6627

BASELINE

ENVIRONMENTAL CONSULTING

31 May 2001
98381-B0

JUN 05 2001

Ms. Ann E. Johnston
Coblentz, Patch, Duffey, & Bass, LLP
222 Kearny Street, 7th Floor
San Francisco, CA 94108-4510

Subject: Work Plan for Continued Subsurface Quality Investigation, 6623 San Pablo Avenue, Oakland, California

Dear Ann:

In response to your request, BASELINE has developed a scope of work for continued investigation of the soil and groundwater quality at the subject site (Figure 1). The scope of work has been prepared in response to the request for additional information and analysis by Mr. Barney Chan of the Alameda County Health Care Services Agency (County). Mr. Chan's concerns regarding the project site were identified in a letter dated 23 April 2001. Specifically, the letter requested the following:

1) *Submittal of historic aerial photographs and Sanborn Fire Insurance Maps referred to in BASELINE's 9 November 1998 Work Plan for Environmental Investigation, 6623 San Pablo Avenue, Oakland, California.*

   The requested photos and maps have been submitted under separate cover.

2) *An explanation of the apparent inconsistency in the groundwater flow direction of the uppermost water-bearing unit at the site.*

   The first flow direction calculation (from May 1999) indicated groundwater flow was to the southwest (S52W)(Table 1). Each of the five subsequent flow direction calculations (over the past one and one-half years) have been relatively consistent (ranging between S23E and S55E). It is not known why the first calculated flow direction differed by approximately 90 degrees from the more recent average flow direction. Please note that according to our data, no variation of "nearly 180 degrees" has been identified, as described in the letter from the County. how about 107° then?

3) *Additional characterization of the extent of the petroleum hydrocarbon plume identified on-site, including determination of the source of the MTBE, to the extent feasible.*

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Emeryville Petaluma San Francisco

The following work plan has been developed to address this request. The County letter states that "The elevated concentration of MTBE is unexpected since the former underground tanks were presumed removed in the late 1970s prior to its usage." We agree that the it appears unlikely that identified on-site land uses are likely responsible for the presence of MTBE at the site. The gasoline station formerly located at the site ceased operation prior to 1969 and MTBE was not introduced as a fuel additive in the U.S. until 1979[1,2]. The site has been operated as a McDonald's restaurant since 1971, and does not use or store MTBE-containing products.

WORK PLAN

The lateral extent of petroleum hydrocarbons in the soil and groundwater at the project site is has not been defined by the historic soil borings and existing monitoring well network (Figure 2; Tables 2 and 3). The vertical extent of contamination has been adequately defined by two wells (MW-1B and MW-3B) which are screened in a lower water-bearing zone (at a depth of approximately 25 to 30 feet below ground surface). The distribution of petroleum hydrocarbons at the site is difficult to explain with the available data. An apparent "hotspot" occurs in the vicinity of MW-1A. This hotspot appears to be limited in extent to the north and south since samples collected from nearby soil borings KB-8 and KB-11 contained little or no petroleum hydrocarbons (Figure 2). However, soil and groundwater samples collected from other portions of the site were found to contain elevated levels of contaminants.

Based on the existing data, BASELINE proposes to conduct a passive soil gas survey at the project site to address the following issues:

- Evaluation of the lateral extent of petroleum affected soil and groundwater; but cannot distinguish whether its from Soil or G-W
- Definition of the concentration gradient for detected petroleum hydrocarbons in shallow soils and water, and
- Evaluation of the possible influence of buried channels and/or coarse-grained lenses on the distribution of contamination.

Passive soil gas surveys are effective in defining source areas of chemical releases and delineation of plumes of volatile compounds in soil and groundwater. Passive gas surveys have been proven successful in defining the distribution of groundwater plumes even when the concentrations of

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[1] U.S. Environmental Protection Agency, 2001, MTBE Overview, http://www.epa.gov.gov/mtbe/faq.htm.

[2] American Petroleum Institute, 1998, 10 Frequently Asked Questions About MTBE in Water *in* The Newsletter of the Association of Groundwater Scientists and Engineers, National Groundwater Association, vol. 14, no. 3.

volatile chemicals in groundwater are relatively low. In comparison with active soil gas surveys (where soil gas actively pumped from the subsurface), passive soil surveys are effective in low permeability environments. The conditions at the project site, including low permeability surface soils, indicate that the use of passive soil gas survey techniques in this situation may be appropriate..

The passive soil gas survey would be performed through installation of 31 soil gas collector probes (GORE-SORBER Modules). The probes contain a chemically inert expanded polytetrafluoroethylene membrane (GORE-TEX). The membrane is microporous and hydrophobic which facilitates the efficient absorption of soil gas. The probes would be installed by BASELINE to a depth of approximately three feet below the existing ground surface at the locations shown in Figure 3. The probe locations were established by the use of a uniform grid with a node spacing of approximately 25 feet.

why 3'

Prior to installation of the probes, a pilot hole would be driven through the surface and a steel rod driven to a depth of three feet. Following extraction of the steel rod, a GORE-SORBER Module would be placed in the pilot hole. The pilot hole would be sealed with a cork counter-sunk cap to prevent material from falling into the pilot hole. The steel rod would be decontaminated prior to use at each probe location.

