LFR
LEVINE • FRICKE

September 27, 2000

LFR 1649.20-012

Mr. James Adams
Catellus Development Corporation
201 Mission Street, Suite 250
San Francisco, California 94105

Subject: Results of the Fate and Transport Modeling/Evaluation of Volatile Organic Compounds in Groundwater at the East Baybridge Development Project Site

Dear Jim:

In accordance with our Task Order dated August 9, 2000, LFR Levine · Fricke (LFR) has completed the groundwater flow and chemical transport modeling to evaluate the effects of shutting down the groundwater extraction and treatment system (GWETS) at the East Baybridge Center located in Emeryville, California (the "Site"; Figure 1). The purpose of this task was to estimate the concentrations of volatile organic compounds (VOCs) that may occur in shallow groundwater near the center of the former Oakland Terminal Railroad Site and at the San Francisco Bay margin 1, 3, 5, and 10 years after the GWETS is turned off. Because the results of the modeling indicated that elevated concentrations of VOCs are not likely to migrate to these downgradient locations at for at least 20 years, the model predictions were extended to simulate conditions for 50 years. The results of the modeling are summarized below.

Background

Catellus Development Corporation ("Catellus") identified and assessed a plume of VOC-affected groundwater at the Site from 1990 to 1992. Site investigation activities identified a plume of VOC-affected groundwater (mainly comprised of 1,1-DCE and 1,1,1-TCA) at the Site. The plume was approximately 1000-ft long and about 150-ft wide at the source area (see Figure 2). The centerline of the plume was defined by monitoring wells LF-5 (later replaced by MW-6), LF-4 (later replaced by MW-7), LF-19 (later replaced by MW-9), and LF-22. The source for the affected groundwater is suspected to be located in the vicinity of well LF-5/MW-6. Concentrations in groundwater at the Site were monitored periodically. The historical concentrations detected along this centerline are summarized in Table 1.

In August 1994, the GWETS was put in operation to control the plume from further migrating off-site. The GWETS consists of two groundwater extraction wells and a groundwater extraction trench. The function of the GWETS is to intercept a plume of VOC-affected groundwater migrating from the Site. VOC concentrations in groundwater samples collected along the plume showed a declining trend between 1990 and July 1993. From 1994 to present, subsequent to the operation of the GWETS, the plume concentrations show a relatively stable trend in samples collected from wells located

1900 Powell Street, 12th Floor, Emeryville, California 94608-1827 • (510) 652-4500 • *fax* (510) 652-2246 • *www.lfr.com*
Offices Worldwide

upgradient of the GWETS. This suggests that some natural attenuation/degradation of VOCs is occurring at the Site.

Modeling Approach

Currently, VOC-affected groundwater is intercepted by the GWETS and is not migrating off site (downgradient). Turning off the GWETS means that VOC-affected groundwater that is currently intercepted will represent a "new" source of VOC-affected groundwater migrating from the Site in the downgradient/off-site direction.

The conceptual model consists of a constant source of VOC-affected groundwater released at the source area. The VOCs are released at a constant concentration over a rectangular region perpendicular to the direction of groundwater flow, and they are assumed to migrate and attenuate by the processes of advection, dispersion, adsorption, and degradation. The BIOCHLOR code is consistent with this conceptual model and was selected to simulate the fate and transport and associated plume development of this release. BIOCHLOR is an analytical fate and transport simulator, based on the Domenico (1987) analytical solute transport model, that has the ability to simulate one-dimensional advection, three dimensional dispersion, linear adsorption, and first-order attenuation. It was developed for the Air Force Center for Environmental Excellence Technology Transfer Division at Brooks Air Force Base (Aziz, 1999).

Input parameters such as seepage velocity, dispersion coefficients, retardation factors, and attenuation rates were estimated or derived from Site-specific data, where available. Steady uniform groundwater flow conditions are assumed to exist on Site and downgradient. Pre-GWETS historical VOC concentrations detected in groundwater along the longitudinal centerline of the plume were used as calibration targets to estimate Site-specific attenuation rates and dispersion coefficients.

The parameters used in modeling evaluations are subject to varying degrees of uncertainty. For this evaluation, the dispersion coefficients and attenuation rates were judged to have the highest degree of uncertainty. To address this uncertainty, conservative assumptions were incorporated into the fate and transport modeling process, as described below:

- Conservatively low transverse and vertical dispersivity values were adopted (0.05 times the longitudinal dispersivity and 0.0008 times the longitudinal dispersivity, respectively. By lowering the degree of transverse and vertical mixing, these values result in a narrow, shallow plume with higher centerline concentrations. Commonly accepted values for transverse dispersivity are about one-tenth of the longitudinal dispersivity (based on high reliability points from Gelhar et al, 1992). Commonly accepted values for vertical dispersivity are about one-twentieth of the longitudinal dispersivity.

- The attenuation rates for 1,1-DCE and for 1,1,1-TCA estimated in the calibration process resulted in values equivalent to a 3-year half-life. These attenuation rates are conservative compared to published rates for these compounds. The maximum half-life values of 185 days for 1,1-DCE and 546 to 1090 days for 1,1,1-TCA are cited in Howard et al., (1991).

- The assumption of a constant, non-depleting source of dissolved VOCs is conservative. The historical monitoring record shows a decreasing concentration trend in the suspected source area.

Attenuation Rate Estimation

A Site-specific natural attenuation rate was estimated based on historical VOC concentrations using BIOCHLOR. The average concentration recorded along the centerline of the plume in 1993 was assumed as the steady state condition of the plume and used as the calibration target of the simulation. This assumption was based on the observation that after 1993, concentrations of VOCs detected in groundwater samples collected from wells located along the centerline of the plume have stabilized.

Calibration simulations were performed with BIOCHLOR by varying the dispersion coefficients and degradation rates within reasonable ranges until the closest fit was obtained between the simulated concentrations and the observed concentrations.

The input parameter values are presented in Table 2. The BIOCHLOR output screens from the final calibration simulation are included as Attachment 1.

Downgradient Plume Prediction with the GWETS Turned-off

The potential effect on downgradient groundwater quality of turning off the GWETS was simulated using the parameters obtained during calibration. The conceptual model assumes that the region currently occupied by the extraction trench acts as a source of VOC-affected groundwater equivalent to affected water now being extracted by the GWETS. Input parameters used to simulate and estimate the VOC concentrations downgradient of the GWETS are summarized in Table 3.

The model was used to estimate the concentrations of 1,1-DCE and 1,1,1-TCA in shallow groundwater at the center of the former Oakland Terminal Railroad Site and at the San Francisco Bay Margin, located approximately 1,000 feet and 2,000 feet downgradient from the GWETS, respectively. 1,1-DCE and 1,1,1-TCA were selected as the compounds for modeling because they have been detected in the highest concentrations relative to other VOCs detected in groundwater samples collected at the Site. The future migration of 1,1-DCE and 1,1,1-TCA were estimated at former Oakland Terminal Railroad Site and at the San Francisco Bay Margin 3, 5, 10, 20 and 50 years after the GWETS was turned off. The results of these migration estimates are summarized in Table 4.

Conclusions and Recommendations

Based on the results of the results of the modeling, shutting down the GWETS at the Site will have a minimal impact on the quality of groundwater downgradient of the Site.

Concentrations of 1,1-DCE in groundwater are not expected to be detectable at the center of the former Oakland Terminal Railroad Site (approximately 1,000 feet downgradient of the Site) for approximately 20 years after the GWETS has been turned-off. After 20 years, the concentrations of 1,1-DCE in groundwater are expected to be approximately 2 micrograms per liter (μg/l) if some degradation occurs, and 7 μg/l if no degradation occurs. Concentrations of 1,1,1-TCA detected in groundwater samples collected onsite are two orders of magnitude lower than concentrations of 1,1-DCE. Model predictions indicate that 1,1,1-TCA is not expected to affect impact at all to future off-site groundwater quality.

The model predictions suggest that the concentrations of 1,1-DCE and 1,1,1-TCA will remain below the US EPA Maximum Contaminant Levels (MCLs) for drinking water at the two identified downgradient locations.

In order to evaluate a "worst-case" scenario, additional simulations were conducted assuming no degradation occurs. Under this assumption, the predictions suggest that concentrations of 1,1-DCE may rise above its MCL at the center of the former Oakland Terminal Railroad Site about 20 years after extraction ceases. However, the model predictions contain many additional conservative assumptions, so these "worst case" predictions should be regarded as highly unlikely.

LFR recommends meeting with the Regional Water Quality Control Board (RWQCB) to present the results of the modeling presented in this letter and to request that the GWETS be turned off for one year while conducting groundwater monitoring at the Site on a quarterly basis. Based on the results of this modeling, the GWETS may not have to be re-started, and we will be able to recommend Site closure after 1 or 2 years of groundwater monitoring.

