

Appendix F

Technical Memorandum: Pemaco Data Evaluation for Natural Attenuation and Biodegradation of Chlorinated Ethenes

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Subject: **Pemaco Data Evaluation for Natural Attenuation and Biodegradation of Chlorinated Ethenes**

Introduction

Groundwater data generated for the Pemaco Superfund Site, Maywood, CA (the Site) was reviewed in order to evaluate the natural attenuation and biodegradation of chlorinated ethenes in groundwater. The evaluation process was conducted for both the perched groundwater zone and the Exposition groundwater zones, and consisted of two steps:

1. Evaluation of the Environmental Conditions, and
2. Screening of Analytical Parameters.

These two evaluation steps were undertaken to ensure thorough review and careful consideration of the Pemaco analytical data in order to determine what kind of natural microbiological processes are present at the site and if these processes have potential to be a viable remedial alternative for the Site.

Evaluation of the Environmental Conditions

Geochemical parameters inside and outside of the plume area were summarized for both the Perched and Exposition hydrogeologic zones. The minimum and maximum groundwater results for the Perched Zone ("B-01" through "B-39" and "SV-01" through "SV-05" wells) and the Exposition Zones ("MW-01-80" through "MW-17-95" wells) are presented in Table 1a and 1b respectively. Selected well locations represent conditions in the following plume zones:

- Upgradient "Clean" Area,
- Source Area,
- Mid-plume Area, and
- Downgradient Plume Fringe Area.

Plume zones are representative of the distinguished environmental and microbiological conditions within both hydrological zones at the site.

Table 1a
Comparison of Geochemical Parameters Inside and Outside of Plume Area for Perched Zone
PEMACO Superfund Site, Maywood, CA

Parameter	Units	Upgradient "Clean"	Source Area	Mid-Plume	Downgradient Plume Fringe
		B-37	B-01, B-27, B-13, and B-22	B-08, B-17, B-20, B-21, SV-02, and SV-05	B-30 and B-31
Electron Acceptors					
Dissolved Oxygen	mg/L	NA	0.5 to 2.3	0.4 to 1.9	0.7 to 4.2
Nitrate	mg/L	1.7	< 0.1	< 0.1	NA
Sulfate	mg/L	210	39 to 230	3 to 220	170
Carbon Dioxide	mg/L	NA	41 to 240	187 to 340	22
Metabolic Byproducts					
Ferrous Iron	mg/L	< 1.0	< 0.1 to 2.51	0.86 to 3.98	1.65
Sulfide	mg/L	< 0.7	< 1.0	< 1.0	< 0.1
Methane	ug/L	NA	1,100 to 1,300	1,000 to 2,600	7.0
Environmental Indicators					
Temperature	C	NA	21.2 to 29.4	23.2 to 29.9	28.6 to 29.1
pH	-	NA	7.0 to 8.3	7.2 to 8.9	5.6 to 6.7
ORP	mV	NA	-121 to -27	- 91 to 69	4 to 41
Alkalinity	mg/L	NA	390 to 910	710 to 1100	550
Contaminants					
Tetrachloroethene	ug/L	0.4 - 11	0.67 to 1,100	< 0.5 to 110	1.2 to 10
Trichloroethene	ug/L	0.5 - 0.8	37 to 270	3 to 22	< 0.5 to 1.0
Biodegradation Products					
cis-1,2-Dichloroethene	ug/L	< 0.5 - 0.3	47 to 490	0.4 to 390	< 1.0 to 15
trans-1,2-Dichloroethene	ug/L	< 0.5	1.6 to 45	0.1 to 91	< 1.0 to < 10
1,1-Dichloroethene	ug/L	< 0.5	0.63 to 1,000	0.43 to 100	< 1.0 to < 10
Vinyl Chloride	ug/L	< 0.5	0.38 to 67	4 to 310	< 0.5
Ethene	ug/L	< 1.3	3.8 to 4.4	< 1.3 to 1,900	< 1.0
Chloride	mg/L	110	30 to 160	22 to 120	NA

"Plume"
Direction of GW Flow

Note:

- 1) < - Parameter was not detected; The reported value is the laboratory reporting limit.
- 2) ug/L - microgram per liter
- 3) mg/L - milligram per liter
- 4) mV - millivolts
- 5) C - degree Celsius
- 6) ORP - Oxidation Reduction Potential

Table 1b
Comparison of Geological Parameters Inside and Outside of Plume Area for Exposition Zone
PEMACO Superfund Site, Maywood, CA

Parameter	Units	Source Area	Mid-Plume	Downgradient "Plume" Fringe
		MW-02-95, MW-17-70, and MW-17-85	MW-03-85, MW-05-85, MW-09-70, MW-09-85 , and MW-13-85	MW-10-75 , MW-10-90 , MW-12-70 , and MW-12-90
Electron Acceptors				
Dissolved Oxygen	mg/L	0.6 to 0.71	0.25 to 0.74	0.33 to 2.18
Nitrate	mg/L	< 0.1	< 0.1 to 40	<0.1 to 0.08
Sulfate	mg/L	95 to 260	99 to 240	130 to 170
Carbon Dioxide	mg/L	215	33 - 148	15 - 26
Metabolic Byproducts				
Ferrous Iron	mg/L	0.7 to 5.0	< 0.02 to 1.1	< 0.02 to 0.5
Sulfide	mg/L	< 1.0 to 8	< 1.0 to 1	< 1.0
Methane	ug/L	4.8 - 24	4.8 - 1,100	1.0 - 1,100
Environmental Indicators				
Temperature	C	24.7 to 27.5	21.7 to 23.7	21.7 to 24.2
pH	-	6.8 to 7	6.6 to 7.1	7.2 to 7.3
ORP	mV	- 59 to 196	-116 to 174	-87 to 74
Alkalinity	mg/L	NA	410 to 510	370
Contaminants				
Tetrachloroethene	ug/L	< 1.0 to 2.6	< 0.5 to 11.0	< 0.5
Trichloroethene	ug/L	5,000 to 15,000	< 0.5 to 12,000	0.2 to 2
Biodegradation Products				
cis-1,2-Dichloroethene	ug/L	130 to 16,000	< 0.5 to 230	< 0.5 to 2
trans-1,2-Dichloroethene	ug/L	< 10 to 180	< 0.5 - 16	< 0.5
1,1-Dichloroethene	ug/L	3.4 to 22	< 0.5 - 9.8	< 0.5
Vinyl Chloride	ug/L	7.9 to 1400	< 0.5 - 14	< 0.5
Ethene	ug/L	1.4 to 130	< 1.3 -2.8	< 1.3
Chloride	mg/L	56 to 100	27 to 530	45 to 92

The diagram illustrates the groundwater plume. A green oval labeled "Plume" is shown with a blue arrow pointing to the right, indicating the "Direction of GW Flow".

Note:

- 1) < - Parameter was not detected; The reported value is the laboratory reporting limit.
- 2) ug/L - microgram per liter
- 3) mg/L - milligram per liter
- 4) mV - millivolts
- 5) C - degree Celsius
- 6) ORP - Oxidation Reduction Potential

In order to facilitate evaluation of the site conditions, the geochemical parameters were divided into the following five groups:

1. Electron Acceptors: Oxygen, Nitrate, Sulfate, and Carbon Dioxide;
2. Metabolic Byproducts: Ferrous iron, Sulfide, and Methane;
3. Environmental Indicators: Temperature, pH, Oxidation Reduction Potential (ORP), and Alkalinity;
4. Contaminants: Perchloroethene (PCE) and Trichloroethene (TCE);
5. Biodegradation Products: cis-1,2-Dichloroethene (cis-1,1-DCE), trans-1,2-Dichloroethene (trans-1,2-DCE), and 1,1-Dichloroethene (1,1-DCE), Vinyl Chloride, Ethene, and Chloride;

These parameter groups delivered significant information on the site conditions and potential for natural attenuation. Type and concentration of the electron acceptors, metabolic byproducts and levels of environmental indicators allowed for determination of the predominant microbiological processes and their extent at the site. In order to evaluate natural presence of biodegradation processes, levels of contaminants and biodegradation products were compared. Ethene and chloride are generally considered as final products of biodegradation of chlorinated ethenes by Enhanced In-Situ Bioremediation (EISB). However, elevated levels of methane, ethane, and carbon dioxide can also be indicative of natural attenuation processes.