The GORE-SORBER Modules would be left in place for 7-14 days. At that point, a BASELINE geologist would extract each module. The retrieved modules would be placed in a glass jar supplied by the manufacturer. The jars would be labeled and placed in a cooler. The samples would be shipped under chain-of-custody to W.L. Gore & Associates laboratories in Elkton, Maryland. The probes would be analyzed by gas chromatography/mass spectroscopy for petroleum hydrocarbon content (including BTEX and MTBE). The results of the analysis would provide a "relative amount" of the analytes based on the mass of the analytes detected. These results would be presented as laboratory reports and in graphics depicting contouring of the "relative amount" of benzene and MTBE from each location. Additional information regarding the passive gas sampling technique is included in Attachment A.

what about T

Following completion of the passive soil gas survey, BASELINE would prepare a summary report describing the outlined field activities and the results of analytical testing of soil gas probes. It is anticipated that the soil gas survey may provide additional information regarding the potential source areas of petroleum hydrocarbon contamination and provide the basis for additional recommendations, as necessary, for additional off-site subsurface investigation. Based on the relatively consistent concentrations of petroleum hydrocarbons identified in the on-site wells in the last two years of quarterly monitoring, we recommend that additional routine monitoring of the on-site wells be temporarily discontinued until after completion of proposed additional site investigation.

No.

Please call us if you have any questions or comments regarding this work plan. A copy of the work plan has been directly submitted to Mr. Barney Chan of the County. Following approval of the work plan, BASELINE would promptly schedule the field work.

Sincerely,

Bruce Abelli-Amen
Senior Hydrogeologist

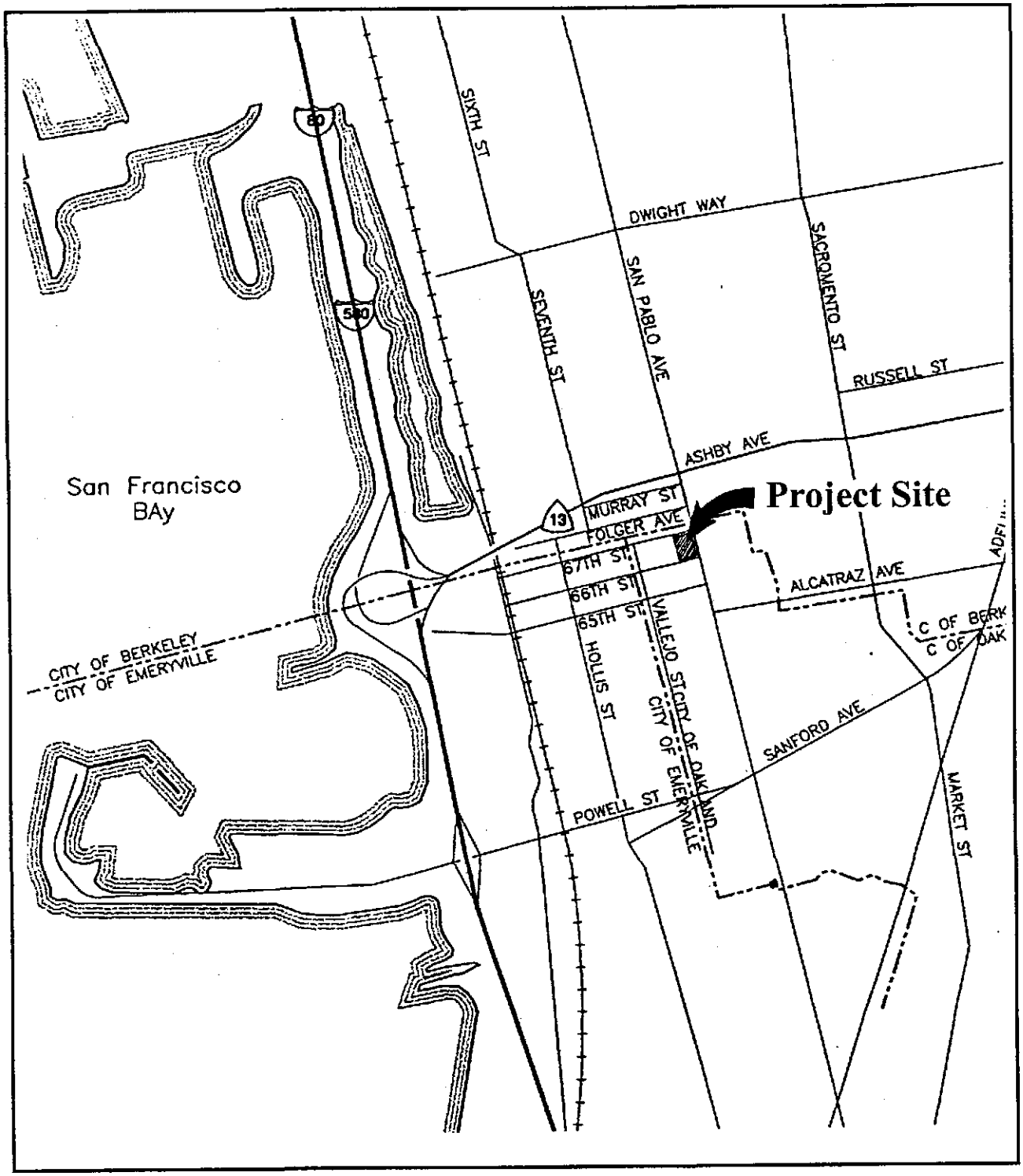
Yane Nordhav
Principal

BAA:YN:km
Attachment

cc: Ms. Helen Loreto, McDonalds Corporation
Mr. Barney Chan, Alameda County Environmental Health Services

