature indicate that the critical pool height does not change significantly. Furthermore, preferential boiling at the DNAPL-water interfaces leads to pool vaporization and shrinking during heat-up.

The present knowledge of DNAPL behavior during heating has been properly included in ISTD design and operational practices, making it very unlikely that DNAPL pools are allowed to penetrate deeper during remediation. DNAPL condensation will be temporary in zones that are eventually heated and treated. The analysis further shows that the presence of DNAPL pools, even if they are undetected prior to starting the remediation, will not hamper the remedial results. However, DNAPL pools can contain substantial chemical mass, and could either prolong the treatment time, or increase the cost of the vapor treatment system operation. Therefore, a robust vapor treatment design which is not sensitive to the recovered mass should be used for sites where DNAPL pools are suspected.

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171 Lombardy Street
Brooklyn, NY
December 31, 2018

Appendix F

SAILER
Environmental, Inc.
environmental consultants

TERRATHERM
a Cascade Company
151 Suffolk Lane
Gardner, MA 01440
Phone: (978) 730-1200
Fax: (978) 632-3422
www.terratherm.com

January 11, 2017

Ted Sailer
Sailer Environmental, Inc.
One Orchard Park Road
PO Box 21
Madison, CT 06443

Re: Proposal for Basis of Design Report for Thermal Conduction Heating
Site Location - 171 Lombardy Street, Brooklyn, NY

Dear Ted,

TerraTherm, Inc. (TerraTherm) is pleased to present Sailer Environmental, Inc. with this proposal to complete a Basis of Design Report (BODR) for Thermal Conduction Heating (TCH) at the above referenced Site. As we discussed and as indicated in our budgetary proposal, TerraTherm recommends TCH as the primary heating technology because this technology has proven to be effective and successful for remediation of contaminants located under buildings and exhibits less risk as compared to alternate heating methods with regards to the spreading of contaminants downwards towards the water table.

Contaminants at the Site have been found underneath the existing building and in the vicinity of the sidewalk along Varick Avenue. TerraTherm's recommendations for a thermal remedy will focus on the area underneath the building with alternate methods by others being utilized to address contamination located in other areas. The Site is known to be impacted by the following contaminants:

- Tetrachloroethene (PCE)
- Trichloroethene (TCE)
- Cis-1,2-Dichlorethene
- Benzene

Remediation Goals:

Chemical Name	**Soil (mg/kg)**	
	Max Level Detected (see note below)	**Target Level**
Tetrachloroethene (PCE)	8,770	<1.3
Trichloroethene (TCE)	8.55	<0.47
Cis-1,2-Dichloroethene	4.61	<0.25
Benzene	0.0696	<0.06

Please note that the maximum soil levels presented above were obtained from Figure 2 (Soil Sample Results Map) dated 9/14/16 and are indicative of maximum soil concentrations in the area underneath the building. They are not indicative of maximum soil concentrations in the sidewalk area. These values do not necessarily align with the values in TerraTherm's budgetary proposal as that proposal included soil concentrations in the sidewalk area.

The BODR will address the following topics to set the foundation for successful TCH design and implementation steps as the project develops:

- Establish a more detailed subsurface heating design strategy
- Establish design criteria for an insulated surface cover to provide insulation to control heat loss into and temperature inside the building, and to facilitate pneumatic control of generated subsurface vapors
- Establish Soil Vapor Extraction (SVE) design criteria
- Define performance and compliance goals for the project
- Define the technical approach for vapor and liquid treatment operations in order to ensure that operations are compliant with applicable discharge requirements and/or appropriate means of water treatment prior to off-site disposal
- Management of phases of work and division of responsibilities
- Overall project schedule
- Updated cost estimate with a +/- 15% variance, cost assumptions, and risk analysis including data gaps/unknowns

TerraTherm has interacted with Sailer Environmental to gain knowledge of the Site from phone calls and an initial review of available site documents. The following documents have been provided to TerraTherm:

- Site plan
- Site plan with soil concentrations

- Conceptual cross sections
- Site Questionnaire

Additional information may be required to more fully develop the BODR, assuming documentation exists.

The development of the BODR includes the following tasks:

- Site visit to confirm Site layout, access issues, and any potential obstructions that could impact construction/implementation/operations
- Review of relevant site data/information as applicable
    - preliminary dimensions of the heating zone; and any possible variations to the heating dimensions
    - site soil and groundwater heating goals
    - geological units present in the heating volume
    - geophysics data
    - building foundations
    - any above ground and subsurface structures/obstacles
    - any existing structures or site features requiring preservation during heating
    - any site access limitations
    - proximity of the Site to any sensitive surrounding areas
    - other special circumstances
- Establish overall work zones at the Site and potential placement locations for treatment equipment and support facilities
- Determine the location of utility tie points (water, sewer, power, internet, etc.) and related capacity limitations
- Further identification of Data Gaps

An example Table of Contents for the BODR is provided in Attachment A.