Pemaco data for the Perched Zone and Exposition Zones indicated that oxygen levels are low in the source area, mid-plume, and at the fringe of the plume indicating favorable anaerobic conditions for reductive dechlorination processes. High methane levels and favorable results of environmental indicators confirmed presence of anaerobic processes. Elevated sulfate and low sulfide levels indicate competing potential for the consumption of organic substrate in the case of implementing the proposed technology. However, this can be easily overcome by supplying sufficient amounts of the substrate for reductive dechlorination and sulfate reduction processes. Positive detection of biodegradation products throughout the site and their elevated levels in the source and mid-plume zones are excellent indicators for naturally occurring biodegradation processes. Based on the character of site contamination, environmental conditions and types of detected biodegradation products, reductive dechlorination process appears to have significant potential for biodegradation of chlorinated ethenes at the site.

Screening of Analytical Parameters

Following the general characterization of site conditions for both zones, detailed evaluation was performed according to US EPA guidelines for preliminary screening of analytical parameters for biodegradation processes (USEPA 1998). Screening results for the Perched Zone are presented in Table 2a and for the Exposition Zones in Table 2b. The approach proposed by US EPA evaluates if natural bioattenuation of PCE, TCE, and DCE is likely to be a viable remedial alternative. In the second step of the evaluation process, a total of twenty-six (26) parameters were taken into account. The parameters under consideration included all parameters evaluated in the first evaluation step, along with the following additional parameters:

- Total Organic Carbon,
- Hydrogen,
- Volatile Fatty Acids,
- Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX),
- Chloroethane,
- 1,1,1-Trichloroethane,
- 1,1-Dichloroethane,
- Carbon Tetrachloride, and
- Chloroform.

As can be noted, the three isomers, namely cis-1,2-DCE, trans-1,2-DCE, and 1,1-DCE, were not present among the parameters. Instead of listing the isomers separately, US EPA recommended to report arithmetic sum of positive detects as "Dichloroethene". Similarly, the parameter named "Ethene/Ethane" indicated arithmetic sum of positive detects for ethene and ethane.

Table 2a
Screening for Biodegradation Processes for Perched Zone,
PEMACO Superfund Site, Maywood, CA

#	Parameter	Score Value Description	Well ID: Zone:	B-37 Upgradient			B-01 Source			B-27 Source			B-21 Mid-Plume						
			Comments	Well Data	Units	Score	Well Data	Units	Score	Well Data	Units	Score	Well Data	Units	Score				
1	Oxygen	if DO <0.5 mg/L score = 3; if 0.5 mg/l< DO < 1.0 mg/L score = 2; if 1.0 < DO < 5.0 mg/L score=0	<0.5 mg/l tolerated; suppresses reductive dechlorination at higher concentrations. >1 mg/L vinyl chloride may be oxidized aerobically, but reductive dechlorination will not occur.	NA	mg/L		2.3	mg/L	0	2.21	mg/L	0	0.48	mg/L	3				
2	Nitrate	if < 1.0 mg/L score = 2; Otherwise score=0	At concentrations greater than 1 mg/L, may compete with reductive pathway.	1.7	mg/L	0	< 0.1	mg/L	2	< 0.1	mg/L	2	< 0.1	mg/L	2				
3	Iron (II)	if > 1.0 mg/L score=3; if 0.5 <Iron(II)< 1.0 mg/L score=2; Otherwise score=0	At concentrations greater than 1 mg/L, reductive pathway is possible.	< 1.0	mg/L	0	2.51	mg/L	3	0.57	ug/L	2	3.98	mg/L	3				
4	Sulfate	if <20 mg/L score=2; Otherwise score=0	At concentrations greater than 20 mg/L, may compete with reductive pathway.	210	mg/L	0	230	mg/L	0	39	mg/L		4	mg/L	2				
5	Sulfide	if > 1.0 mg/L score =3; Otherwise score=0	At concentrations greater than 1 mg/L, reductive pathway is possible.	< 0.7	mg/L	0	< 1.0	mg/L	0	< 1.0	mg/L		< 1.0	mg/L					
6	Methane	if < 500 ug/L score =0; if > 500 ug/L score=3	At concentrations less than 0.5 mg/L, vinyl chloride oxidizes; at concentrations greater than 0.5 mg/L, ultimate reductive daughter product, vinyl chloride accumulates	NA	ug/L		1300	ug/L	3	1100	ug/L	3	1000	ug/L	3				
7	Oxidation Reduction Potential (ORP)	if < 50 millivolts (mV) score=1; if <-100 mV score=2	At levels less than -100 mV, reductive pathway likely. At levels less than 50 mV, reductive pathway possible.	NA	mV		-121	mV	2	-27	mV	1	31	mV	1				
8	pH	if 5 < pH < 9 score=0; if 5 > pH > 9 score = -2;	If between pH 5 and 9, optimal range for reductive pathway. If less than or greater than pH's of 5 and 9 (resp.), outside range for reductive pathway.	NA	--		7.9	--	0	7	--	0	7.3	--	0				
9	Total organic carbon	if > 20 mg/L score =2; Otherwise score = 0	Carbon and energy source; drives dechlorination; can be natural or anthropogenic.	NA	mg/L		7.7	mg/L	0	23	mg/L	2	40	mg/L	2				
10	Temperature	if > 20C score=1	At T>20 C biochemical process accelerated.	NA	C		21.2	C	1	29.1	C	1	26.5	C	1				
11	Carbon Dioxide	if > 107 mg/L score = 1; Otherwise score=0	Ultimate daughter product	NA	mg/L		160	mg/L	1	150	mg/L	1	340	mg/L	1				
12	Alkalinity	if > 700 mg/L score = 1; Otherwise score=0	Results from interaction between CO2 and aquifer minerals	NA	mg/L		910	mg/L	1	760	mg/L	1	1100	mg/L	1				
13	Chloride	if > 100 mg/L score = 2; Otherwise score =0	Daughter product of organic chlorine	NA	mg/L		160	mg/L	2	30	mg/L	0	120	mg/L	2				
14	Hydrogen	if > 1nM score=3; if < 1nM score=0	If >1 nM reductive pathway possible, VC may accumulate. If <1 nM, VC oxidized.	NA	nM		NA	nM		NA	nM		NA	nM					
15	Volatile Fatty Acids	if > 0.1 mg/L score=2; Otherwise score =0	If >0.1 mg/L intermediates resulting from biodegradation of more complex compounds; carbon and energy source.	NA	mg/L		NA	mg/L		NA	mg/L		NA	mg/L					
16	BTEX	if > 100 ug/L score =2, Otherwise score = 0	Carbon and energy source; drives dechlorination. If >0.1 mg/L then score=2, otherwise score=0.	< 0.5	ug/L	0	4.17	ug/L	0	37.8	ug/L	0	657.9	ug/L	2				
17	Perchloroethene	For released material score =0	Material released	11	ug/L	0	1100	ug/L	0	2	ug/L	0	< 1.0	ug/L	0				
18	Trichloroethene	For released material score=0; Otherwise score =2	Likely a daughter product of PCE	1	ug/L	2	87	ug/L	2	160	ug/L	2	18	ug/L	0				
19	Dichloroethene	score=2	Daughter product of chlorinated organic compound	0.3	ug/L	2	1099.6	ug/L	2	535	ug/L	2	288.43	ug/L	2				
20	Vinyl chloride	score=2	Daughter product of chlorinated organic compound	< 0.5	ug/L	0	67	ug/L	2	42	ug/L	2	75	ug/L	2				
21	Ethene/Ethane	if >10 ug/L score = 2; if >100 ug/L score = 3, otherwise = 0	If >10 ug/L score = 2; if >100 ug/L score = 3, otherwise = 0	NA	ug/L		3.8	ug/L		7	ug/L		1900	ug/L	3				
22	Chloroethane	score=2	Daughter product of VC under reducing conditions	< 0.5	ug/L	0	< 1.0	ug/L		4	ug/L		35	ug/L					
23	1,1,1-Trichloroethane	For released material score =0	Material released	7	ug/L	0	7.5	ug/L	0	< 0.5	ug/L	0	< 1.0	ug/L	0				
24	1,1-Dichloroethane	score=2	Daughter product of TCA	2	ug/L	2	364.3	ug/L	2	3	ug/L	0	2.6	ug/L	0				
25	Carbon Tetrachloride	For released material score =0	Material released	< 0.5	ug/L	0	< 0.50	ug/L	0	< 0.5	ug/L	0	< 0.50	ug/L	0				
26	Chloroform	score=2	Daughter product of Carbon Tetrachloride	0.3	ug/L	0	1.7	ug/L	0	< 0.5	ug/L	0	< 1.0	ug/L	0				
				Score:			6	Score:			23	Score:			19	Score:			30