If you have any questions or need any more information, please do not hesitate to call me.

Sincerely,

Ron Goloubow
Project Geologist

References

Aziz, Carol E. and Charles J. Newell. 1999. BIOCHLOR. Groundwater Services, Inc., Houston, Texas.

Domenico, P.A., and F.W.Schwartz. 1990. Physical and Chemical Hydrogeology. John Wiley & Sons, New York.

Howard, Philip H., Robert S. Boethling, William F. Jarvis, William M. Maylan, and Edward M. Michalenko. 1991. Handbook of Environmental Degradation Rates. Lewis Publishers. Chelsea, Michigan.

Spence, Lynn R., and Mark M. Gomez. 1999. Oakland Risk-Based Corrective Action: Technical Background Document. City of Oakland Urban Land Redevelopment Program, Oakland, California.

LFR. 1993. Quarterly Monitoring Report for the Period October 1 through December 31, 1992. Area A and the South-Central Portion of Area B, Yerba Buena/East Baybridge Center Emeryville and Oakland, California, January 29.

LFR. 1994. Report of Combined Well Replacement and Quarterly Monitoring Report for July 1 through September 30, 1994, Yerba Buena/East Baybridge Center Emeryville and Oakland, California, October 94.

LFR. 2000. Semi-annual Monitoring Report for January 1 through June 30, 2000, East Baybridge Center Emeryville and Oakland, California, July 31.

LFR. 2000. Semi-annual Self-Monitoring Report for January 1 through June 30, 2000, Groundwater Extraction and Treatment System, Catellus Development Corporation, East Baybridge Center, 3838 Hollis Street, Emeryville, California, July 31.

Table 1
Historical Concentrations of 1,1-DCE and 1,1,1-TCA Detected in Groundwater Monitoring Wells Along the Plume Centerline at the East Baybridge Development in Emeryville, California

Concentrations are in micrograms per liter (µg/l)

Well Identification	LF-5/MW-6		LF-4/MW-7		LF-19/MW-9		EXTRACTION-TRENCH		LF-22	
Distance from the source, in feet	0		250		850		900		1000	
Sample date	1,1-DCE	1,1,1-TCA	1,1-DCE	1,1,1-TCA	1,1-DCE	1,1,1-TCA	1,1-DCE	1,1,1-TCA	1,1-DCE	1,1,1-TCA
Feb-90	**730**	**270**	**490**	**82**	**150**	34				
Jul-91									**53.0**	**12.0**
Jan-92	880	10	430	78	100	18			41.0	9.0
Apr-92	440	100	250	25	64	8			15.0	2.6
Jul-92	470	80	220	24	32	39			27.0	3.4
Oct-92	390	42	190	20					14.0	1.3
Average 1992	**545**	**58**	**273**	**37**	**65**	**22**			**24**	**4**
May-93	520	95	160	14	13	1.2			6.1	0.8
Jul-93	340	76	160	21	10	1.3			7.7	1.0
Average 1993	**430**	**86**	**160**	**18**	**12**	**1**			**6.9**	**0.9**
Sep-94	280	41	160	17	120	15	Groundwater extraction and treatement system begins operation		3.0	0.5
Dec-94	300	41	170	16	150	16			0.6	0.5
Average 1994	**290**	**41**	**165**	**17**	**135**	**16**			**1.8**	**0.5**
Feb-95	285	42	120	11	120	14			0.7	0.5
May-95	260	31	180	15	110	13			0.6	0.5
Aug-95	270	32	140	12	130	13			1.0	0.5
Dec-95	280	40	170	11	92	9			0.5	0.5
Average 1995	**274**	**36**	**153**	**12**	**113**	**12**			**0.7**	**0.5**
Feb-96	270	31	210	18	87	10	66	7	0.5	0.5
May-96	200	26	220	16			63	6	0.5	0.5
Sep-96	330	33	290	21	99	8	99	8	0.5	0.5
Dec-96	310	60	280	50	59	5	74	8	0.5	0.5
Average 1996	**278**	**38**	**250**	**26**	**82**	**8**	**76**	**7**	**0.5**	**0.5**
Feb-97	260	29	150	7	87	8	59	3	0.5	0.5
May-97	200	18	230	14	63	6	60	4	0.5	0.5
Aug-97	230	19	250	13	63	6	73	7	0.5	0.5
Dec-97	210	20	220	14	67	8	75	6	0.5	0.5
Average 1997	**225**	**22**	**213**	**12**	**70**	**7**	**67**	**5**	**0.5**	**0.5**
Mar-98	180	15	170	10	58	5	64	4	0.5	0.5
Sep-98	210	10	230	8	84	6	150	1	0.5	0.5
Average 1998	**195**	**12**	**200**	**9**	**71**	**6**	**107**	**2**	**0.5**	**0.5**
Mar-99	210	15	200	11	78	4	68	4	0.5	0.5
Sep-99	240	15	220	10	78	5	47	2	0.5	0.5
Average 1999	**225**	**15**	**210**	**11**	**78**	**5**	**58**	**3**	**0.5**	**0.5**
May-00	**190**	**10**	**220**	**8**	**91**	**5**	**68**	**3**	**0.5**	**0.5**

Notes:

1,1-DCE 1,1-dichloroethene

1,1,1-TCA 1,1,1-trichloroethane

Table 2
BIOCHLOR INPUT PARAMETERS
Calibration Run
East Bay Bridge Center, Emeryville, California

Data Type	Parameter	Value	Source of Data
Hydrogeology	Hydraulic Conductivity (K)	0.001 to 0.005 cm/sec use 0.003 (constant estimate)	Estimated based on extraction rates from trench and type of aquifer material
	Hydraulic Gradient (I)	0.007	Static water level measurements
	Porosity (n)	0.3	Estimated based on type of aquifer material
	Seepage Velocity (V)	72.4 feet/year	Calculated K * I / n
Dispersion	Original:		Based on estimated plume length (1993) of
	Long. Dispersivity	100 feet	1000 feet (Long.Disp. = 0.1x X) based on Pickens and Grisak (1981).
	Tran. Dispersivity	10 feet	based on Gelhar et al, 1992, Trans.Disp.= 0.1 Long. Disp.
	Vert. Dispersivity	0.1 feet	set to very low number to yield a conservative estimate
	After Calibration:		Based on calibration to plume length.
	Long. Dispersivity	120	
	Tran. Dispersivity	6	
	Vert. Dispersivity	0.1	
Adsorption	Retardation Factor:	11DCE =2.55 111TCA=4.34	Calculated from R = 1 + Koc x foc x D/n
	Soil Bulk Density (D)	1.59 kg/L	Estimated based on Spence & Gomez (99)
	foc	0.015	Estimated based on Spence & Gomez (99)
	koc	11DCE = 65 cm3/g 111TCA = 140 cm3/g	EPA Region 9 PRGs
Degradation	half life in groundwater (Y)	11DCE = 185 days 111TCA= 546-1090day	For reference, published degradation rates in groundwater (Howard et al, 1991)
	calibrated half lives	11DCE = 3 years 111TCA= 3 years	Based on calibration of plume concentration and length
General	Modeled Area Length	1200 ft	Based on area of affected groundwater plume
	Modeled Area Width	300 ft	2 x plume width
	Simulation Time	20 years	Start of spill not known, estimated in the 70's.
Source Data	Source Thickness	12 ft	Based on boring logs and VOC monitoring data
	Source Width	150 ft	Plume width at source area
	Source concentration	430 (μg/l) (11DCE) 86 (μg/l) (111TCA)	
Actual Data	Distance From Source (ft)	250 850 1000	Based on observed concentrations at site
	VOC Conc. (ug/L)	160 12 7 (11DCE) 18 1 0.9 (111TCA)	
Output	Centerline Conc.		See attached Figure 2.
	Input		See attached Figure 2.

Notes:
Based on monitoring well data from from 1991 to July 1993, prior to start of the groundwater extraction system 1,1,1-DCE and 1,1,1-TCA concentrations along the plume centerline were defined by data from wells LF-5/MW-6, LF-4/MW-7, LF-19/MW-9 and LF-22. These data indicate a declining trend over distance and time. Use of this data assumes that concentrations measured in July 1993 represent a steady state condition (a conservative assumption). This condition is used as input for analysis using BIOCHLOR to estimate the first-order attenuation rates of 1,1-DCE and 1,1,1- TCA. Even though no reductive daughter products (such as vinyl chloride) were detected, attenuation is assumed to occur because measured concentrations of these chemicals show a decreasing trend over distance and time. The assumption that attenuation is occuring is also supported by the observation that concentrations measured subsequent to the operation of the extraction trench show a stable trend over time.

Table 3

BIOCHLOR INPUT PARAMETERS

Predictive Run

East Bay Bridge Center, Emeryville, California

Input parameters to predict/estimate VOC concentrations downgradient of extraction trench.