REGIONAL LOCATION

Figure 1



6623 San Pablo Avenue
Oakland, California

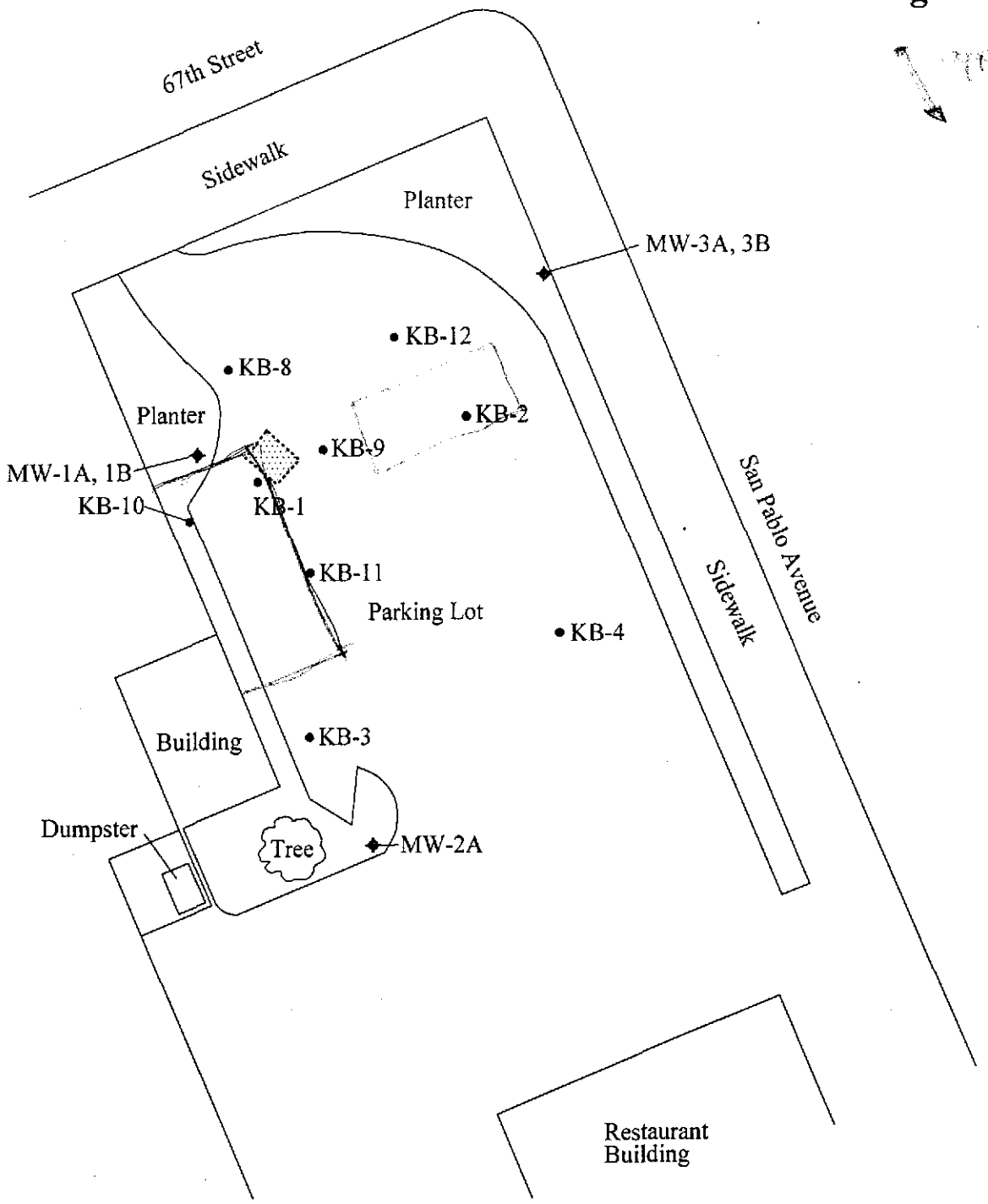
0 2000 Feet

BASELINE

98381RL 6/24/98

SITE PLAN

Figure 2



Legend

Location of Geophysical Anomally (two borings installed within the bounds of mapped anomally to confirm that no UST is present)

B-1 • Soil Boring Location (Kleinfelder)

MW-2A ✦ Monitoring Well Location (BASELINE)