Table 2a - Continuation
Screening for Biodegradation Processes for Perched Zone,
PEMACO Superfund Site, Maywood, CA

#	Parameter	Score Value Description	Well ID: Zone: Comments	B-17 Mid-Plume			B-20 Mid-Plume			B-30 Downgradient Plume Fringe		
				Well Data	Units	Score	Well Data	Units	Score	Well Data	Units	Score
1	Oxygen	if DO <0.5 mg/L score = 3; if 0.5 mg/L< DO < 1.0 mg/L score = 2; if 1.0 < DO < 5.0 mg/L score=0	<0.5 mg/l tolerated; suppresses reductive dechlorination at higher concentrations. >1 mg/L vinyl chloride may be oxidized aerobically, but reductive dechlorination will not occur.	1.21	mg/L	0	0.4	mg/L	3	4.72	mg/L	0
2	Nitrate	if < 1.0 mg/L score = 2; Otherwise score=0	At concentrations greater than 1 mg/L, may compete with reductive pathway.	< 0.1	mg/L	2	< 0.1	mg/L	2	NA	mg/L	
3	Iron (II)	if > 1.0 mg/L score=3; if 0.5 <Iron(II)< 1.0 mg/L score=2; Otherwise score=0	At concentrations greater than 1 mg/L, reductive pathway is possible.	0.86	mg/L	2	NA	mg/L		1.65	mg/L	3
4	Sulfate	if <20 mg/L score=2; Otherwise score=0	At concentrations greater than 20 mg/L, may compete with reductive pathway.	220	mg/L		3	mg/L	2	170	mg/L	
5	Sulfide	if > 1.0 mg/L score =3; Otherwise score=0	At concentrations greater than 1 mg/L, reductive pathway is possible.	< 1.0	mg/L		< 1.0	mg/L		< 0.1	mg/L	
6	Methane	if < 500 ug/L score =0; if > 500 ug/L score=3	At concentrations less than 0.5 mg/L, vinyl chloride oxidizes; at concentrations greater than 0.5 mg/L, ultimate reductive daughter product, vinyl chloride accumulates	2100	ug/L	3	2600	ug/L	3	NA	ug/L	
7	Oxidation Reduction Potential (ORP)	if < 50 millivolts (mV) score=1; if <-100 mV score=2	At levels less than -100 mV, reductive pathway likely. At levels less than 50 mV, reductive pathway possible.	-5	mV	1	-31	mV	1	41	mV	1
8	pH	if 5 < pH < 9 score=0; if 5 > pH > 9 score = -2;	If between pH 5 and 9, optimal range for reductive pathway. If less than or greater than pH's of 5 and 9 (resp.), outside range for reductive pathway.	7.5	--	0	7.3	--	0	6.7	--	0
9	Total organic carbon	if > 20 mg/L score =2; Otherwise score = 0	Carbon and energy source; drives dechlorination; can be natural or anthropogenic.	7.8	mg/L	0	22	mg/L	2	NA	mg/L	
10	Temperature	if > 20C score=1	At T>20 C biochemical process accelerated.	23.4	C	1	29.9	C	1	21.3	C	1
11	Carbon Dioxide	if > 107 mg/L score = 1; Otherwise score=0	Ultimate daughter product	187	mg/L	1	312	mg/L	1	NA	mg/L	
12	Alkalinity	if > 700 mg/L score = 1; Otherwise score=0	Results from interaction between CO2 and aquifer minerals	710	mg/L	1	NA	mg/L		550	mg/L	0
13	Chloride	if > 100 mg/L score = 2; Otherwise score = 0	Daughter product of organic chlorine	90	mg/L	0	22	mg/L	0	NA	mg/L	
14	Hydrogen	if > 1nM score=3; if < 1nM score=0	If > 1 nM reductive pathway possible, VC may accumulate. If < 1 nM, VC oxidized.	NA	nM		NA	nM		NA	nM	
15	Volatile Fatty Acids	if > 0.1 mg/L score=2; Otherwise score =0	If >0.1 mg/L intermediates resulting from biodegradation of more complex compounds; carbon and energy source.	NA	mg/L		NA	mg/L		NA	mg/L	
16	BTEX	if > 100 ug/L score =2, Otherwise score = 0	Carbon and energy source; drives dechlorination. If >0.1 mg/L then score=2, otherwise score=0.	< 2.0	ug/L	0	18.9	ug/L	0	122.7	ug/L	2
17	Perchloroethene	For released material score =0	Material released	0.3	ug/L	0	< 0.5	ug/L	0	1.2	ug/L	0
18	Trichloroethene	For released material score=0; Otherwise score =2	Likely a daughter product of PCE	3	ug/L	2	< 0.2	ug/L	0	< 0.5	ug/L	0
19	Dichloroethene	score=2	Daughter product of chlorinated organic compound	7.7	ug/L	2	0.6	ug/L	0	< 1.0	ug/L	0
20	Vinyl chloride	score=2	Daughter product of chlorinated organic compound	4	ug/L	2	< 0.5	ug/L	0	< 0.5	ug/L	0
21	Ethene/Ethane	if >10 ug/L score = 2; if >100 ug/L score = 3, otherwise = 0	If >10 ug/L score = 2; if >100 ug/L score = 3, otherwise = 0	11	ug/L	2	4.1	ug/L	0	< 1.0	ug/L	0
22	Chloroethane	score=2	Daughter product of VC under reducing conditions	1	ug/L		2	ug/L		< 0.5	ug/L	
23	1,1,1-Trichloroethane	For released material score =0	Material released	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
24	1,1-Dichloroethane	score=2	Daughter product of TCA	4	ug/L	0	63	ug/L	0	< 1.0	ug/L	0
25	Carbon Tetrachloride	For released material score =0	Material released	< 0.5	ug/L	0	< 0.5	ug/L	0	< 1.0	ug/L	0
26	Chloroform	score=2	Daughter product of Carbon Tetrachloride	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
				Score:			Score:			Score:		
				19			15			7		

Table 2b
Screening for Biodegradation Processes for Exposition Zone,
PEMACO Superfund Site, Maywood, CA