Proposed Schedule

The following schedule (in working days) is proposed:

Day 0:	Notice to Proceed
Day 2:	Kick-off Call
Day 5:	Additional data to TerraTherm, if necessary
Day 10:	Site visit
Day 15:	TTZ definition discussion/review
Day 30:	Draft BODR
Day 40:	Final BODR (based on an assumed five (5) day review of Draft BODR)

Note: TerraTherm currently has adequate resources to complete this report according to the schedule above. The schedule presented above is valid for 30 days from the date of this proposal.

Proposed Cost

The lump sum price for the proposed effort is **$20,500.** This price is valid for 90 days from the date of this proposal. In accordance with invoicing protocols, it is TerraTherm's policy to invoice in full for the BODR upon submission of the Draft document, and receive payment within 30 days after that Draft submission.

TerraTherm appreciates the opportunity to provide this BODR proposal and we are excited about the possibility of working with you and Chris Carpentieri to develop the design basis for thermal remediation of the Site. Please feel free to call me with any questions and/or if you need additional information.

Sincerely,

TerraTherm, Inc.

John Haas

John Haas
Technical Sales Specialist

Cc: Steffen Griepke Nielsen
Alejandro Daza

Attachment A: BODR Example Table of Contents

- Site Summary / Project Background
    - Documents and data evaluated
    - Geology and hydrogeology
    - Contaminants of concern and mass estimate
    - Remediation goals
- Technical Approach
    - Target treatment zone definition
    - Subsurface heating strategy
        - Heating technology selection
        - Remediation mechanisms
    - Preliminary well-field
    - Extraction strategy
        - Vapor extraction and pneumatic control
        - Hydraulic control
    - Preliminary process flow diagram
    - Numerical modeling – energy and heating forecast
    - Estimated utility needs
    - Proposed schedule of operations
- Uncertainties and Data Gaps
- Cost Estimate and Cost Assumptions
    - Cost comparison
- Project Execution Approach
    - Project delivery – Design/build/operate method
    - Work plan/final design
    - Permitting
    - Implementation schedule
- Proposed Next Steps

171 Lombardy Street
Brooklyn, NY
December 31, 2018

Appendix G

SAILER
Environmental, Inc.
environmental consultants

From: Steffen Griepke <sgriepke@terratherm.com>
Sent: Thursday, February 16, 2017 2:56 AM
To: John Haas; Edward N. Sailer
Cc: Alejandro Daza
Subject: RE: Sailer Environmental - Brooklyn NY, Work plan project

John and Ted,

The preferred sampling location is definitely after the stream is conditioned (see below), for the following reasons:

- Before the condenser, the humidity is extremely high. For this site it will even be higher, because we are doing the co-located vapor extraction. I would expect that up to 60% by volume of the vapor at the sample location before the condenser to be steam at peak operations. What that means, is that it is difficult to get a good sample before conditioning the vapor. The high water content will not only disturb any reference measurement (field PID etc.) but also pose a challenge at the lab. It's not unusual that substantial condensate will collect in the summa (if a summa is used), and typically that prevents the lab from cleaning the 600$ summa canister (which we then get billed).
- The high temperature can pose a challenge for sampling equipment.
- This is a chlorinated site. We would expect more than 95-98% of the contaminants to remain in the vapor phase after the condensing step. So collecting a vapor sample after the condenser will still be very representative.
- For mass tracking purposes, we would still obtain liquid concentrations of the condensate, such that whatever small mass is separated out with the condensate will still be tracked.
- Between the knock-out and the blower the temperature is way lower (~60-80 F). The humidity is still 100%, but at a much lower temperature (and therefore we have to deal with much less water).

So in summary, I'll suggest a sample location either between the liquid-vapor separator and the blower or at the inlet to the carbon, since the sample quality there will be much better. Since the blower heats the stream up slightly (typically 10-30 F) and therefore lowers the saturation in the vapor stream due to the higher temperature, right after the blower is actually an even better stream to sample.

Hope this makes sense.