6623 San Pablo Avenue
Oakland, California

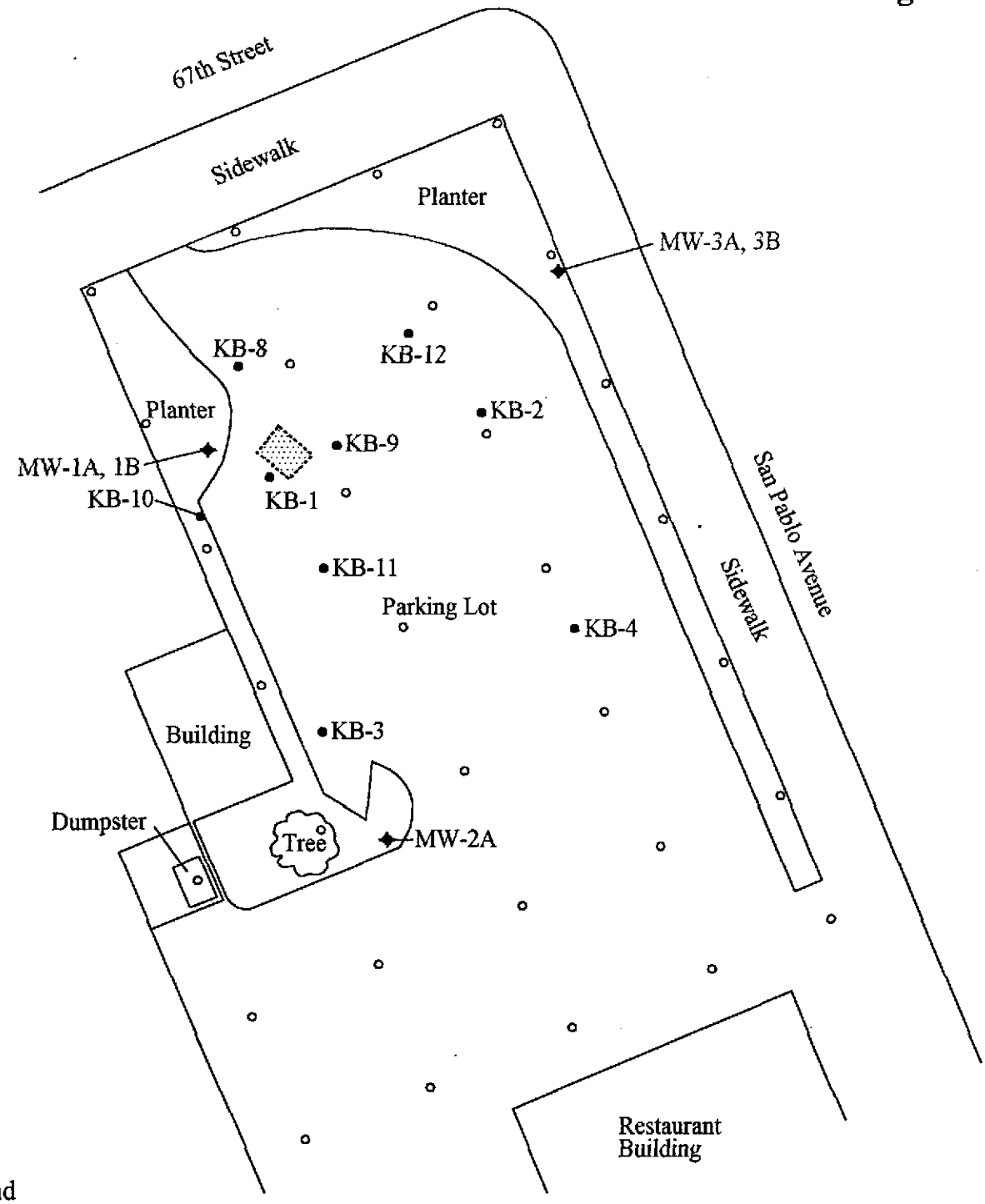
0 30 Feet

BASELINE

D:\Graphics\98381\Site Plan II.vcd 2/24/99

PROPOSED SAMPLING LOCATIONS

Figure 3



Legend

- Location of Geophysical Anomally (two borings installed within the bounds of mapped anomally to confirm that no UST is present)
- B-1 • Soil Boring Location (Kleinfelder)
- MW-2A ✦ Monitoring Well Location (BASELINE)
- ○ Proposed Passive Soil Gas Sampling Location

6623 San Pablo Avenue
Oakland, California

0 30 Feet

BASELINE

D:\Graphics\98381\Fig-3 Proposed Sampling Locations 5/21/01

TABLE 1
GROUNDWATER ELEVATIONS AND GRADIENT MAGNITUDES
6623 San Pablo Avenue, Oakland

	MW-1A[1]			MW-1B[2]			MW-2A[3]			MW-3A[4]			MW-3B[5]			Gradient[8]
Date	Time	Depth to Ground-water[6]	Ground-water Elevation[7]	Time	Depth to Ground-water[6]	Ground-water Elevation[7]	Time	Depth to Ground-water[6]	Ground-water Elevation[7]	Time	Depth to Ground-water[6]	Ground-water Elevation[7]	Time	Depth to Ground-water[6]	Ground-water Elevation[7]	feet/foot
1/15/99	12:44	Dry	--	12:44	21.60	18.35	12:52	7.15	31.77	12:50	7.0	32.76	12:50	22.50	17.29	--
1/19/99	8:11	Dry	--	8:11	9.10	30.85	8:17	7.32	31.60	8:13	7.27	32.49	8:14	8.77	31.02	--
1/19/99	16:58	Dry	--	16:55	26.81[9]	13.14	17:82	7.05[9]	31.87	17:08	7.79[9]	31.97	17:11	26.71[9]	13.08	--
1/20/99	8:46	Dry	--	8:43	16.76	23.19	8:50	6.94	31.98	8:55	7.18	32.58	8:58	15.40	24.39	--
1/20/99	17:48	Dry	--	17:44	13.48	26.47	17:51	6.89	32.03	17:56	7.04	32.72	17:58	12.50	27.29	--
2/8/99	7:45	Dry	--	7:42	10.74	29.21	7:50	6.80	32.12	6:48	5.45	34.31	6:45	6.82	32.97	--
2/12/99	6:54	9.10	30.86	--	--	--	6:58	6.90	32.02	7:04	5.94	33.82	--	--	--	--
5/18/99	12:05	8.42	31.54	12:24	9.09	30.86	12:25	7.77	31.15	12:02	6.78	32.98	12:03	8.65	31.14	S52°W@0.02
8/9/99	11:09	4.69	35.27	11:10	9.10	30.85	11:18	7.34	31.58	11:14	4.30	35.46	11:13	8.23	31.56	S23°E@0.0038
11/5/99	8:00	5.23	34.73	8:02	9.15	30.80	8:10	7.43	31.49	8:06	5.87	33.89	8:08	8.37	31.42	S40°E@0.042
9/19/00	10:30	5.53	34.43	10:33	9.36	30.59	9:55	8.13	30.79	10:50	7.10	32.66	10:49	9.71	30.08	S53°E@0.026
1/5/01	11:16	6.62	33.34	11:14	9.39	30.56	11:25	8.13	30.79	11:18	7.30	32.46	11:17	8.55	31.24	S43°E@0.03

Notes: Monitoring well locations are shown on Figure 2.
-- = Not collected / Not determined.
The water level data collected on 20 January and 8 and 12 February 1999 indicate that the water levels had not stabilized in either the shallow or deeper wells on the site.

[1] Top of well casing elevation = 39.96 feet above City of Oakland datum.
[2] Top of well casing elevation = 39.95 feet above City of Oakland datum.
[3] Top of well casing elevation = 38.92 feet above City of Oakland datum.
[4] Top of well casing elevation = 39.76 feet above City of Oakland datum.
[5] Top of well casing elevation = 39.79 feet above City of Oakland datum.
[6] Depths are in feet below top of casing.
[7] Elevations are in feet above City of Oakland datum.
[8] Gradient direction and magnitude based on MW-1A, MW-2A, MW-3A
[9] Water level measurements were collected after removal of one well volume on 19 January 1999.