#	Parameter	Score Value Description	Well ID:	MW-17-85 Source			MW-02-95 Source			MW-09-85 Mid-Plume			MW-13-85 Mid-Plume		
			Zone:	Well Data	Units	Score	Well Data	Units	Score	Well Data	Units	Score	Well Data	Units	Score
1	Oxygen	if DO <0.5 mg/L score = 3; if 0.5 mg/L < DO < 1.0 mg/L score = 2; if 1.0 < DO < 5.0 mg/L score=0	<0.5 mg/l tolerated; suppresses reductive dechlorination at higher concentrations. >1 mg/L vinyl chloride may be oxidized aerobically, but reductive dechlorination will not occur.	0.48	mg/L	3	0.45	mg/L	3	0.26	mg/L	3	0.74	mg/L	2
2	Nitrate	if < 1.0 mg/L score = 2; Otherwise score=0	At concentrations greater than 1 mg/L, may compete with reductive pathway.	< 0.1	mg/L	2	< 0.1	mg/L	2	1.2	mg/L		< 0.1	mg/L	2
3	Iron (II)	if > 1.0 mg/L score=3; if 0.5 <Iron(II)< 1.0 mg/L score=2; Otherwise score=0	At concentrations greater than 1 mg/L, reductive pathway is possible.	NA	ug/L		NA	mg/L		< 0.1	mg/L		NA	mg/L	
4	Sulfate	if <20 mg/L score=2; Otherwise score=0	At concentrations greater than 20 mg/L, may compete with reductive pathway.	95	mg/L	0	260	mg/L	0	240	mg/L	0	99	mg/L	0
5	Sulfide	if > 1.0 mg/L score =3; Otherwise score=0	At concentrations greater than 1 mg/L, reductive pathway is possible.	8	mg/L	3	< 1.0	mg/L	0	1	mg/L	3	< 1.0	mg/L	0
6	Methane	if < 500 ug/L score =0; if > 500 ug/L score=3	At concentrations less than 0.5 mg/L, vinyl chloride oxidizes; at concentrations greater than 0.5 mg/L, ultimate reductive daughter product, vinyl chloride accumulates	22	ug/L	0	24	ug/L	0	230	ug/L	0	1100	ug/L	3
7	Oxidation Reduction Potential (ORP)	if < 50 millivolts (mV) score=1; if <-100 mV score=2	At levels less than -100 mV, reductive pathway likely. At levels less than 50 mV, reductive pathway possible.	-59	mV	1	87	mV	0	-116	mV	2	158	mV	0
8	pH	if 5 < pH < 9 score=0; if 5 > pH > 9 score = -2;	If between pH 5 and 9, optimal range for reductive pathway. If less than or greater than pH's of 5 and 9 (resp.), outside range for reductive pathway.	6.8	--	0	7.0	--	0	7	--	0	6.9	--	0
9	Total organic carbon	if > 20 mg/L score =2; Otherwise score = 0	Carbon and energy source; drives dechlorination; can be natural or anthropogenic.	NA	mg/L		5.6	mg/L	0	28	mg/L	2	35	mg/L	2
10	Temperature	if > 20C score=1	At T>20 C biochemical process accelerated.	24.7	C	1	27.5	C	1	21.7	C	1	21.7	C	1
11	Carbon Dioxide	if > 40 mg/L score = 1; Otherwise score=0	Ultimate daughter product	NA			215	mg/L	1	67	mg/L	1	52	mg/L	1
12	Alkalinity	if > 350 mg/L score = 1; Otherwise score=0	Results from interaction between CO2 and aquifer minerals	NA	mg/L		NA	mg/L		510	mg/L	1	NA	mg/L	
13	Chloride	if > 100 mg/L score = 2; Otherwise score =0	Daughter product of organic chlorine	56	mg/L	0	100	mg/L	2	260	mg/L	2	27	mg/L	0
14	Hydrogen	if > 1nM score=3; if < 1nM score=0	If >1 nM reductive pathway possible, VC may accumulate. If <1 nM, VC oxidized.	NA	nM		NA	nM		NA	nM		NA	nM	
15	Volatile Fatty Acids	if > 0.1 mg/L score=2; Otherwise score =0	If >0.1 mg/L intermediates resulting from biodegradation of more complex compounds; carbon and energy source.	NA	mg/L		NA	mg/L		NA	mg/L		NA	mg/L	
16	BTEX	if > 100 ug/L score =2, Otherwise score = 0	Carbon and energy source; drives dechlorination. If >0.1 mg/L then score=2, otherwise score=0.	28	ug/L	0	< 10	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
17	Perchloroethene	For released material score =0	Material released	< 20	ug/L	0	< 10	ug/L	0	0.3	ug/L	0	0.2	ug/L	0
18	Trichloroethene	For released material score=0; Otherwise score =2	Likely a daughter product of PCE	7,600	ug/L	0	5,000	ug/L	0	52	ug/L	2	60	ug/L	2
19	Dichloroethene	Score=2	Daughter product of chlorinated organic compound	16,202	ug/L	2	133.4	ug/L	2	8	ug/L	2	9	ug/L	2
20	Vinyl chloride	Score=2	Daughter product of chlorinated organic compound	1,400	ug/L	2	7.9	ug/L	2	< 0.5	ug/L	0	< 0.5	ug/L	0
21	Ethene/Ethane	if >10 ug/L score = 2; if >100 ug/L score = 3, otherwise = 0	If >10 ug/L score = 2; if >100 ug/L score = 3, otherwise = 0	130	ug/L	3	1.4	ug/L	0	< 1.2	ug/L	0	< 1.2	ug/L	0
22	Chloroethane	Score=2	Daughter product of VC under reducing conditions	< 20	ug/L	0	< 10	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
23	1,1,1-Trichloroethane	For released material score =0	Material released	< 20	ug/L	0	< 10	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
24	1,1-Dichloroethane	Score=2	Daughter product of TCA	< 20	ug/L	0	< 10	ug/L	0	0.3	ug/L	0	0.5	ug/L	0
25	Carbon Tetrachloride	For released material score =0	Material released	< 20	ug/L	0	< 10	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
26	Chloroform	Score=2	Daughter product of Carbon Tetrachloride	< 20	ug/L	0	< 10	ug/L	0	7	ug/L	0	0.3	ug/L	0
				Score:			Score:			Score:			Score:		
				17			13			19			15		

Table 2b - Continuation
Screening for Biodegradation Processes for Exposition Zone,
PEMACO Superfund Site, Maywood, CA