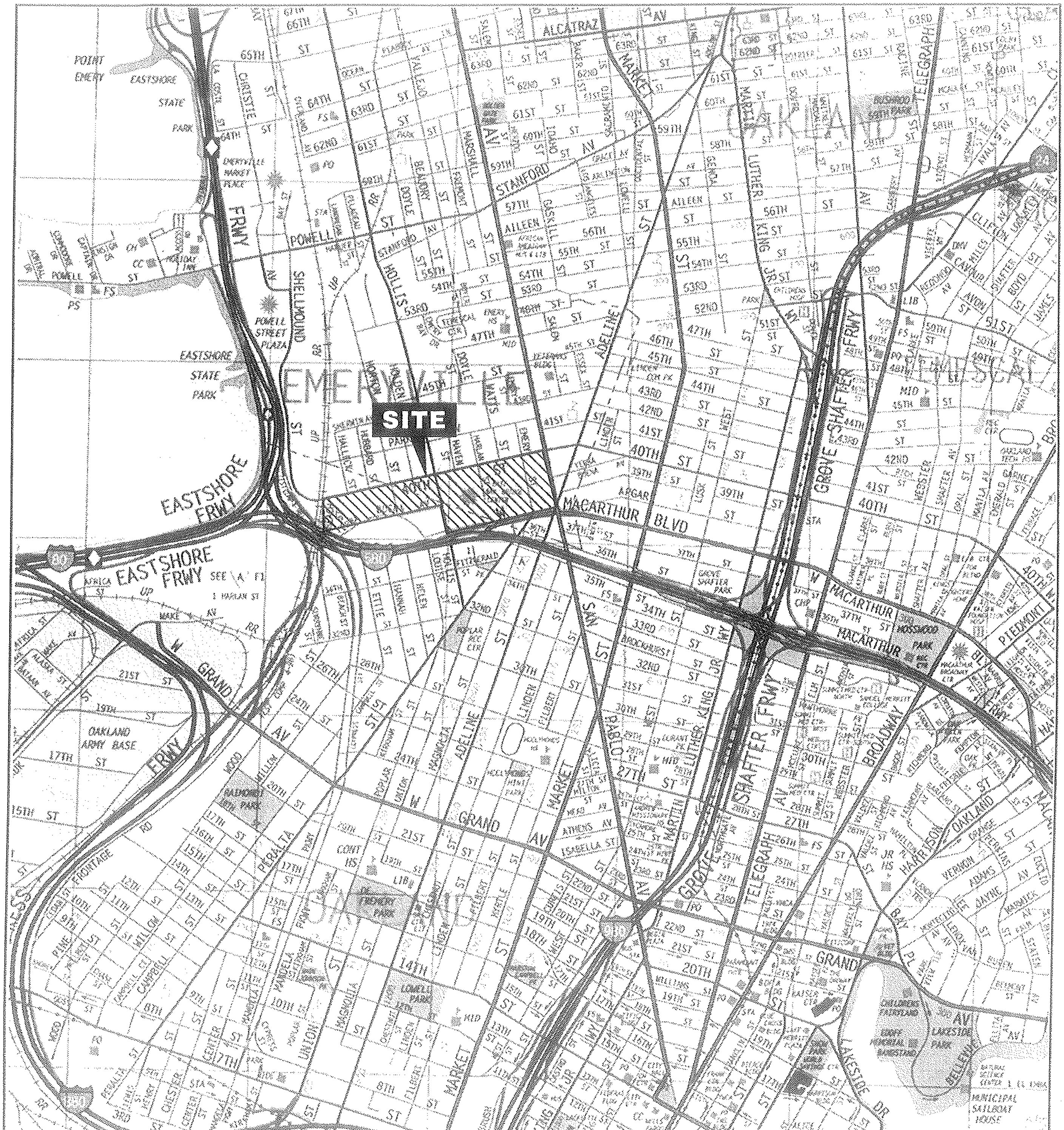
Data Type	Parameter	Value	Source of Data
ydrogeology	Hydraulic Conductivity (K)	0.001 to 0.005 cm/sec; used 0.003 cm/sec	Range based on extraction rates from trench and type of aquifer material Conservative value within estimated range
	Hydraulic Gradient (I)	0.007	Static water level measurements
	Porosity (n)	0.3	Estimated based on type of aquifer material
	Seepage Velocity (V)	72.4 ft/yr	Calculated using K * I / n
spersion	Original:		Based on distance from extraction trench to center of the former Oakland Terminal Railroad Site, approximately 1000 ft downgradient of trench.
	Long. Dispersivity	100 ft	Long. Disp. = 0.1 times distance of interest (Pickens and Grisak, 1981)
	Tran. Dispersivity	10 ft	Trans. Disp.= 0.1 times Long. Disp. (Gelhar et al., 1992)
	Vert. Dispersivity	0.1 ft	Very low value minimizes vertical dispersion; results in a conservative estimate
	After Calibration:		**Based on calibration to observed VOC concentrations**
	Long. Dispersivity	120	
	Tran. Dispersivity	6	
	Vert. Dispersivity	0.1	
lsorption	Retardation Factor:	1,1-DCE = 2.55 1,1,1-TCA = 4.34	Calculated from $R = 1 + (K_{oc}\ f_{oc}\ D)/n$
	Soil Bulk Density (D)	1.59 kg/L	Estimated based on Spence & Gomez (1999)
	f_{oc}	0.015	Estimated based on Spence & Gomez (1999)
	K_{oc}	1,1-DCE = 65 cm^3/g 1,1,1-TCA = 140 cm^3/g	EPA Region 9 PRGs (USEPA, 1999)
:gradation	Half-Life in Groundwater	1,1-DCE = 0.5 years 1,1,1-TCA = 1.5 - 3 years	Howard et al. (1991)
	Calibrated Half-Life	1,1-DCE = 3 years 1,1,1-TCA = 3 years	**Based on calibration. A no-degradation scenario was also simulated.**
:neral	Modeled Area Length	2000 ft	Based on distance to the San Francisco Bay Margin
	Modeled Area Width	300 ft	
	Simulation Duration	3, 5, 10, 20 and 50 years	
..urce Data	Source Thickness	12 ft	Based on boring logs and VOC monitoring data (LFR, 1994)
	Source Width	130 feet	Assumed equal to trench width
	Source Concentration	107 (μg/l) (1,1-DCE) 7 (μg/l) (1,1,1-TCA)	Based on highest yearly average concentration in extracted groundwater
Output	Centerline Concentration		See attached Figure 2.
	Input Parameter Summary		See attached Figure 2.

Table 4
BIOCHLOR SIMULATION RESULTS
VOC Concentration Estimates
at the Center of the Former Oakland Terminal Railroad Site and
at the San Francisco Bay Margin

Elapsed Time (years)	Simulated Concentrations at Former Terminal (micrograms per liter)				Simulated Concentrations at Bay Margin (micrograms per liter)			
	1,1-DCE		1,1,1-TCA		1,1-DCE		1,1,1-TCA	
	No Degradation	Degradation	No Degradation	Degradation	No Degradation	Degradation	No Degradation	Degradation
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	7.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
50	39.0	4.0	2.0	0.0	6.0	0.0	0.0	0.0

Notes:

No degradation indicates that no degradation factor was input into the model.
Degradation indicates that a degradation factor was input into the model.