TABLE 2
SUMMARY OF ANALYTICAL RESULTS, SOIL
6623 San Pablo Avenue, Oakland
(mg/kg)

Sample ID	Sample Depth (feet)	Date	Diesel[1,2]	Gasoline[1]	Total Lead[3]	Benzene[4]	Toluene[4]	Ethyl-benzene[4]	Xylenes[4]	MTBE[4]
KB-1[5]	8.5	9/23/96	1,000	4,600	--	13	27	49	230	--
KB-2[5]	10.5	9/23/96	160	220	--	2.1	0.4	2.1	8	--
KB-3[5]	7.0	9/23/96	160	370	--	0.91	0.87	2.8	6.8	--
KB-4[5]	10.5	9/23/96	1.3	5.2	--	1.1	0.009	0.31	0.099	--
KB-8[5]	8-10	2/5/97	6.4[6,7]	<1	5.7	<0.005	<0.005	<0.005	<0.005	--
	13-15	2/5/97	<1	<1	--	<0.005	<0.005	<0.005	<0.005	--
KB-9[5]	8.0-8.5	2/5/97	27[6,7]	380	6.5	<0.5	1.2	3.6	8.9	--
KB-9[5]	14-14.5	2/5/97	<1	<1	--	<0.005	<0.005	<0.005	<0.005	--
KB-10[5]	8-9	2/5/97	76[6,7]	1,900[6,8]	7.4	<0.5	3.8	16	56	--
KB-10[5]	14-16	2/5/97	<1	<1	--	<0.005	<0.005	<0.005	<0.005	--
KB-11[5]	8-10	2/5/97	<1	<1	4.3	<0.005	<0.005	<0.005	<0.005	--
KB-11[5]	13-15	2/5/97	<1	<1	--	<0.005	<0.005	<0.005	<0.005	--
KB-12[5]	8-10	2/5/97	5[6,9]	69[6,8]	5.3	<0.13	<0.13	0.34	0.28[12]	--
KB-12[5]	13-15	2/5/97	<1	<1	--	<0.005	<0.005	<0.005	<0.005	--
MW-1[11]	7.0-7.5	1/14/99	67[6,9]	2,800	--	2.9[10]	4.2	24	79	5.4
	10.0-10.5		3.1[6,9]	170	--	<0.025	<0.025	1.4	29.5	1.1
	15.0-15.5		13[6,9]	<1	--	<0.005	<0.005	<0.005	<0.005	0.022
MW-2[11]	5.5-6.0	1/14/99	9[6,9]	<1	--	<0.005	<0.005	<0.005	<0.005	<0.02
	10.0-10.5		12[6,7]	340	--	0.37	0.44[10]	4.7	20.1	0.41
	16.0-16.5		2.5[6,9]	<1	--	<0.005	<0.005	<0.005	0.0056	0.087
MW-3[11]	5.0-5.5	1/14/99	1.6[6,9]	<1	--	<0.005	<0.005	<0.005	<0.005	<0.02
	10.0-10.5		23[6,7,8]	340	--	0.66	5.7	6.4	26.6	2.1
	15.0-15.5		5.3[6,9]	<1	--	<0.005	<0.005	<0.005	<0.005	<0.02

TABLE 2 - *continued*

Notes: <x.x = Compound not detected above laboratory reporting limit of x.x. (e.g. <1.0 indicates that the constituent was not present in the sample above 1.0 mg/kg)
x.x = Compound reported at indicated concentration.
-- = Not analyzed.
Soil sampling locations are shown on Figure 2.
Laboratory reports for 1999 analytical results are included in Appendix F

[1] Analyzed using EPA Method 8015M.
[2] Samples analyzed in 1999 for TPH as diesel were subjected to a silica gel cleanup prior to analysis.
[3] Analyzed using EPA Method 6010A.
[4] Samples collected in 1996 and 1997 were analyzed by EPA Method 8020; samples collected in 1999 were analyzed by EPA Method 8021 B.
[5] Samples collected by Kleinfelder, Inc.
[6] The laboratory indicated that the sample chromatogram exhibited a fuel pattern which does not resemble the standard.
[7] The laboratory indicated that the sample chromatogram contained hydrocarbons that were lighter than the standard.
[8] The laboratory indicated that the sample chromatogram contained heavier hydrocarbons than the indicated standard.
[9] The laboratory indicated that the sample chromatogram contained unknown single peak or peaks.
[10] Laboratory indicated that presence of this compound was confirmed by second column; however, the confirmation concentration differed from the reported result by more than a factor of two.
[11] Samples collected by BASELINE.
[12] The sample contained 0.28mg/kg of m,p-xylenes; o-xylene was not identified in the sample at concentrations above 0.13mg/kg.

TABLE 3
SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER
6623 San Pablo Avenue, Oakland
(mg/L)