#	Parameter	Score Value Description	Well ID: Zone: Comments	MW-05-85 Mid-Plume			MW-08-85 Downgradient Plume Fringe			MW-06-85 Downgradient Plume Fringe			MW-10-90 Downgradient Plume Fringe		
				Well Data	Units	Score	Well Data	Units	Score	Well Data	Units	Score	Well Data	Units	Score
1	Oxygen	if DO <0.5 mg/L score = 3; if 0.5 mg/L < DO < 1.0 mg/L score = 2; if 1.0 < DO < 5.0 mg/L score=0	<0.5 mg/l tolerated; suppresses reductive dechlorination at higher concentrations. >1 mg/L vinyl chloride may be oxidized aerobically, but reductive dechlorination will not occur.	0.25	mg/L	3	0.42	mg/L	3	0.45	mg/L	3	0.33	mg/L	3
2	Nitrate	if < 1.0 mg/L score = 2; Otherwise score=0	At concentrations greater than 1 mg/L, may compete with reductive pathway.	40	mg/L		< 0.1	mg/L	2	< 0.1	mg/L	2	0.08	mg/L	2
3	Iron (II)	if > 1.0 mg/L score=3; if 0.5 <Iron(II)< 1.0 mg/L score=2; Otherwise score=0	At concentrations greater than 1 mg/L, reductive pathway is possible.	0.02	mg/L	0	0.34	mg/L	0	0.24	mg/L	0	< 1.0	mg/L	0
4	Sulfate	if <20 mg/L score=2; Otherwise score=0	At concentrations greater than 20 mg/L, may compete with reductive pathway.	130	mg/L	0	140	mg/L	0	490	mg/L	0	170	mg/L	0
5	Sulfide	if > 1.0 mg/L score =3; Otherwise score=0	At concentrations greater than 1 mg/L, reductive pathway is possible.	< 0.1	mg/L	0	< 1.0	mg/L	0	4	mg/L	3	< 1.0	mg/L	0
6	Methane	if < 500 ug/L score =0; if > 500 ug/L score=3	At concentrations less than 0.5 mg/L, vinyl chloride oxidizes; at concentrations greater than 0.5 mg/L, ultimate reductive daughter product, vinyl chloride accumulates	18	ug/L	0	1100	ug/L	3	4.4	ug/L	0	1.0	ug/L	0
7	Oxidation Reduction Potential (ORP)	if < 50 millivolts (mV) score=1; if <-100 mV score=2	At levels less than -100 mV, reductive pathway likely. At levels less than 50 mV, reductive pathway possible.	48	mV	1	-89	mV	1	20	mV	1	-87	mV	1
8	pH	if 5 < pH < 9 score=0; if 5 > pH > 9 score = -2;	If between pH 5 and 9, optimal range for reductive pathway. If less than or greater than pH's of 5 and 9 (resp.), outside range for reductive pathway.	6.6	--	0	7.1	--	0	7.0	--	0	7.2	--	0
9	Total organic carbon	if > 20 mg/L score =2; Otherwise score = 0	Carbon and energy source; drives dechlorination; can be natural or anthropogenic.	4.5	mg/L	0	56	mg/L	2	11	mg/L	0	34	mg/L	2
10	Temperature	if > 20C score=1	At T>20 C biochemical process accelerated.	22.3	C	1	22.9	C	1	23.1	C	1	21.7	C	1
11	Carbon Dioxide	if > 40 mg/L score = 1; Otherwise score=0	Ultimate daughter product	148	mg/L	1	42	mg/L	1	49	mg/L	1	26	mg/L	0
12	Alkalinity	if > 350 mg/L score = 1; Otherwise score=0	Results from interaction between CO2 and aquifer minerals	410	mg/L	1	NA	mg/L		410	mg/L	1	370	mg/L	1
13	Chloride	if > 100 mg/L score = 2; Otherwise score = 0	Daughter product of organic chlorine	530	mg/L	2	210	mg/L	2	90	mg/L	0	68	mg/L	0
14	Hydrogen	if > 1nM score=3; if < 1nM score=0	If >1 nM reductive pathway possible, VC may accumulate. If <1 nM, VC oxidized.	NA	nM		NA	nM		NA	nM		NA	nM	
15	Volatile Fatty Acids	if > 0.1 mg/L score=2; Otherwise score =0	If >0.1 mg/L intermediates resulting from biodegradation of more complex compounds; carbon and energy source.	NA	mg/L		NA	mg/L		NA	mg/L		NA	mg/L	
16	BTEX	if > 100 ug/L score =2, Otherwise score = 0	Carbon and energy source; drives dechlorination. If >0.1 mg/L then score=2, otherwise score=0.	0.22	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
17	Perchloroethene	For released material score =0	Material released	0.26	ug/L	0	< 0.5	ug/L	0	< 1.0	ug/L	0	< 0.5	ug/L	0
18	Trichloroethene	For released material score=0; Otherwise score =2	Likely a daughter product of PCE	210	ug/L	2	2	ug/L	0	1.1	ug/L	0	2	ug/L	0
19	Dichloroethene	Score=2	Daughter product of chlorinated organic compound	9.6	ug/L	2	0.3	ug/L	2	4.9	ug/L	2	2	ug/L	2
20	Vinyl chloride	Score=2	Daughter product of chlorinated organic compound	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
21	Ethene/Ethane	If >10 ug/L score = 2; if >100 ug/L score = 3, otherwise = 0	If >10 ug/L score = 2; if >100 ug/L score = 3, c	< 1.2	ug/L	0	< 1.2	ug/L	0	0.68	ug/L	0	< 1.2	ug/L	0
22	Chloroethane	Score=2	Daughter product of VC under reducing conditions	< 1.0	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
23	1,1,1-Trichloroethane	For released material score =0	Material released	< 1.0	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
24	1,1-Dichloroethane	Score=2	Daughter product of TCA	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
25	Carbon Tetrachloride	For released material score =0	Material released	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
26	Chloroform	Score=2	Daughter product of Carbon Tetrachloride	33	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0	< 0.5	ug/L	0
				Score:			Score:			Score:			Score:		
				13			17			14			12		

None of groundwater samples collected at the site were analyzed for either hydrogen or volatile fatty acids, and thus the results for these parameters are not available and no points could be awarded. Both parameters would increase significantly upon subsurface injection of an organic substrate due to its fermentation/degradation. Other parameters such as nitrate, iron (II), sulfate, sulfide, methane, total organic carbon, carbon dioxide, alkalinity, and chloride, were only analyzed in selected groundwater samples, and thus results are not available for some of the monitoring wells. Lack of the analytical results for some parameters at some wells did not allow for complete screening point consideration. The fact that analyses of some of the parameters were not performed was weighted when interpreting the evaluation results. An interpretation summary is presented in Table 3; the score values are listed according to US EPA guidelines and adjusted for the analytical results availability.

Table 3. Interpretation of Points Awarded During Data Screening

Score	Adjusted Score	Interpretation
0 to 5	0 to 3	Inadequate evidence for anaerobic biodegradation of chlorinated ethenes by reductive dechlorination
6 to 14	4 to 12	Limited evidence for anaerobic biodegradation of chlorinated ethenes by reductive dechlorination
15 to 20	13 to 16	Adequate evidence for anaerobic biodegradation of chlorinated ethenes by reductive dechlorination
> 20	> 16	Strong evidence for anaerobic biodegradation of chlorinated ethenes by reductive dechlorination

Description of the parameters and the score values assigned are provided in Tables 2a and 2b. According to the US EPA guidelines, score values for carbon dioxide, alkalinity and chloride are assigned based on the background levels. Based on the estimations, in the Perched Zone score points were awarded if carbon dioxide levels were greater than 107 mg/L, alkalinity levels were greater than 700 mg/L, and chloride levels were greater than 100 mg/L. In the Exposition Zones, score points were assigned for carbon dioxide levels greater than 40 mg/L, for alkalinity levels greater than 350 mg/L, and chloride levels greater than 100 mg/L.

The point award system was modified for dissolved oxygen and ferrous iron (iron II) by awarding partial points for the following conditions:

- For oxygen concentrations greater than 0.5 mg/L and less than 1.0 mg/L, two points were awarded (score=2), and
- For Iron II concentrations greater than 0.5 mg/L and less than 1.0 mg/L, two points were awarded (score=2).

Pemaco data screening for Perched Zone resulted in total scores for the source area of 23 and 19, and for the mid-plume area of 30, 19, and 15. According to the score interpretation adjusted for Pemaco data availability, there is a strong evidence for intrinsic biodegradation of chlorinated ethenes via reductive dechlorination process in these areas of the Perched Zone plume. In the upgradient and downgradient wells the evidence for anaerobic biodegradation appeared to be limited, with scores at 6 and 7 points, respectively.

Data screening for Exposition Zones yielded source zone scores between 17 and 13 points, for the mid-plume zone between 19 and 13, and for the downgradient plume fringe zone between 17 and 12. This indicates that in some locations the evidence for intrinsic reductive dechlorination process is strong (scores > 16), in some locations the evidence is adequate (scores between 13 and 16), and in one of the locations within plume fringe the evidence is limited.