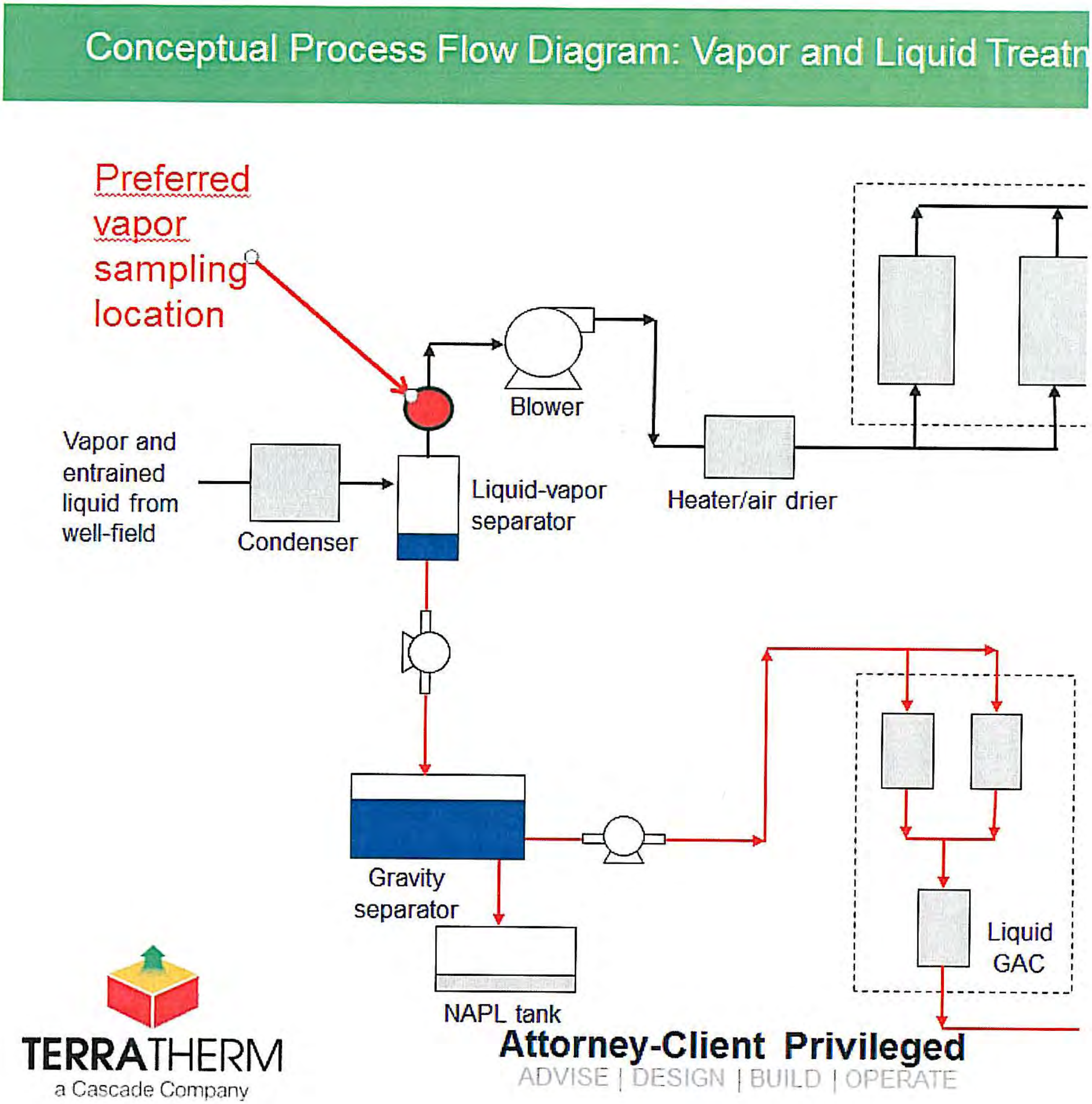
Steffen

TERRATHERM
a Cascade Company

Steffen Griepke TECHNICAL DIRECTOR

TerraTherm, Inc. | 151 Suffolk Lane, Gardner, MA 01440
P 978.730.1217 C 978.394.9629

THINK THERMAL



Conceptual Process Flow Diagram: Vapor and Liquid Treatn

Preferred vapor sampling location

Vapor and entrained liquid from well-field

Condenser

Liquid-vapor separator

Blower

Heater/air drier

Gravity separator

NAPL tank

Liquid GAC

TERRATHERM
a Cascade Company

Attorney-Client Privileged

ADVISE | DESIGN | BUILD | OPERATE

From: John Haas
Sent: 16. februar 2017 01:29
To: Edward N. Sailer
Cc: Alejandro Daza; Steffen Griepke
Subject: Sailer Environmental - Brooklyn NY, Work plan project

Hello Ted:

Thank you for reaching out – hope everything is well with you.

A vapor sample can be obtained at the inlet of the condenser (as shown on page 16 of our budgetary proposal) as long as the sampling equipment and protocol aligns with the stream temperature at approx. 100 C.

Please let me know if you have any questions and/or if you need additional information.

Thanks again, as always.