Sample ID	Date	Diesel[1]	Gasoline[1]	Total Lead[2]	Benzene[3]	Toluene[3]	Ethyl-benzene[3]	Xylenes[3]	MTBE[3]	MTBE Confirmation[4]
Grab Groundwater Samples from Borings:										
KB-8	2/5/97	**0.86**	**0.12**	<0.003	**0.0013**	<0.0005	**0.0021**	**0.001**	--	--
KB-9	2/5/97	<0.05	**0.47**	<0.003	**0.0048**	<0.0005	**0.011**	**0.0183**	--	--
KB-10	2/5/97	**3.1**	**0.45**	<0.003	**0.03**	**0.0036**	**0.013**	**0.071**	--	--
KB-11	2/5/97	**0.97**	**0.82**	<0.003	**0.1**	**0.0022**	**0.028**	**0.129**	--	--
KB-12	2/5/97	**0.20**	**0.096**	<0.003	**0.02**	<0.0005	**0.005**	**0.0122**	--	--
Groundwater Samples From Monitoring Wells										
MW-1A	2/8/99[5]	--	--	--	--	--	--	--	--	--
	5/21/99	**0.56**[6]	**19**	--	**6.7**	**0.12**	**1.2**	**3.28**	**38**	--
	8/11/99	**0.63**[6]	**14**	--	**3.9**	<0.1	**0.68**	**1.65**	**40**	--
	11/8/99	**0.36**[6]	**15**	--	**4.3**	<0.13	**0.78**	**1.3**	**42**	--
	9/20/00	--	**14**	--	**4.0**	**0.063**	**0.45**	**0.66**	**47**	**48**
	1/5/01	--[5]	**20**	--	**4.0**	**0.054**	**0.66**	**1.1**	**36**	--[8]
MW-1B	2/8/99	<0.049	**0.059**	--	**0.0013**	<0.0005	**0.0055**	**0.14**	**0.033**	--
	5/21/99	<0.05	<0.05	--	**0.00066**	<0.0005	<0.0005	<0.0005	**0.0041**	--
	8/11/99	<0.05	<0.05	--	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	--
	11/8/99	<0.05	<0.05	--	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	--
	9/20/00	--	<0.05	--	<0.0005	<0.0005	<0.0005	<0.0005	**0.0035**	**0.002**
	1/5/01	--	<0.05	--	<0.0005	<0.0005	<0.0005	<0.0005	**0.0039**	--[8]
MW-2A	2/8/99	**0.53**[7]	**3.6**	--	**0.87**	**0.079**	**0.14**	**0.58**	**5.1**	--
	5/21/99	**0.064**[6]	**0.91**	--	**0.62**	**0.018**	**0.038**	**0.078**	**4.0**	--
	8/11/99	**0.130**[6]	**1.4**	--	**0.96**	**0.032**	**0.065**	**0.093**	**4.0**	--
	11/8/99	**0.116**	**2.5**	--	**1.1**	**0.033**	**0.081**	**0.142**	**4.1**	--
	9/20/00	--	**2.5**	--	**0.98**	**0.033**	**0.073**	**0.178**	**6.6**	**4.6**
	1/5/01	**0.25**[6]	**3.5**	--	**0.56**	**0.022**	**0.090**	**0.390**	**4.1**	--[8]

Table 3 - *continued*

Sample ID	Date	Diesel[1]	Gasoline[1]	Total Lead[2]	Benzene[3]	Toluene[3]	Ethyl-benzene[3]	Xylenes[3]	MTBE[3]	MTBE Confirmation[4]
MW-3A	2/8/99	**0.21**[7]	**24**	--	**2.1**	**3.4**	**1.5**	**6.1**	<0.05	--
	5/21/99	**0.23**[6]	**17**	--	**3.5**	**3.1**	**0.85**	**3.6**	**0.077**	--
	8/11/99	**0.80**[6]	**68**	--	**7.4**	**6.8**	**2.9**	**11.6**	<0.2	--
	11/8/99	**0.47**[6]	**55**	--	**5.8**	**5.4**	**2.5**	**10.4**	<0.08	--
	9/20/00	--	**1.8**	--	**0.17**	**0.13**	**0.082**	**3.09**	<0.002	**0.0019**
	1/5/01	--[5]	**1.8**	--	**0.26**	**0.18**	**0.082**	**0.320**	<0.010	--
MW-3B	2/8/99	<0.047	**0.08**	--	**0.0015**	**0.0048**	**0.0025**	**0.0061**	**0.00455**	--
	5/21/99	<0.05	<0.05	--	<0.0005	<0.0005	<0.0005	**0.00057**	<0.002	--
	8/11/99	<0.05	<0.05	--	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	--
	11/8/99	<0.05	<0.05	--	<0.0005	<0.0005	**0.00059**	<0.0005	<0.002	--
	9/20/00	--	<0.05	--	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	<0.0005
	1/5/01	--	<0.05	--	<0.0005	<0.0005	<0.0005	<0.0005	<0.002	--

Notes: <x.x = Compound not detected above laboratory reporting limit (e.g., <0.05 indicates that the constituent was not present in the sample above 0.05 mg/L).
x.x = Compound detected at indicated concentration.
-- = Not analyzed.
Groundwater sampling locations are shown on Figure 2.
Laboratory reports for January 2001 sampling event are included in Appendix B.

1 Analyzed using EPA Method 8015M with silica gel cleanup (EPA Method 3520) for diesel analyses.
2 Analyzed using EPA Method 6010A.
3 Analyzed using EPA Method 8020 or 8021B.
4 Analyzed using EPA Method 8260B.
5 Insufficient groundwater in well to allow sample collection.
6 Sample exhibits a fuel pattern which does not resemble standard; lighter hydrocarbons were exhibited than the indicated standard.
7 The chromatograms for these samples suggest that the concentrations quantified as diesel may be in the gasoline range of hydrocarbons; the laboratory also indicates that the samples exhibit patterns lighter than diesel.
8 MTBE confirmation by EPA Method 8260B not performed because the September 2000 monitoring event indicated that Method 8021B provided representative results.

ATTACHMENT A

PASSIVE GAS SAMPLING METHODOLOGY

THE FOLLOWING PAGES DOCUMENT A REVOLUTION. A REVOLUTION THAT STARTED WITH GORE-TEX® MEMBRANE—THE INSPIRATION BEHIND A NEW GENERATION OF HIGHLY EFFECTIVE SOIL GAS SCREENING TECHNOLOGY. YOU'LL LEARN ABOUT THE UNIQUE PROPERTIES OF GORE-SORBER® MODULES—AND WHY THEY ARE SENSITIVE ENOUGH TO DETECT BOTH VOLATILE AND SEMI-VOLATILE ORGANIC COMPOUNDS, AND VERSATILE ENOUGH TO PERFORM WELL IN CLAYS AND SATURATED SOILS. AND WE WILL

THE REVOLUTION BEGINS BENEATH YOUR FEET

DEMONSTRATE HOW OUR ATTENTION TO HIGH QUALITY METHODS AND PRACTICES ENSURES CONSISTENTLY RELIABLE AND REPRODUCIBLE RESULTS, EVERY STEP OF THE WAY.