Conclusions

The two-step Pemaco data evaluation process for evaluation of natural attenuation and biodegradation of chlorinated ethenes in the Perched and Exposition zones indicated that:

1. Anaerobic conditions are present in the both Perched and Exposition zones.
2. Reductive dechlorination is predominant intrinsic bioremediation process at the site.
3. There is strong/adequate evidence that natural bioattenuation of chlorinated ethenes is occurring in both the Perched an Exposition zones.

Based on the evaluation and screening results, EISB and Monitored Natural Attenuation (MNA) should be evaluated in detail as remedial alternatives for the Pemaco Superfund Site in the Perched and Exposition groundwater zones.

Analytical results for all the Perched Zone wells are presented in Table A-1 (Appendix A) and for all the Exposition Zone(s) wells in Table A-2 (Appendix A).

Reference

United States Environmental Protection Agency (USEPA 1998), Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, September 1998.

APPENDIX A

ANALYTICAL DATA

Table A-1
Analytical Data for Perched Zone
PEMACO Superfund Site, Maywood, CA

		Well ID:		B-01	B-03	B-04	B-05	B-08	B-10	B-12	B-13	B-17	B-18	B-19	B-20
#	Parameter	Units													
1	Oxygen	mg/L	2.3	0.08	1.31	0.48	1.89	NA	1.7	0.67	1.21	2.74	NA	0.4	
2	Nitrate	mg/L	< 0.1	NA	NA	NA	NA	NA	NA	NA	< 0.1	NA	NA	< 0.1	
3	Iron (II)	mg/L	2.51	NA	NA	NA	NA	NA	NA	NA	0.86	0.74	NA	NA	
4	Sulfate	mg/L	230	NA	NA	NA	NA	NA	NA	NA	220	NA	NA	3.0	
5	Sulfide	mg/L	< 1.0	NA	NA	NA	NA	NA	NA	NA	< 1.0	NA	NA	< 1.0	
6	Methane	ug/L	1,300	15,000	570	8,900	720	< 1.0	< 1.0	6,200	2,100	4.0	222	2,600	
7	Oxidation Reduction Potential (ORP)	mV	-121	-161	-11	-47	-22	NA	-61	-133	-5	-107	NA	-31	
8	pH	--	7.9	7.8	7.7	7.7	8.9	NA	10.7	9.8	7.5	7.8	NA	7.3	
9	Total organic carbon	mg/L	7.7	27	34	28	9.5	13	3.2	19	7.8	5.6	4.3	22	
10	Temperature	C	21.2	30	27.9	26.4	29.1	NA	21.9	22.3	23.4	30.3	NA	29.9	
11	Carbon Dioxide	mg/L	160	480	1,300	490	200	50	49	240	187	107	104	312	
12	Alkalinity	mg/L	910	NA	NA	NA	NA	NA	NA	NA	710	780	NA	NA	
13	Chloride	mg/L	160	NA	NA	NA	NA	NA	NA	NA	90	NA	NA	22	
16	Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX)	ug/L	4.2	60	1.4	62	1200.8	0.9	< 2.0	135.6	< 2.0	< 0.5	1.0	18.9	
17	Perchloroethene	ug/L	1,100	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.0	0.67	0.3	2.0	14	< 0.5	
18	Trichloroethene	ug/L	87	< 0.3	< 0.1	< 0.2	< 0.5	6.0	150	37	3.0	< 0.3	30	< 0.2	
19	cis-1,2-Dichloroethene	ug/L	98	1.0	0.2	0.4	0.5	38	7.0	47	0.6	< 0.5	78	0.4	
20	trans-1,2-Dichloroethene	ug/L	1.6	< 0.5	< 0.5	< 0.5	5.0	26	0.4	12	0.1	< 0.5	2.0	0.2	
21	1,1-Dichloroethene	ug/L	1,000	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 1.0	7.0	0.2	1.0	< 0.5	
22	Vinyl chloride	ug/L	67	< 0.5	< 0.5	< 0.5	240	44	< 10	11	4.0	< 0.5	28	< 0.5	
23	Ethane	ug/L	< 1.2	8.0	1.0	120	< 1.0	< 1.0	< 1.0	890	< 1.2	< 1.0	< 1.0	4.1	
24	Ethene	ug/L	3.8	11	< 1.0	9.0	26	19	< 1.0	18,000	11	< 1.0	< 1.0	< 1.3	
25	1,1,1-Trichloroethane	ug/L	7.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 1.0	< 0.5	1.0	< 10	< 0.5	
26	1,1-Dichloroethane	ug/L	360	< 0.5	9.0	< 0.5	4.0	1.0	< 10	< 1.0	4.0	0.9	5.0	63	
27	1,2-Dichloroethane	ug/L	4.3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 0.50	< 0.5	< 0.5	< 10	< 0.5	
28	Carbon Tetrachloride	ug/L	< 0.50	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 0.50	< 0.5	< 0.5	< 10	< 0.5	
29	Chloroethane	ug/L	< 1.0	0.4	0.7	1.0	< 0.5	< 0.5	< 10	0.81	1.0	< 0.5	2.0	2.0	
30	Chloroform	ug/L	1.7	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 1.0	< 0.5	0.1	< 10	< 0.5	

Note:

- 1) < - Parameter was not detected; The reported value is the laboratory reporting limit.
- 2) NA - Not available.
- 3) ug/L - microgram per liter.
- 4) mg/L - milligram per liter.

**Table A-1 Continuation
Analytical Data for Perched Zone
PEMACO Superfund Site, Maywood, CA**

#	Parameter	Well ID:	B-21	B-22	B-23	B-24	B-26	B-27	B-30	B-31	B-32	B-33	B-35	B-36
		Units												
1	Oxygen	mg/L	0.48	0.4	NA	NA	NA	2.21	1.72	0.7	NA	NA	NA	NA
2	Nitrate	mg/L	< 0.1	NA	NA	NA	NA	< 0.1	NA	NA	5.9	NA	NA	NA
3	Iron (II)	mg/L	3.98	< 0.1	NA	0.1	NA	0.57	1.65	NA	NA	NA	NA	NA
4	Sulfate	mg/L	4.0	39	NA	84	NA	39	170	NA	78	NA	NA	NA
5	Sulfide	mg/L	< 1.0	NA	< 1.0	NA	NA	< 1.0	NA	NA	NA	NA	NA	NA
6	Methane	ug/L	1,000	< 1.0	< 0.43	< 1.0	< 1.0	1,100	NA	7.0	113	NA	NA	NA
7	Oxidation Reduction Potential (ORP)	mV	31	-103	NA	NA	NA	-27	41	4.0	NA	NA	NA	NA
8	pH	--	7.3	8.3	NA	NA	NA	7.0	6.7	5.6	NA	NA	NA	NA
9	Total organic carbon	mg/L	40	3.7	NA	5.4	4.3	23	NA	3.7	3.6	NA	NA	NA
10	Temperature	C	26.5	27.3	NA	NA	NA	29.1	21.3	28.6	NA	NA	NA	NA
11	Carbon Dioxide	mg/L	340	41	NA	57	57	150	NA	22	82	NA	NA	NA
12	Alkalinity	mg/L	1100	390	NA	470	NA	760	550	NA	NA	NA	NA	NA
13	Chloride	mg/L	120	NA	NA	NA	NA	30	NA	NA	24	NA	NA	NA
16	Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX)	ug/L	657.9	< 1.0	< 0.5	< 0.5	< 0.5	37.8	122.7	9.0	7.0	< 0.5	< 0.5	< 1.0
17	Perchloroethene	ug/L	< 1.0	1.5	0.2	0.3	0.5	2.0	1.2	10	37	< 0.5	< 0.5	< 1.0
18	Trichloroethene	ug/L	18	270	0.5	< 0.3	160	160	< 0.5	1.0	6.0	0.6	< 0.5	130
19	cis-1,2-Dichloroethene	ug/L	270	150	< 0.5	< 0.5	< 10	490	< 1.0	15	170	0.8	< 0.5	6.6
20	trans-1,2-Dichloroethene	ug/L	18	1.6	< 0.5	< 0.5	< 10	45	< 1.0	10 U	1.0	< 0.5	< 0.5	0.98
21	1,1-Dichloroethene	ug/L	0.43	0.63	< 0.5	< 0.5	< 10	< 0.5	< 1.0	10 U	< 0.5	< 0.5	< 0.5	1.5
22	Vinyl chloride	ug/L	75	0.38	< 0.5	< 0.5	< 10	42	< 0.5	10 U	< 0.5	< 0.5	< 0.5	< 0.50
23	Ethane	ug/L	< 1.3	1.0	< 1.2	< 1.0	< 1.0	2.1	NA	< 1.0	< 1.0	NA	NA	NA
24	Ethene	ug/L	1,900	10	< 1.3	5.0	2.0	4.4	NA	< 1.0	7.0	NA	NA	NA
25	1,1,1-Trichloroethane	ug/L	< 1.0	< 1.0	< 0.5	< 0.5	< 1.0	< 0.5	< 1.0	< 1.0	< 0.5	< 10	< 10	< 1.0
26	1,1-Dichloroethane	ug/L	2.6	< 1.0	< 0.5	< 0.5	< 1.0	3.0	< 1.0	< 1.0	2.0	< 10	< 10	< 1.0
27	1,2-Dichloroethane	ug/L	< 0.50	< 0.50	< 0.5	< 0.5	< 1.0	< 0.5	< 1.0	< 1.0	< 0.5	< 10	< 10	< 0.50
28	Carbon Tetrachloride	ug/L	< 0.50	< 0.50	< 0.5	< 0.5	< 1.0	< 0.5	< 1.0	< 1.0	< 0.5	< 10	< 10	< 0.50
29	Chloroethane	ug/L	35	< 1.0	< 0.5	< 0.5	< 1.0	4.0	< 1.0	< 1.0	< 0.5	< 10	< 10	< 1.0
30	Chloroform	ug/L	< 1.0	< 1.0	11	< 0.5	< 1.0	< 0.5	< 1.0	< 1.0	< 0.5	< 10	< 10	< 1.0