© Copyright 1997, Thomas Bros. Map ®
Alameda/Contra Costa County
1998 Edition

0 1/2 1 MILE

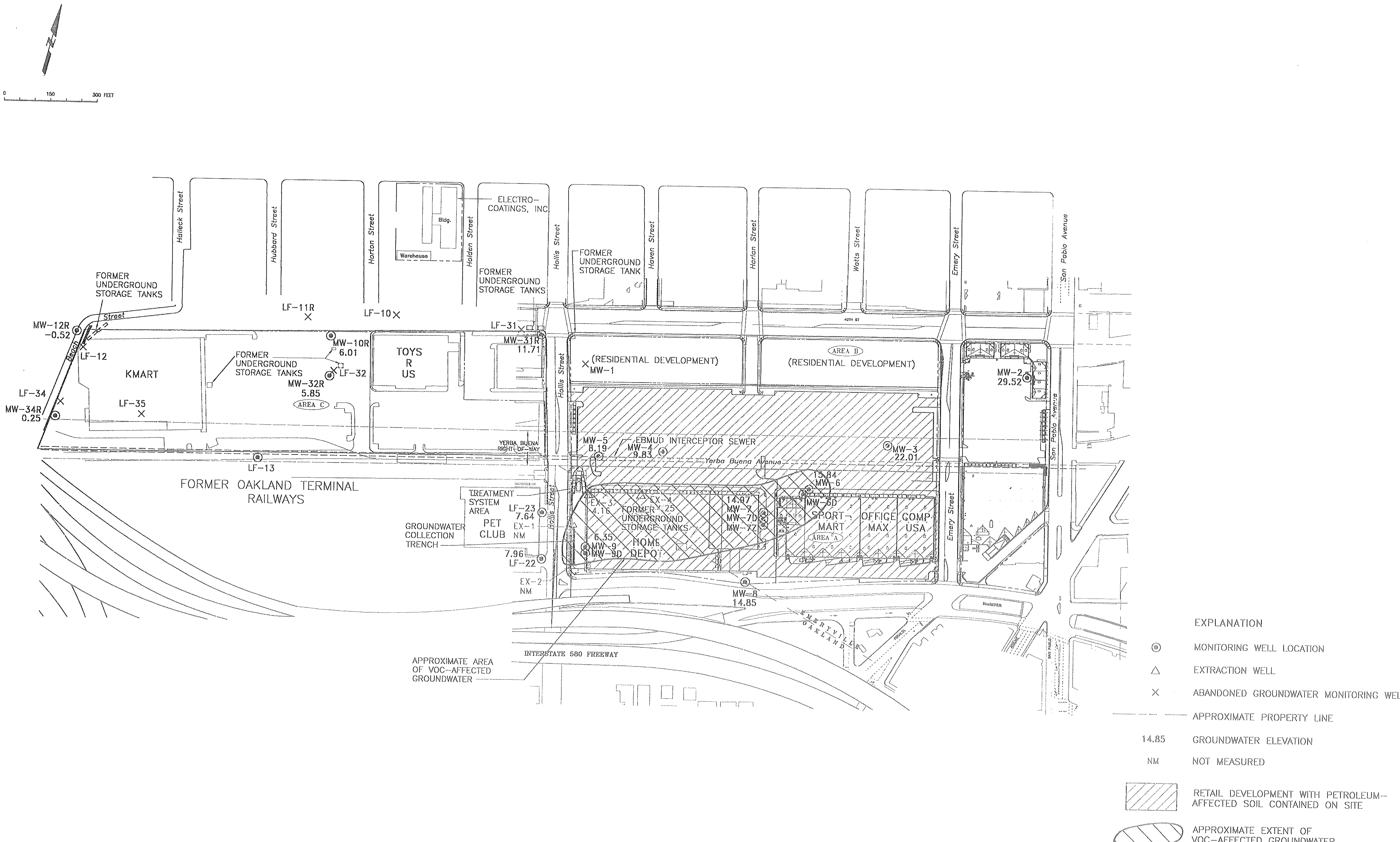
Site Location Map

EAST BAY BRIDGE CENTER

LFR
LEVINE•FRICKE

Figure 1

G:\16591\1649SV03.CDR 1/19/00



REVISION	DESIGN	DRAWN	CHECKED	DATE

SCALE :
DESIGN :
DRAWN :
CHECKED :

LFR
LEVINE•FRICKE
Emeryville, California

APPROVED :

DATE

CATELLUS DEVELOPMENT CORPORATION

YERBA BUENA/EAST BAYBRIDGE DEVELOPMENT

Figure 2

SITE PLAN SHOWING APPROXIMATE EXTENT OF VOC–AFFECTED GROUNDWATER

Project No. 1649
Date SEPT. 00
Sheet of
Issue

Attachment 1

Final Calibration Simulation - BIOCHLOR Output

BIOCHLOR Natural Attenuation Decision Support System

Version Beta 1.0b3

Bay Bridge Center
1,1-DCE Calibration
Run Name

Data Input Instructions:

115 ← 1. Enter value directly....or
or 2. Calculate by filling in grey
0.02 cells. Press Enter, then (C)
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biodegradation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	72.4	(ft/yr)
or		or	
Hydraulic Conductivity	K	3.0E-03	(cm/sec)
Hydraulic Gradient	i	0.007	(ft/ft)
Porosity	n	0.3	(-)

2. DISPERSION

Alpha x Calc. Method	Linear	
(Alpha y) / (Alpha x)	0.05	(-)
(Alpha z) / (Alpha x)	1.E-99	(-)

Change Alpha x Calc. Method

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho		(kg/L)		
FractionOrganicCarbon, foc		(-)		
Partition Coefficient	Koc			
PCE		(L/kg)		(-)
TCE		(L/kg)		(-)
DCE		(L/kg)		(-)
VC		(L/kg)		(-)
ETH		(L/kg)		(-)
Common R (used in model)* =			2.6	

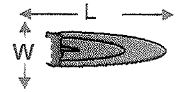
4. BIODEGRADATION -1st Order Decay Coef*

Zone 1	λ (1/yr)		half-live (yrs)	Yield*
PCE → TCE	0.00	←		0.79
TCE → DCE	0.00	←		0.74
DCE → VC	0.23	←	3.00	0.64
VC → ETH	0.00	←		0.45

Zone 2	λ (1/yr)		half-live (yrs)
PCE → TCE	0.00	←	
TCE → DCE	0.00	←	
DCE → VC	0.00	←	
VC → ETH	0.00	←	
ETH → Product	0.00	←	

5. GENERAL

Simulation Time*	20	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	1200	(ft)
Zone 1 Length*	1200	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA

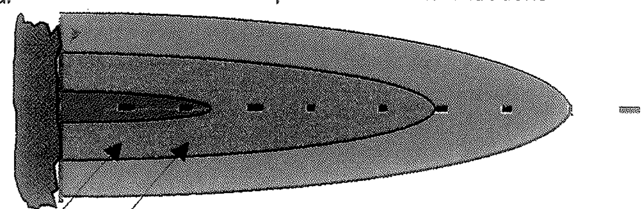
Source Options TYPE: Single Planar

Source Thickness in Sat. Zone* 12 (ft)

Width* (ft) 150

Conc. (mg/L)*	C1
PCE	.0
TCE	.0
DCE	.43
VC	.0
ETH	.0

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)	.43		.16					.012		.007	
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Dist. from Source (ft)	0	120	240	360	480	600	720	850	970	1000	1120

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example Dataset

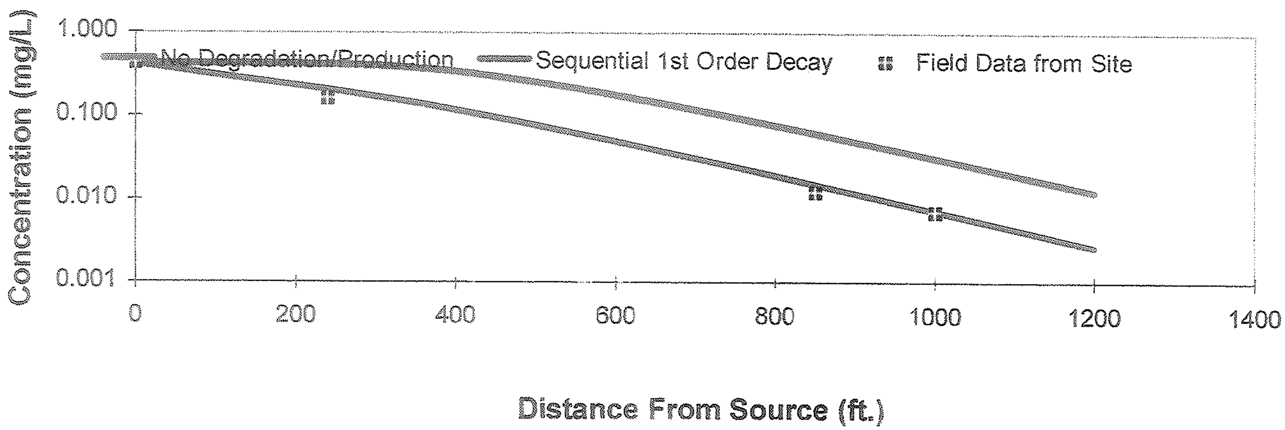
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

Distance from Source (ft)

DCE	0	120	240	360	480	600	720	840	960	1080	1200
No Degradation	0.430	0.430	0.424	0.371	0.275	0.182	0.112	0.066	0.039	0.022	0.012
Biodegradation	0.430	0.297	0.209	0.141	0.088	0.052	0.029	0.016	0.009	0.005	0.003

Monitoring Well Locations (ft)

	0	120	240	360	480	600	720	850	970	1000	1120
Field Data from Site	0.430		0.160					0.012		0.007	



See PCE

See TCE

See DCE

See VC

See ETH

Log ⟺ Linear

Time:

20 Years

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support System

Version Beta 1.0b3

Bay Bridge Center
1,1,1 TCA Calibration
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
or 2. Calculate by filling in grey
0.02 cells. Press Enter, then (C)
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biodegradation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ○ Ethanes ●

1. ADVECTION

Seepage Velocity*	Vs	72.4	(ft/yr)
or		or	
Hydraulic Conductivity	K	3.0E-03	(cm/sec)
Hydraulic Gradient	i	0.007	(ft/ft)
Porosity	n	0.3	(-)