FINDING HIDDEN ANSWERS

Impact to ground water and soil quality from organic compounds is of widespread concern throughout the world. The most common method of investigating the extent of contamination at impacted sites is analysis of samples from monitoring wells and soil borings. Results from this type of testing provide the quantitative data that is typically required to evaluate site environmental risks. However, the use of borings and wells for investigative purposes can be expensive and may result in an incomplete delineation of the problem due to limited sampling points.

Soil Gas

Soil gas measurements have proven to be successful predictors of actual measurements of organic compounds in soil and ground water[1]. Virtually all volatile organic and several semi-volatile organic compounds are present in the soil as a gas due to their vapor pressure and solubility[2]. By measuring the amount and composition of these gases, the source areas and ground water plumes can be delineated. Soil gas investigations, used in conjunction with actual soil and ground water sampling, can provide a more thorough and cost-effective site investigation than borings and well samples alone. This shifts the primary role of soil and ground water sampling to confirmation rather than investigation.

Historically, the most common type of soil gas measurement has been made by actively pumping a sample from the subsurface, analyzing it and mapping the results. Although this method can provide fast results it is limited to detection of only the most volatile organics and on sites with relatively high soil permeability.

Passive Soil Gas

Passive soil gas techniques provide a more sensitive and representative means of measuring soil gases. Typically, passive methods involve integrated sampling over time and collection of the sample on an adsorbent material. This combination provides high sensitivity to volatile as well as semi-volatile organics, allows for success on sites with low soil permeability and minimizes fluctuations in soil gas availability due to changing ambient and subsurface conditions. Also, passive soil gas sampling does not disrupt the natural equilibrium of vapors in the subsurface, as is the case with active sampling methods.

All of these considerations contribute to the increasing application and acceptance of passive soil gas surveys around the world.

Factors Influencing a Soil Gas Survey

① Target Chemistry

Vapor Pressure & Henry's Law
Volatile organic compounds are most easily detected by soil gas techniques[1]. However, detection of dissolved phase constituents is primarily governed by Henry's Law[1] which describes the air/water partitioning of hydrocarbons as a function of solubility and vapor pressure. Heavy organic compounds with lower vapor pressures, like PAHs can also be detected by passive soil gas methods.

Specific Gravity -LNAPL/DNAPL (Light Non-Aqueous Phase Liquids/ Dense Non-Aqueous Phase Liquids)
Although LNAPLs are more easily detected in soil gas surveys, DNAPL constituents have also been successfully found using these technologies. However, detection of DNAPLs is dependent on their path through the subsurface and their associated dissolved phase components.

② Survey Design

Sample Depth
Soil gas samples should be deep enough to avoid background contamination from surface spills or exhaust. Installations directly beneath concrete or paved surfaces should also be to a depth below the zone of lateral migration of soil gas to avoid misleading results. Depths of at least 2-3 feet are typically sufficient to insure good sampling.

Sample Spacing
Spacing is largely dictated by survey objectives and site conditions. A 25-75 ft. sample spacing typically allows for meaningful contouring of soil gas survey results.

Sampling Strategy
Use of grids, transects or random patterns is primarily dependent on the overall objective and understanding of site specific factors including soil and ground water conditions.

③ Hydrogeologic Conditions

Ground Water Depth & Gradient
Detection of dissolved organics in ground water depends upon their diffusion from the saturated zone, through the capillary fringe and into the vadose zone where samples are typically collected[1]. Successful detection is impacted by the length of this migration and to dilution and adsorption onto soil particles.

Contours of soil gas data often reveal direction of the ground water gradient.

Soil Permeability
Permeability has significant impact on vapor migration and detection.

Active soil gas methods are limited to sites with favorable permeability. Some passive methods can be applied in tight soils such as clays and silts with low air-filled porosity, as well as directly into the saturated zone.

④ Site History

Chemical Storage, Handling & Use
Understanding site history and practices helps define the chemicals of concern, probable source areas and fate and transport mechanisms of releases.

COMMON APPLICATIONS FOR PASSIVE SOIL GAS SURVEYS

- Refineries & Fuel Storage Terminals
- Fire Training Areas
- Manufactured Gas Plants
- Railroad Sites
- Low Permeability Soils
- Solvent Manufacturing & Dry Cleaners
- Airports
- Remedial System Monitoring & Siting
- Military Sites
- Property Transfers
- Landfills

COMMON MIXTURES DETECTED BY PASSIVE SOIL GAS SURVEYS

- Solvents/degreasers
- Fuel additives
- Gasoline
- Diesel fuel
- Jet fuel
- Heating oils
- Heavy oils & lubricants
- Coal tars
- Explosives

GORE-SORBER® Screening Surveys

The GORE-SORBER Screening Survey is a comprehensive soil gas survey developed by W. L. Gore & Associates, Inc. (Gore). This service features unique sensing elements, the GORE-SORBER Modules, analysis of the modules and a final report of results including color contour maps. Gore's staff also provides support in survey design and discussion of results.

The following is a sequential description of how a typical survey is carried out:

① The GORE-SORBER Screening Survey Final Report includes analytical results presented in tabular format and as color contour overlays on a CAD map of the site.

Survey Design

The objectives of the survey and the site description and history are discussed with Gore's staff. Based on this information the sampling strategy, location and number of sampling points are recommended.

GORE-SORBER Modules

Modules and an installation kit are shipped to clients in coolers to the destination specified by the client.

② As each GORE-SORBER Module is removed from its sample container, the serial number and corresponding site identification number are noted on the Gore Chain-of-Custody form and on the site map.