Note:

- 1) < - Parameter was not detected; The reported value is the laboratory reporting limit.
- 2) NA - Not available.
- 3) ug/L - microgram per liter.
- 4) mg/L - milligram per liter.

**Table A-1 Continuation
Analytical Data for Perched Zone
PEMACO Superfund Site, Maywood, CA**

#	Parameter	Well ID:	B-37	B-38	B-39	SV-01	SV-02	SV-03	SV-04	SV-05
		Units								
1	Oxygen	mg/L	NA	NA	NA	NA	0.9	0.4	NA	0.2
2	Nitrate	mg/L	1.7	1.7	0.1	NA	NA	NA	NA	NA
3	Iron (II)	mg/L	< 1.0	NA	NA	NA	NA	NA	NA	NA
4	Sulfate	mg/L	210	210	25	NA	NA	NA	NA	NA
5	Sulfide	mg/L	< 0.7	< 1.0	< 1.0	NA	NA	NA	NA	NA
6	Methane	ug/L	NA	< 0.7	< 1.7	4,900	6,500	40	7,500	4,000
7	Oxidation Reduction Potential (ORP)	mV	NA	NA	NA	NA	-91	-105	NA	-177
8	pH	--	NA	NA	NA	NA	7.3	7.7	NA	8.8
9	Total organic carbon	mg/L	NA	NA	NA	100	6.4	9.9	16	5.9
10	Temperature	C	NA	NA	NA	NA	23.2	22.9	NA	24.8
11	Carbon Dioxide	mg/L	NA	NA	NA	340	260	208	440	260
12	Alkalinity	mg/L	NA	NA	NA	NA	NA	NA	NA	NA
13	Chloride	mg/L	NA	110	5.0	NA	NA	NA	NA	NA
16	Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX)	ug/L	< 0.5	< 0.5	0.8	19	1.9	0.3	43	23.9
17	Perchloroethene	ug/L	11	0.4	0.1	0.1	110	130	< 0.5	< 1.0
18	Trichloroethene	ug/L	1.0	0.8	0.2	0.1	22	9	0.2	13
19	cis-1,2-Dichloroethene	ug/L	0.3	< 0.5	< 0.5	1.0	140	6.0	0.8	390
20	trans-1,2-Dichloroethene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	0.76	< 0.5	0.1	91
21	1,1-Dichloroethene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	100	23	< 0.5	3.2
22	Vinyl chloride	ug/L	< 0.5	< 0.5	< 0.5	0.6	150	0.2	0.9	310
23	Ethane	ug/L	NA	< 1.2	< 1.2	< 1.0	15	< 1.0	2.0	< 1.0
24	Ethene	ug/L	NA	< 1.3	< 1.3	3.0	53	< 1.0	96	2.0
25	1,1,1-Trichloroethane	ug/L	7.0	1.0	< 0.5	< 0.5	51	43	< 0.5	< 1.0
26	1,1-Dichloroethane	ug/L	2.0	< 0.5	0.7	< 0.5	81	20	6.0	28
27	1,2-Dichloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.50	< 10	< 0.5	< 0.50
28	Carbon Tetrachloride	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.50	< 10	< 0.5	< 0.50
29	Chloroethane	ug/L	< 0.5	< 0.5	< 0.5	1.0	< 1.0	< 10	1.0	5.0
30	Chloroform	ug/L	0.3	< 0.5	< 0.5	< 0.5	3.2	2.0	< 0.5	< 1.0

Note:

- 1) < - Parameter was not detected; The reported value is the laboratory reporting limit.
- 2) NA - Not available.
- 3) ug/L - microgram per liter.
- 4) mg/L - milligram per liter.