TERRATHERM
a Cascade Company

JOHN HAAS TECHNICAL SALES SPECIALIST

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P 978.730.1200 x2648 C 781.733.6042

THINK THERMAL

From: Edward N. Sailer [mailto:esailer@sailerenv.com]
Sent: Wednesday, February 15, 2017 5:00 PM
To: John Haas
Subject: FW: Work plan project

Hi John:

Please see the question below from the CSIA lab.

Thanks,

Ted

Edward N. Sailer, CHMM, LEP
President
Sailer Environmental, Inc.
One Orchard Park Road
P.O. Box 21
Madison, CT
(203) 245-7744
Fax (203) 245-2422

From: Patrick McLoughlin [mailto:Patrick.McLoughlin@pacelabs.com]
Sent: Wednesday, February 15, 2017 4:52 PM
To: esailer@sailerenv.com
Subject: RE: Work plan project

I don't envy that task, and I'm sorry you can't avoid it. On page 16 of the TerraTherm doc. they have a nice little diagram of how the vapor and entrained liquid are treated. That makes it look like all 92 extraction points are merged to go into the condenser. Is there some way I could get vapor phase a sample from there? (after the merge but before the condenser.)

Pat
>>> "Edward N. Sailer" <esailer@sailerenv.com> 2/15/2017 3:29 PM >>>
Wise choice. Trying to scroll through a 35,000 page PDF is a nightmare!

From: Patrick McLoughlin [mailto:Patrick.McLoughlin@pacelabs.com]
Sent: Wednesday, February 15, 2017 3:11 PM
To: esailer@sailerenv.com
Subject: RE: Work plan project

Thanks - for now I'll work with what you've already supplied.
>>> "Edward N. Sailer" <esailer@sailerenv.com> 2/15/2017 3:08 PM >>>
Hi Pat:

In response to your questions I have attached the TerraTherm preliminary scope of work which should answer most of your questions as well as the Zymax report. We have a CD from NYSDEC in response to our original FOIL request for Meeker Avenue files that we can mail to you if you would like. It is a PDF with 35,000 pages of information. Let me know if you want a copy of it.

Thanks,

Ted

Edward N. Sailer, CHMM, LEP
President
Sailer Environmental, Inc.
One Orchard Park Road
P.O. Box 21
Madison, CT
(203) 245-7744
Fax (203) 245-2422

From: Patrick McLoughlin [mailto:Patrick.McLoughlin@pacelabs.com]
Sent: Friday, February 03, 2017 3:14 PM
To: esailer@sailerenv.com
Subject: RE: Work plan project

Ted,

Happy Friday! If we could, I'd like to ask you a couple of questions about the Lombardi street site:

1) How many vapor extraction points will you have?
2)How long do you expect to operate the system?

3)Will the soil be heated for that whole time?
4)Are you planning to do any concentration monitoring so you can check progress, etc?
4)I can't seem to find my copy of the Zymax report. Could you send me that?
5)Do you have any more recent Meeker reports you could send me?

Thanks!

Pat McLoughlin, Ph.D.
Technical Director
Pace Analytical Energy Services
412-826-5245, x107

>>> "Edward N. Sailer" <esailer@sailerenv.com> 2/2/2017 9:32 AM >>>
Pat:

Yes. 11am works.

Ted

From: Patrick McLoughlin [mailto:Patrick.McLoughlin@pacelabs.com]
Sent: Thursday, February 02, 2017 9:22 AM
To: esailer@sailerenv.com
Subject: RE: Work plan project

Ed - Good to hear from you. I figured we'd connect sooner or later. Can I give you a call around 11 AM today? - Pat
>>> "Edward N. Sailer" <esailer@sailerenv.com> 2/1/2017 4:52 PM >>>
Pat:

Sorry not to respond sooner. I am available any time tomorrow or Friday. Can you do a call one of those two days.

My number is below.

Ted

Edward N. Sailer, CHMM, LEP
President
Sailer Environmental, Inc.
One Orchard Park Road
P.O. Box 21
Madison, CT
(203) 245-7744
Fax (203) 245-2422

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From: Patrick McLoughlin [mailto:Patrick.McLoughlin@pacelabs.com]
Sent: Tuesday, January 31, 2017 12:10 PM
To: esailer@sailerenv.com
Cc: Aaron Peacock <Aaron.Peacock@pacelabs.com>
Subject: Work plan project

Ed,

Aaron has asked me to develop a work plan with you, which I'll be glad to do? Can we start with a call sometime this afternoon or tomorrow? My schedule for today and tomorrow is pretty accommodating, so what works for you? What number shall I call? If you prefer, we can start with email, just tell me what you need and please give me the starting material.

Pat McLoughlin, Ph.D.
Technical Director
Pace Analytical Energy Services
412-826-5245, x107

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