Module Installation/Retrieval

Based on the survey design, modules are installed in the field by the client's personnel. After exposure to the subsurface for the recommended time, modules are retrieved from the pilot holes, returned to their original sample container and placed in the cooler which is then shipped back to Gore's laboratory.

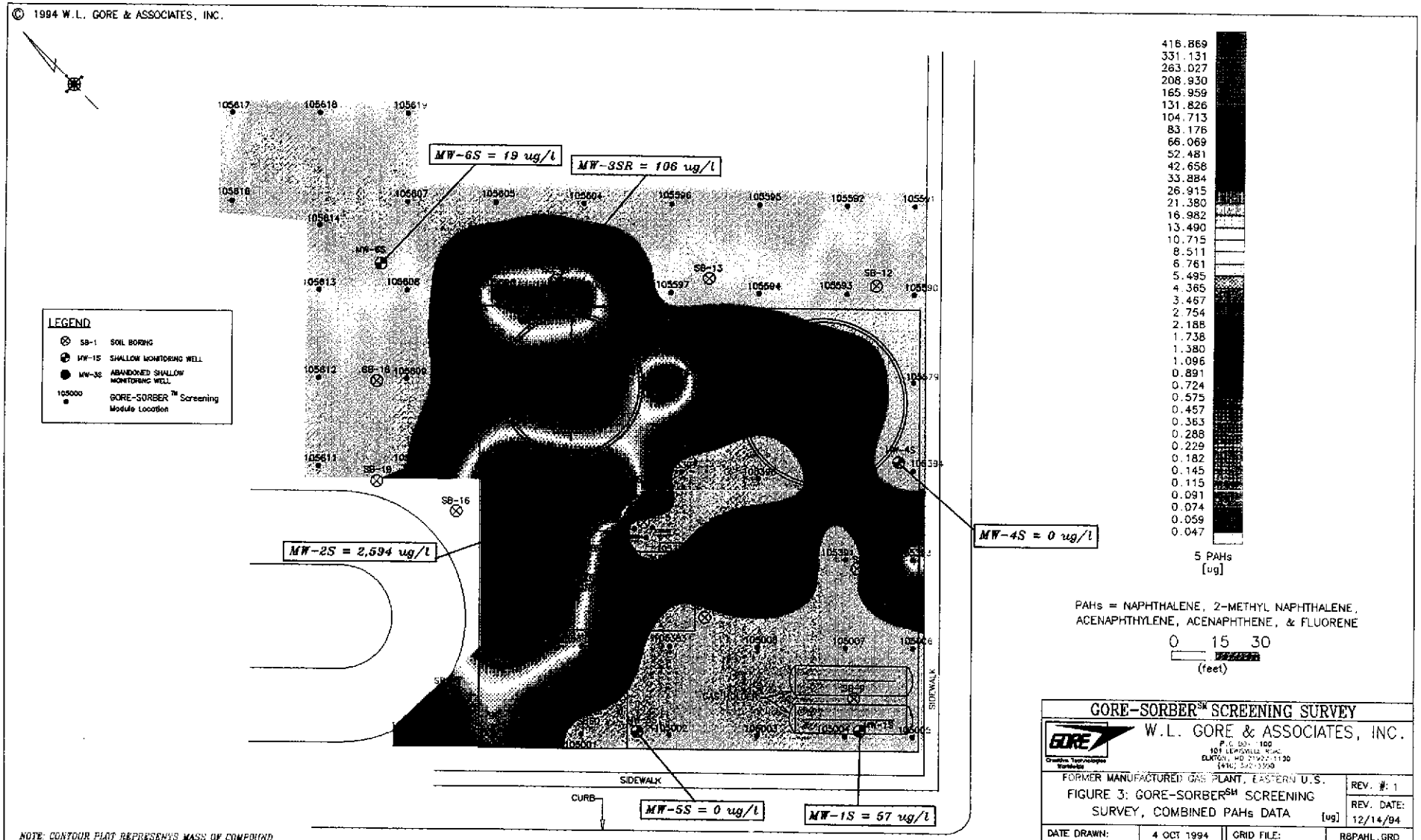
Analysis

After sample check-in, the modules are stored in a freezer until analysis. Typically, the modules are desorbed and samples are analyzed via gas chromatography/mass spectroscopy. Quality Assurance (QA) protocols are followed based on Gore's QA Manual and the client's choice of QA Screening Procedures available from Gore. Results for standardized target compounds or non-standard analytes are typically presented in terms of mass recovered per sorber. Matches to Gore's fluids library or client-supplied samples can also be made.

Final Report

The GORE-SORBER Screening Survey Final Report is the deliverable document to the client. It includes analytical results in tabular format and as color contour overlays on client-supplied site CAD maps. Survey conclusions, chain-of-custody forms and any pertinent QA information are also included. Gore's staff is available for post-survey discussion of results to assist the client in understanding how surveys may be interpreted.

④ The hole is sealed off at the surface with a cork that has been secured to the insertion/retrieval cord and then marked for retrieval purposes.



NOTE: CONTOUR PLOT REPRESENTS MASS OF COMPOUND DESORBED FROM GORE-SORBER® SCREENING MODULES, IDENTIFIED AND QUANTIFIED BY GAS CHROMATOGRAPH MASS SELECTIVE DETECTION

GORE-SORBER℠ SCREENING SURVEY

W.L. GORE & ASSOCIATES, INC.

FORMER MANUFACTURED GAS PLANT, EASTERN U.S.

FIGURE 3: GORE-SORBER℠ SCREENING SURVEY, COMBINED PAHs DATA [ug]

REV. #:	1		
REV. DATE:	12/14/94		
DATE DRAWN:	4 OCT 1994	GRID FILE:	RBPAHL.GRD
DRAWN BY:	JH	PLOT FILE:	WELLFNL.PLT
DATE GRIDDED:	14 DEC 1994	PROJECT NUMBER:	
GRIDDED BY:	JH	SITE CODE:	SITE_CZ
ORIG. CAD:			