Table A-2
Analytical Data for Exposition Zone
PEMACO Superfund Site, Maywood, CA

Well ID:		MW-01-80	MW-02-95	MW-03-85	MW-04-85	MW-05-85	MW-05-135	MW-06-85	MW-07-75	MW-07-130	
#	Parameter	Units									
1	Oxygen	mg/L	0.86	0.45	0.47	0.77	0.25	3.05	0.45	1.23	3.51
2	Nitrate	mg/L	< 0.1	< 0.1	0.2	< 0.1	40	0.8	< 0.1	0.06	2.2
3	Iron (II)	mg/L	0.07	NA	0.05	NA	0.02	NA	0.24	NA	NA
4	Sulfate	mg/L	160	260	100	190	130	340	490	190	260
5	Sulfide	mg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 0.1	< 1.0	4.0	< 1.0	< 1.0
6	Methane	ug/L	14	24	35	23	18	< 1.0	4.4	2.2	< 1.0
7	Oxidation Reduction Potential (ORP)	mV	112	87	176	225	48	37	20	172	160
8	pH	--	7.0	7.0	7.2	7.0	6.6	7.2	7.0	7.2	7.1
9	Total organic carbon	mg/L	3.0	5.6	4.4	3.3	4.5	2.7	11	2.2	1.8
10	Temperature	C	23.2	27.5	23.3	24.2	22.3	21.6	23.1	22.3	21.7
11	Carbon Dioxide	mg/L	59	215	59	51	148	30	49	17	21
12	Alkalinity	mg/L	440	NA	490	NA	410	NA	410	NA	NA
13	Chloride	mg/L	100	100	39	120	530	150	90	110	150
16	Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX)	ug/L	< 0.5	< 5.0	67.7	< 5.0	0.22	1.1	101	< 0.5	< 0.5
17	Perchloroethene	ug/L	< 0.5	< 10	11	7.0	0.26	< 0.5	< 1.0	< 0.5	< 0.5
18	Trichloroethene	ug/L	1.0	5,000	12,000	5,000	210	< 0.5	1.1	2.0	0.6
19	cis-1,2-Dichloroethene	ug/L	4.0	130	230	21	9.6	0.3	4.5	0.9	0.6
20	trans-1,2-Dichloroethene	ug/L	< 0.5	< 10	16	< 10	< 1.0	< 0.5	< 1.0	< 0.5	< 0.5
21	1,1-Dichloroethene	ug/L	< 0.5	3.4	9.8	9.6	< 1.0	< 0.5	0.35	< 0.5	< 0.5
22	Vinyl chloride	ug/L	0.7	7.9	14	< 5.0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
23	Ethane	ug/L	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
24	Ethene	ug/L	< 1.3	1.4	2.8	3.2	< 1.3	< 1.3	0.68	< 1.3	< 1.3
25	1,1,1-Trichloroethane	ug/L	< 0.5	< 10	< 10	< 140	< 1.0	< 0.5	< 1.0	< 0.5	< 0.5
26	1,1-Dichloroethane	ug/L	0.3	< 10	< 10	< 140	< 1.0	< 0.5	< 1.0	< 0.5	< 0.5
27	1,2-Dichloroethane	ug/L	< 0.5	< 5.0	< 5.0	< 140	< 0.5	0.4	< 0.5	< 0.5	< 0.5
28	Carbon Tetrachloride	ug/L	< 0.5	< 5.0	< 5.0	< 140	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
29	Chloroethane	ug/L	< 0.5	< 10	< 10	< 140	< 1.0	< 0.5	< 1.0	< 0.5	< 0.5
30	Chloroform	ug/L	< 0.5	< 10	< 10	< 140	33	< 0.5	< 1.0	< 0.5	< 0.5

Note:

- 1) < - Parameter was not detected; The reported value is the laboratory reporting limit.
- 2) NA - Not available.
- 3) ug/L - microgram per liter.
- 4) mg/L - milligram per liter.

**Table A-2 Continuation
Analytical Data for Exposition Zone
PEMACO Superfund Site, Maywood, CA**

Well ID:			MW-08-70	MW-08-85	MW-09-70	MW-09-85	MW-10-75	MW-10-90	MW-10-110	MW-10-175	MW-11-100
#	Parameter	Units									
1	Oxygen	mg/L	0.66	0.42	0.43	0.26	0.62	0.33	1.28	0.62	0.44
2	Nitrate	mg/L	0.3	< 0.1	< 0.1	1.2	< 0.1	0.08	< 0.1	0.3	3.8
3	Iron (II)	mg/L	NA	0.34	NA	< 0.1	NA	< 0.1	NA	NA	NA
4	Sulfate	mg/L	160	140	210	240	130	170	140	130	280
5	Sulfide	mg/L	< 1.0	< 1.0	< 1.0	1.0	< 1.0	< 1.0	0.9	< 1.0	< 1.0
6	Methane	ug/L	< 0.86	1100	4.8	230	1.9	1.0	210	280	11
7	Oxidation Reduction Potential (ORP)	mV	-37	-89	-92	-116	-45	-87	-41	-50	224
8	pH	--	7.1	7.1	7.1	7.0	7.2	7.2	7.4	7.2	7.0
9	Total organic carbon	mg/L	3.9	56	3.3	28	3.1	34	40	0.9	2.3
10	Temperature	C	24.4	22.9	22.5	21.7	23.6	21.7	28.6	23.3	24.5
11	Carbon Dioxide	mg/L	39	42	33	67	21	26	27	9.0	21
12	Alkalinity	mg/L	NA	NA	NA	510	NA	370	NA	NA	NA
13	Chloride	mg/L	62	210	120	260	69	68	73	74	130
16	Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX)	ug/L	0.5	2.0	< 0.5	0.1	< 0.5	0.1	0.3	< 0.5	< 0.5
17	Perchloroethene	ug/L	0.1	< 0.5	< 0.5	0.3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
18	Trichloroethene	ug/L	3.0	2.0	< 0.5	52	< 0.5	2.0	1.0	< 0.5	0.7
19	cis-1,2-Dichloroethene	ug/L	< 0.5	0.3	< 0.5	8.0	< 0.5	2.0	2.0	< 0.5	< 0.5
20	trans-1,2-Dichloroethene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
21	1,1-Dichloroethene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
22	Vinyl chloride	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
23	Ethane	ug/L	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
24	Ethene	ug/L	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3
25	1,1,1-Trichloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
26	1,1-Dichloroethane	ug/L	< 0.5	< 0.5	< 0.5	0.3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
27	1,2-Dichloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
28	Carbon Tetrachloride	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
29	Chloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
30	Chloroform	ug/L	< 0.5	< 0.5	< 0.5	7.0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Note:

- 1) < - Parameter was not detected; The reported value is the laboratory reporting limit.
- 2) NA - Not available.
- 3) ug/L - microgram per liter.
- 4) mg/L - milligram per liter.

**Table A-2 Continuation
Analytical Data for Exposition Zone
PEMACO Superfund Site, Maywood, CA**

Well ID:			MW-12-70	MW-12-90	MW-12-150	MW-13-85	MW-14-80	MW-17-70	MW-17-85
#	Parameter	Units							
1	Oxygen	mg/L	2.18	0.43	2.72	0.74	0.67	NA	0.48
2	Nitrate	mg/L	< 0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1
3	Iron (II)	mg/L	NA	NA	NA	NA	NA	NA	NA
4	Sulfate	mg/L	130	160	200	99	240	170	95
5	Sulfide	mg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	8.0
6	Methane	ug/L	19	1,100	< 0.78	1,100	74	4.8	22
7	Oxidation Reduction Potential (ORP)	mV	74	-22	-22	158	202	NA	-59
8	pH	--	7.3	7.2	7.2	6.9	7.1	NA	6.8
9	Total organic carbon	mg/L	4.9	12	1.6	35	NA	NA	NA
10	Temperature	C	24.2	23.1	21.1	21.7	25	NA	24.7
11	Carbon Dioxide	mg/L	15	22	16	52	NA	NA	NA
12	Alkalinity	mg/L	NA	NA	NA	NA	NA	NA	NA
13	Chloride	mg/L	45	92	130	27	130	75	56
16	Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX)	ug/L	0.6	0.3	0.2	0.5	< 5.0	12.4	27.8
17	Perchloroethene	ug/L	< 0.5	< 0.5	< 0.5	0.2	< 5.0	2.6	< 20
18	Trichloroethene	ug/L	0.3	0.2	0.5	60	4,500	15,000	7,600
19	cis-1,2-Dichloroethene	ug/L	< 0.5	< 0.5	< 0.5	9.0	18	1,700	16,000
20	trans-1,2-Dichloroethene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 5.0	34	180
21	1,1-Dichloroethene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	3.2	5.9	22
22	Vinyl chloride	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 2.5	90	1,400
23	Ethane	ug/L	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
24	Ethene	ug/L	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	2.2	130
25	1,1,1-Trichloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 5.0	< 10	< 20
26	1,1-Dichloroethane	ug/L	< 0.5	< 0.5	< 0.5	0.5	< 5.0	< 10	< 20
27	1,2-Dichloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 2.5	< 5.0	< 10
28	Carbon Tetrachloride	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 2.5	< 5.0	< 10
29	Chloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 5.0	< 10	< 20
30	Chloroform	ug/L	< 0.5	< 0.5	< 0.5	0.3	< 5.0	< 10	< 20

Note:

- 1) < - Parameter was not detected; The reported value is the laboratory reporting limit.
- 2) NA - Not available.
- 3) ug/L - microgram per liter.
- 4) mg/L - milligram per liter.