2. DISPERSION

Alpha x Calc. Method	Linear	
(Alpha y) / (Alpha x)	0.05	(-)
(Alpha z) / (Alpha x)	1.E-99	(-)

Change Alpha x Calc. Method

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho		(kg/L)		
FractionOrganicCarbon, foc		(-)		
Partition Coefficient	Koc			
TCA		(L/kg)		(-)
DCA		(L/kg)		(-)
CA		(L/kg)		(-)

Common R (used in model)* = 3.2

4. BIODEGRADATION

-1st Order Decay Coef*

Zone 1

	λ (1/yr)	half-live (yrs)	Yield*
TCA → DCA	0.23	3.00	0.74
DCA → CA	0.00		0.65
CA → Ethane	0.00		0.47

Zone 2

	λ (1/yr)	half-live (yrs)
TCA → DCA	0.00	
DCA → CA	0.00	
CA → Ethane	0.00	

5. GENERAL

Simulation Time*	20	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	1200	(ft)
Zone 1 Length*	1200	(ft)
Zone 2 Length*	0	(ft)

L, W
Zone 2= L - Zone 1

6. SOURCE DATA

Source Options

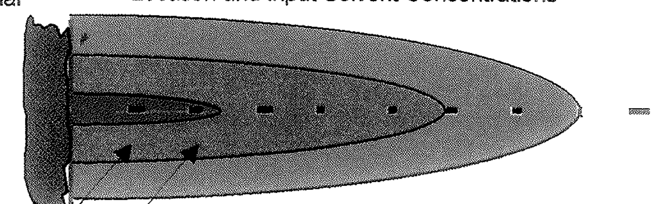
TYPE: Single Planar

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

Source Thickness in Sat. Zone* 12 (ft)

Width* (ft) 150

Conc. (mg/L)*	C1
TCA	.086
DCA	.0
CA	.0



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

TCA Conc. (mg/L)	.086		.018					.001		.001	
DCA Conc. (mg/L)											
CA Conc. (mg/L)											
Dist. from Source (ft)	0	120	240	360	480	600	720	850	970	1000	1200

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example Dataset

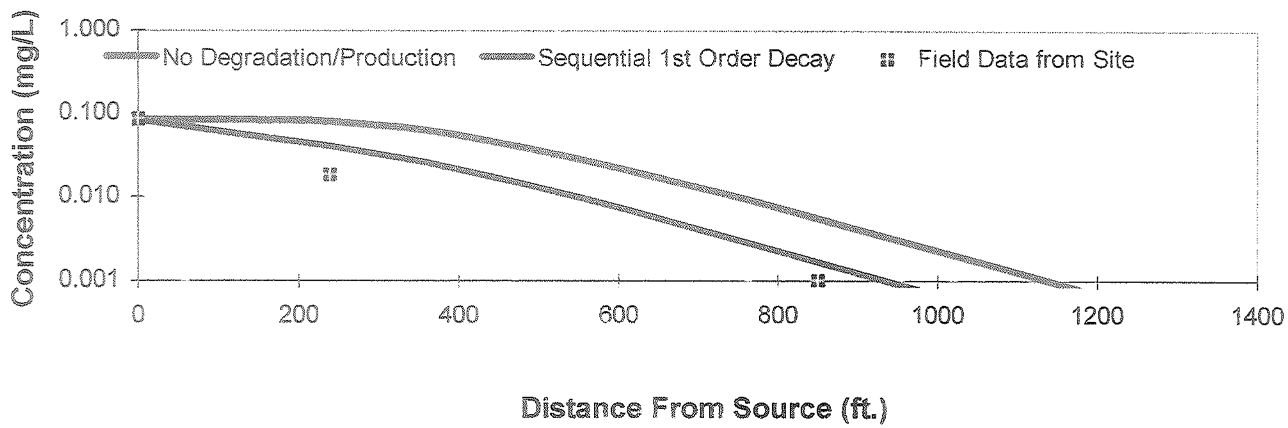
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

Distance from Source (ft)

TCA	0	120	240	360	480	600	720	840	960	1080	1200
No Degradation	0.086	0.086	0.082	0.064	0.040	0.023	0.012	0.006	0.003	0.001	0.001
Biodegradation	0.086	0.059	0.041	0.026	0.015	0.008	0.004	0.002	0.001	0.000	0.000

Monitoring Well Locations (ft)

	0	120	240	360	480	600	720	850	970	1000	1200
Field Data from Site	0.086		0.018					0.001		0.001	



See TCA

See DCA

See CA

Log ⟺ Linear

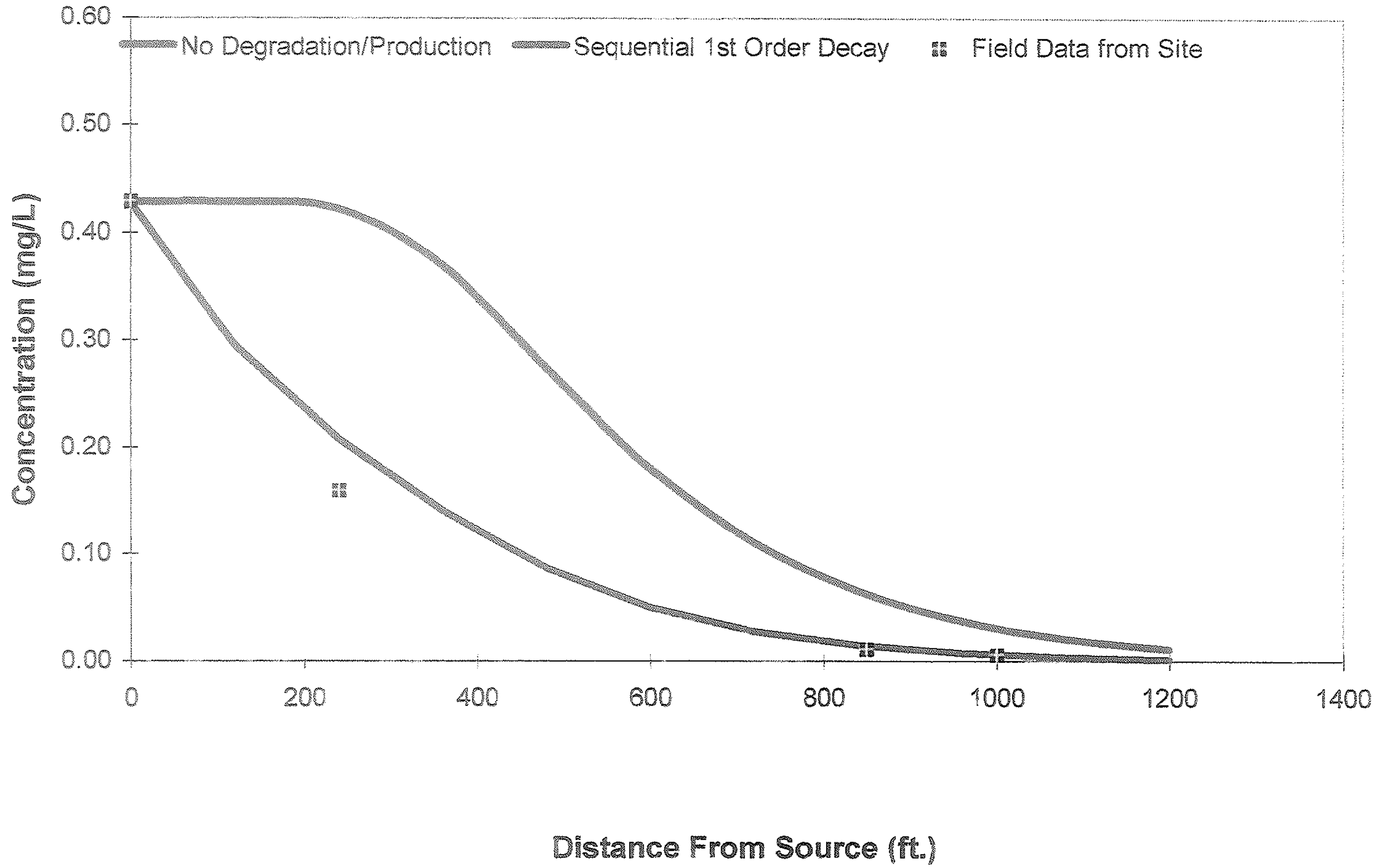
Time:

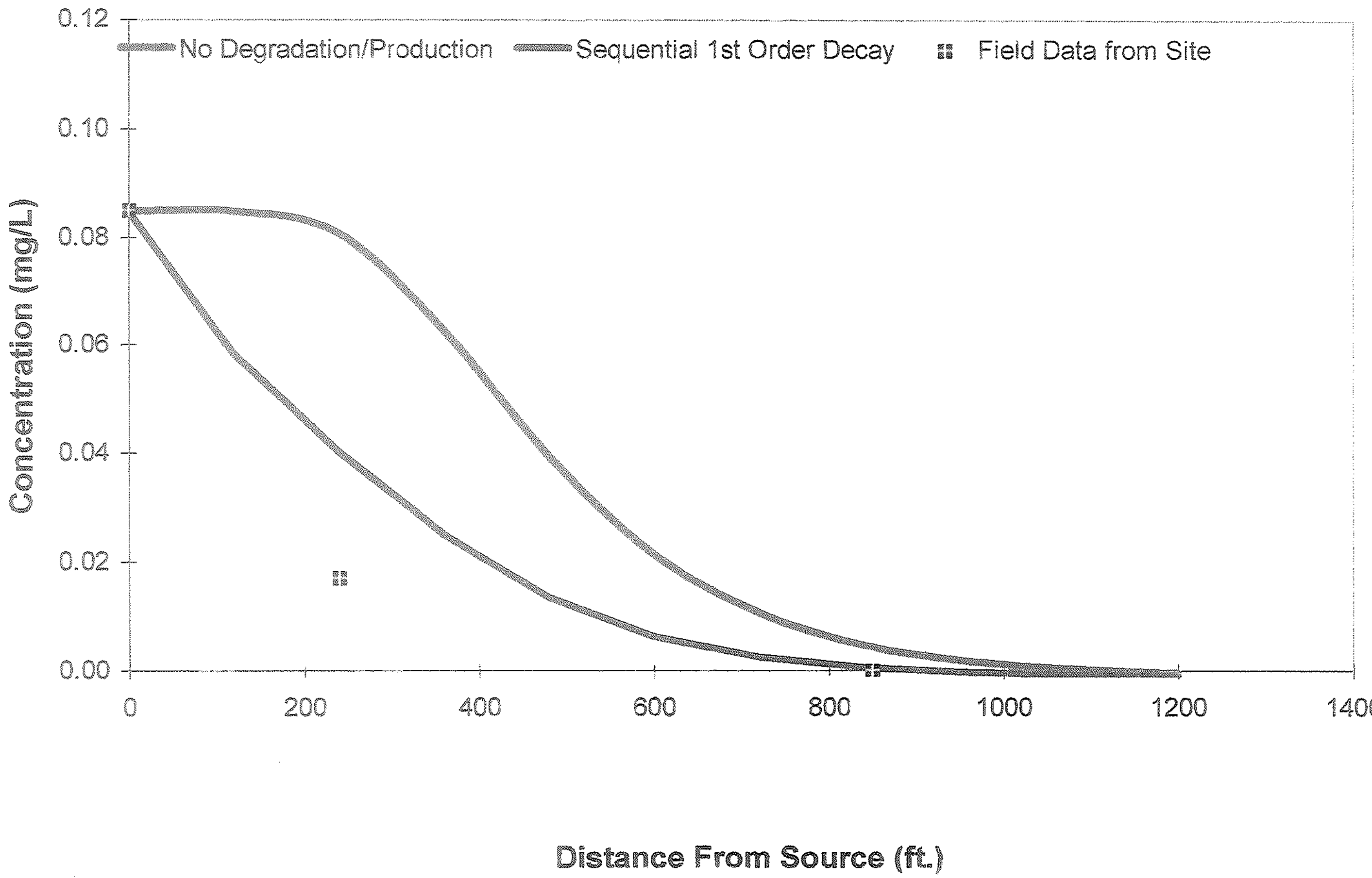
20 Years

Return to Input

To All

To Array


No Degradation/Production
Sequential 1st Order Decay
Field Data from Site
Concentration (mg/L)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
200
400
600
800
1000
1200
1400
Distance From Source (ft.)


0.12
0.10
0.08
0.06
0.04
0.02
0.00
Concentration (mg/L)
No Degradation/Production
Sequential 1st Order Decay
Field Data from Site
0
200
400
600
800
1000
1200
1400
Distance From Source (ft.)

BIOCHLOR Natural Attenuation Decision Support System

Version Beta 1.0b3

Bay Bridge Center
Predicted 1,1-DCE
0

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or 2. Calculate by filling in grey
0.02 cells. Press Enter, then (C)
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biodegradation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	72.4	(ft/yr)
or		or	
Hydraulic Conductivity	K	3.0E-03	(cm/sec)
Hydraulic Gradient	i	0.007	(ft/ft)
Porosity	n	0.3	(-)

2. DISPERSION

Alpha x Calc. Method	120	(ft)
(Alpha y) / (Alpha x)	0.05	(-)
(Alpha z) / (Alpha x)	1.E-99	(-)

Change Alpha x Calc. Method

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho		(kg/L)		
FractionOrganicCarbon, foc		(-)		
Partition Coefficient	Koc			
PCE		(L/kg)		(-)
TCE		(L/kg)		(-)
DCE		(L/kg)		(-)
VC		(L/kg)		(-)
ETH		(L/kg)		(-)

Common R (used in model)* = 2.6

4. BIODEGRADATION -1st Order Decay Coef*

Zone 1	λ (1/yr)	half-live (yrs)	Yield*
PCE → TCE	0.00		0.79
TCE → DCE	0.00		0.74
DCE → VC	0.23	3.00	0.64
VC → ETH	0.00		0.45

Zone 2	λ (1/yr)	half-live (yrs)
PCE → TCE	0.00	
TCE → DCE	0.00	
DCE → VC	0.00	
VC → ETH	0.00	
ETH → Product	0.00	

5. GENERAL

Simulation Time*	10	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	2000	(ft)
Zone 1 Length*	2000	(ft)
Zone 2 Length*	0	(ft)

Zone 2= L - Zone 1

6. SOURCE DATA

Source Options

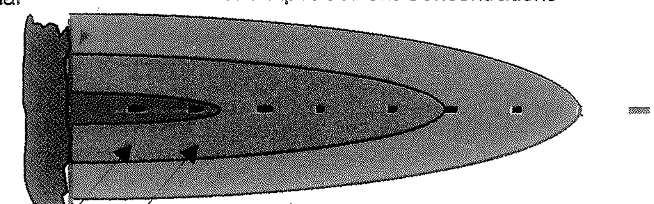
TYPE: Single Planar

Source Thickness in Sat. Zone* 12 (ft)

Width* (ft) 130

Conc. (mg/L)*	C1
PCE	.0
TCE	.0
DCE	.107
VC	.0
ETH	.0

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)	.1										
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Dist. from Source (ft)	0	200	400	600	800	1000	1200	1400	1600	1800	2000

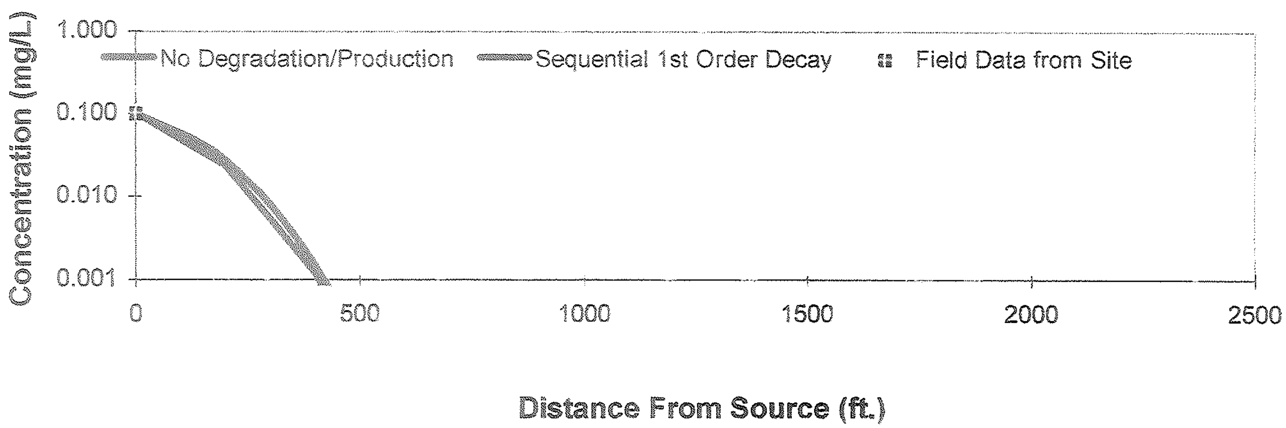
8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example Dataset

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

DCE	Distance from Source (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.107	0.028	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biodegradation	0.107	0.024	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Monitoring Well Locations (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Field Data from Site	0.100										



See PCE

See TCE

See DCE

See VC

See ETH

Log ⟺ Linear

Time:

3 Years

Return to Input

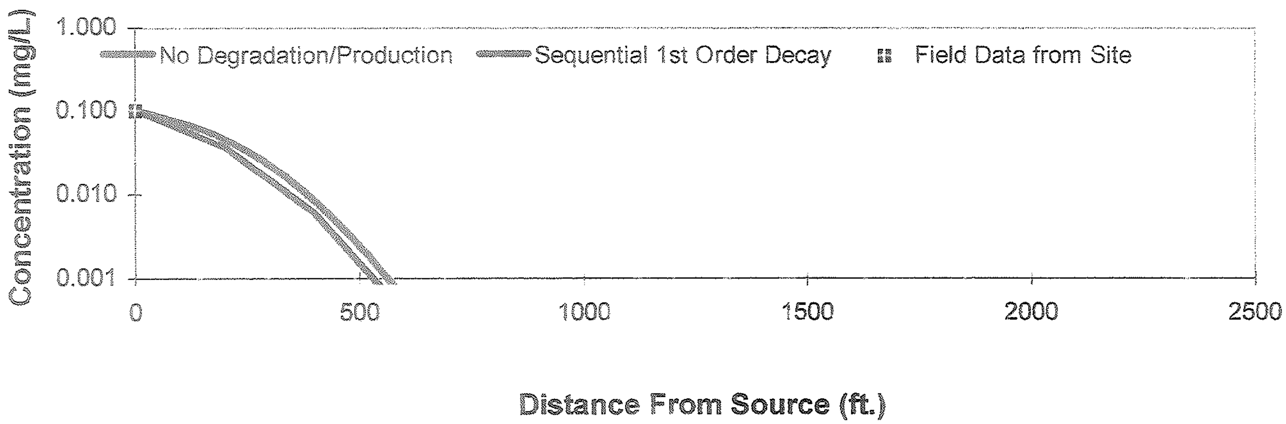
To All

To Array

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

DCE	Distance from Source (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.107	0.047	0.008	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biodegradation	0.107	0.037	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Monitoring Well Locations (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Field Data from Site	0.100										



See PCE

See TCE

See DCE

See VC

See ETH

Log ⟺ Linear

Time:

5 Years

Return to Input

To All

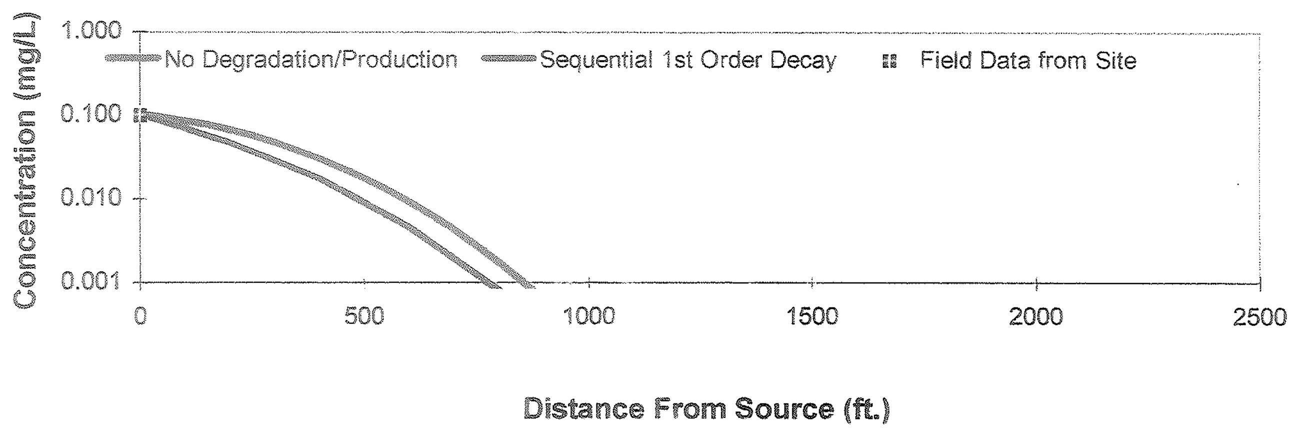
To Array

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

DCE

	Distance from Source (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.107	0.069	0.031	0.009	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Biodegradation	0.107	0.049	0.018	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000

	Monitoring Well Locations (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Field Data from Site	0.100										



See PCE

See TCE

See DCE

See VC

See ETH

Log ⟺ Linear

Time: *10 Years*

Return to Input

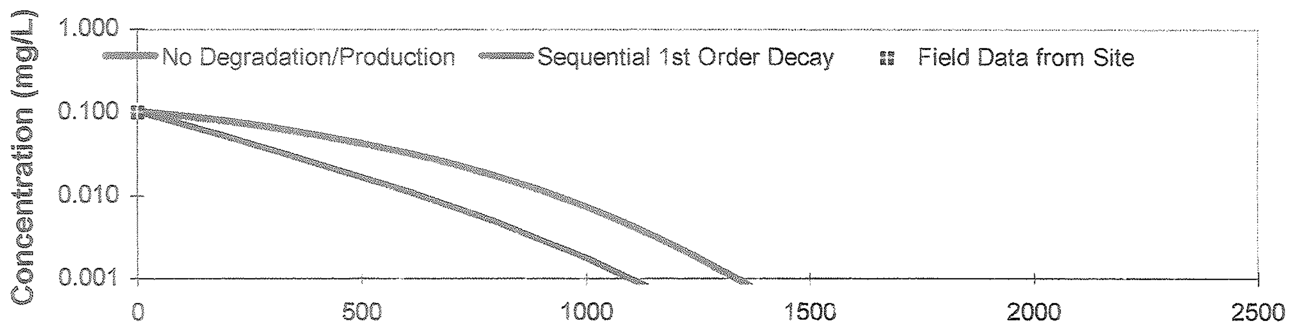
To All

To Array

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

DCE	Distance from Source (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.107	0.082	0.055	0.034	0.018	0.007	0.002	0.001	0.000	0.000	0.000
Biodegradation	0.107	0.053	0.025	0.012	0.005	0.002	0.001	0.000	0.000	0.000	0.000

	Monitoring Well Locations (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Field Data from Site	0.100										



Distance From Source (ft.)

See PCE

See TCE

See DCE

See VC

See ETH

Log ⟺ Linear

Time:

20 Years

Return to Input

To All

To Array

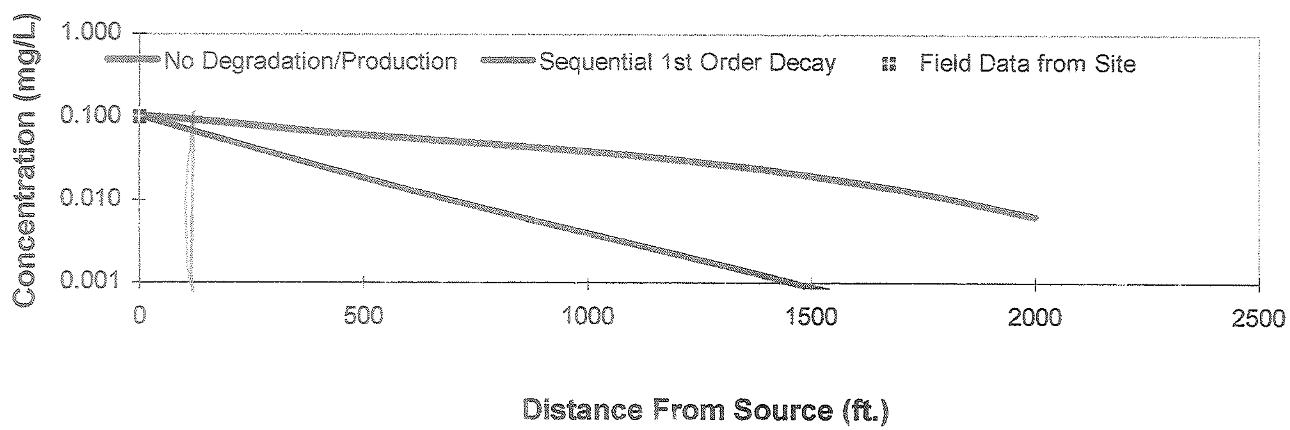
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

Distance from Source (ft)

DCE	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.107	0.087	0.069	0.057	0.048	0.039	0.031	0.024	0.017	0.011	0.006
Biodegradation	0.107	0.053	0.026	0.014	0.007	0.004	0.002	0.001	0.001	0.000	0.000

Monitoring Well Locations (ft)

	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Field Data from Site	0.100										



See PCE

See TCE

See DCE

See VC

See ETH

Log ⟺ Linear

Time: *50 Years*

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support System

Version Beta 1.0b3

Bay Bridge Center
Predicted 1,1,1-TCA
0

Data Input Instructions:

115 → 1. Enter value directly....or
↑ or 2. Calculate by filling in grey
0.02 cells. Press Enter, then (C)
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biodegradation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ○ Ethanes ●

1. ADVECTION

Seepage Velocity*	Vs	72.4	(ft/yr)
or		or	
Hydraulic Conductivity	K	3.0E-03	(cm/sec)
Hydraulic Gradient	i	0.007	(ft/ft)
Porosity	n	0.3	(-)

2. DISPERSION

Alpha x Calc. Method	120	(ft)
(Alpha y) / (Alpha x)	0.05	(-)
(Alpha z) / (Alpha x)	1.E-99	(-)

Change Alpha x Calc. Method

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho		(kg/L)		
FractionOrganicCarbon, foc		(-)		
Partition Coefficient	Koc			
TCA		(L/kg)		(-)
DCA		(L/kg)		(-)
CA		(L/kg)		(-)

Common R (used in model)* = 3.2

4. BIODEGRADATION -1st Order Decay Coef*

Zone 1

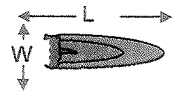
	λ (1/yr)	half-live (yrs)	Yield*
TCA → DCA	0.23	3.00	0.74
DCA → CA	0.00		0.65
CA → Ethane	0.00		0.47

Zone 2

	λ (1/yr)	half-live (yrs)
TCA → DCA	0.00	
DCA → CA	0.00	
CA → Ethane	0.00	

5. GENERAL

Simulation Time*	10	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	2000	(ft)
Zone 1 Length*	2000	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA

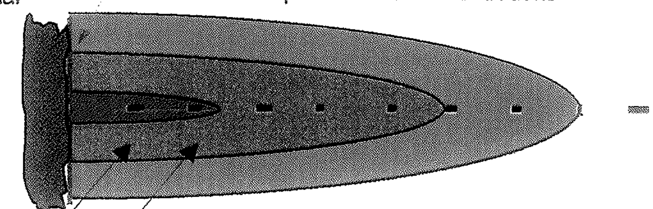
Source Options TYPE: Single Planar

Source Thickness in Sat. Zone* 12 (ft)

Width* (ft) 130

Conc. (mg/L)*	C1
TCA	.007
DCA	.0
CA	.0

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

TCA Conc. (mg/L)	.007										
DCA Conc. (mg/L)											
CA Conc. (mg/L)											
Dist. from Source (ft)	0	200	400	600	800	1000	1200	1400	1600	1800	2000

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | *Help* | Restore Formulas | RESET | *SEE OUTPUT* | Paste Example Dataset

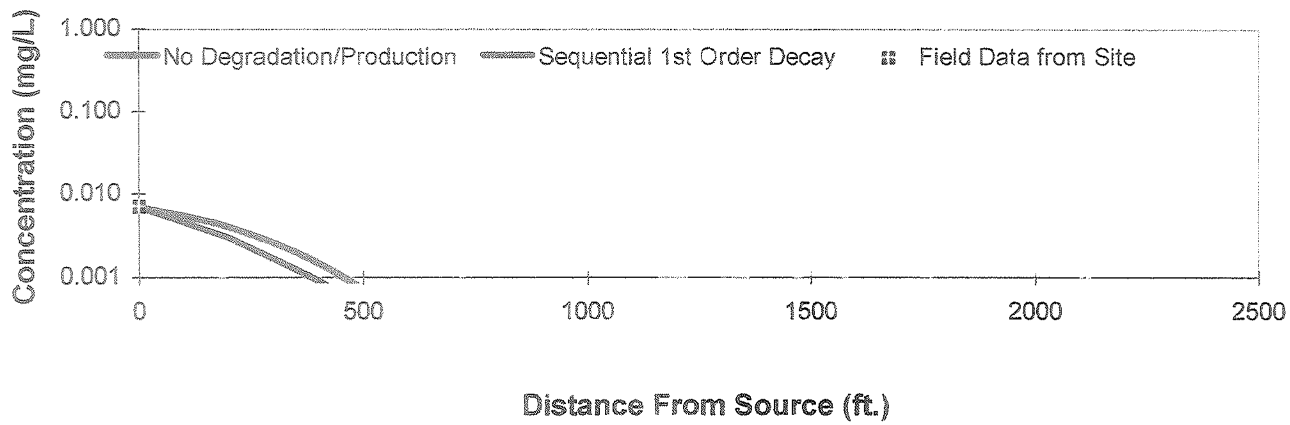
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

Distance from Source (ft)

TCA	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.007	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biodegradation	0.007	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Monitoring Well Locations (ft)

	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Field Data from Site	0.007										



See TCA

See DCA

See CA

Log ⟺ Linear

Time:

10 Years

Return to Input

To All

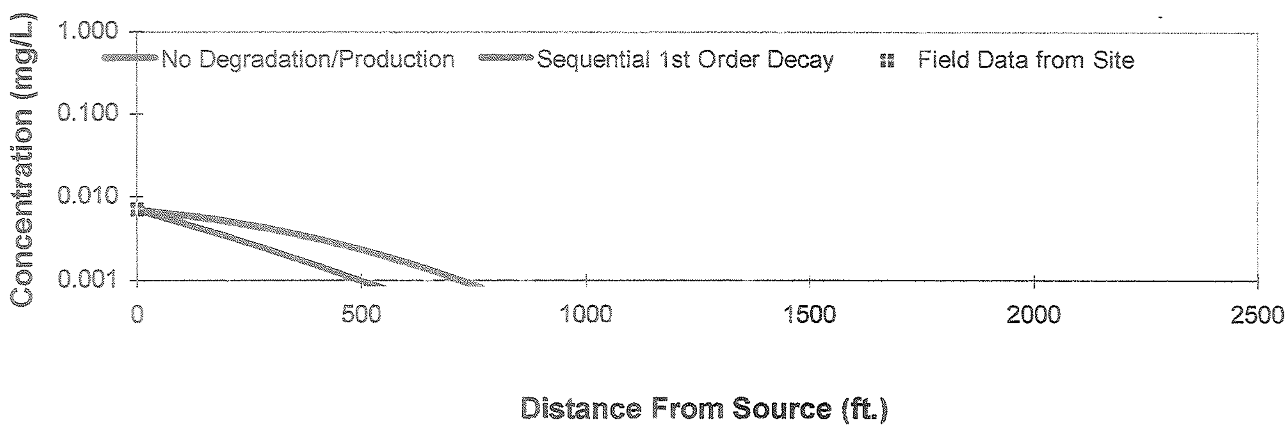
To Array

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

TCA

	Distance from Source (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.007	0.005	0.003	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Biodegradation	0.007	0.003	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Monitoring Well Locations (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Field Data from Site	0.007										



See TCA

See DCA

See CA

Log ⟺ Linear

Time: *20 Years*

Return to Input

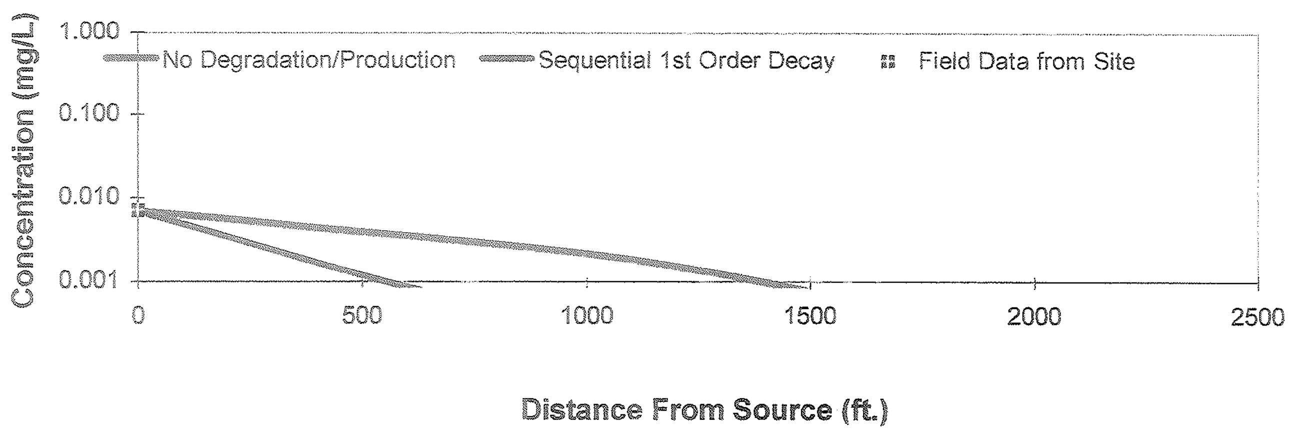
To All

To Array

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE

TCA	Distance from Source (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
No Degradation	0.007	0.006	0.004	0.004	0.003	0.002	0.002	0.001	0.001	0.000	0.000
Biodegradation	0.007	0.003	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Monitoring Well Locations (ft)										
	0	200	400	600	800	1000	1200	1400	1600	1800	2000
Field Data from Site	0.007										



See TCA

See DCA

See CA

Log ⟺ Linear

Time:

50 Years

Return to Input

To All

To Array