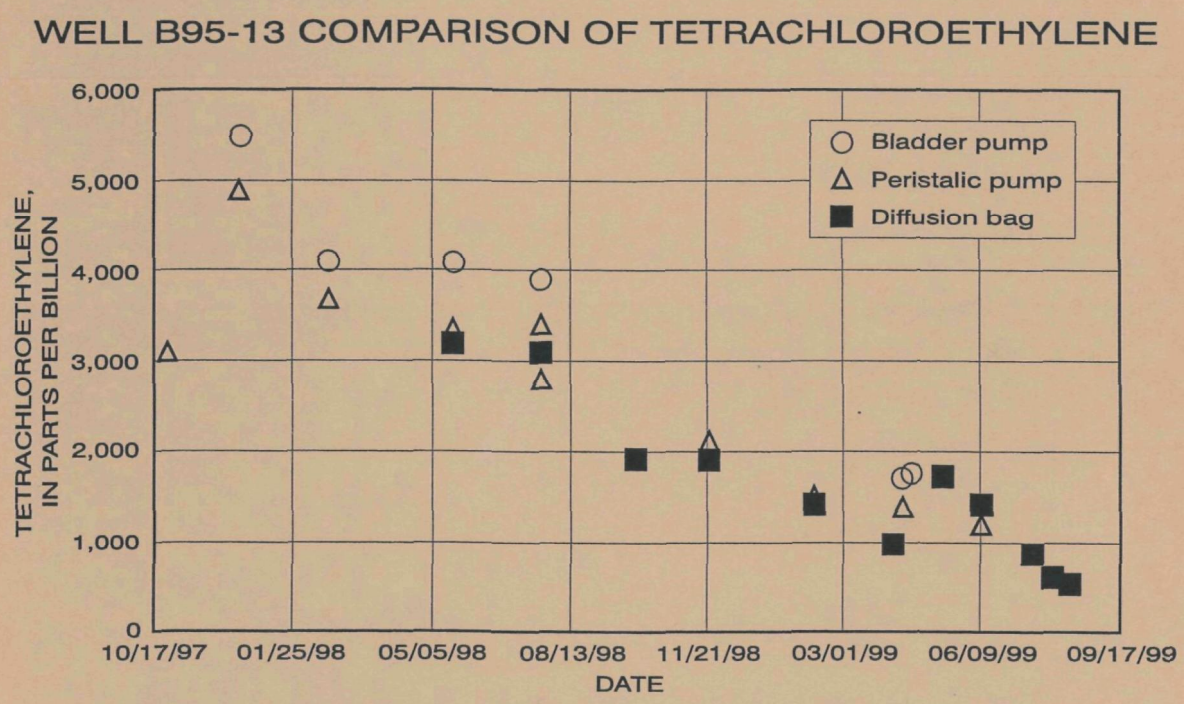
In Cooperation with the
New Hampshire Department of Environmental Services and the
U.S. Environmental Protection Agency, Region 1

Testing and Application of Water-Diffusion Samplers to Identify Temporal Trends in Volatile-Organic Compounds

U.S. Geological Survey Open-File Report 00-196



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The graph on the cover shows that the concentration of tetrachloroethylene (PCE) in ground-water samples collected with a diffusion sampler are comparable to concentrations in samples collected by other sampling devices.

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By Philip T. Harte, Michael J. Brayton, Wayne Ives, Sharon Perkins, and Carroll Brown Jr.

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Pembroke, New Hampshire
2001

U.S. Department of the Interior

Bruce Babbitt, Secretary

U.S. Geological Survey

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.590	square kilometer
	Volume	
cubic foot (ft^3)	0.02832	cubic meter
gallon (gal)	3.785	liter
	Flow	
cubic feet per second (ft^3/s)	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06308	liter per second
million gallons per day (Mgal/d)	0.04381	cubic meter per second
million gallons per day (Mgal/d)	1.547	cubic feet per second (cfs)
	Hydraulic Conductivity	
foot per day (ft/d)	0.3048	meter per day

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:
°C = 5/9 (°F - 32).

Vertical Datum: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

ABBREVIATIONS AND EXPLANATIONS OF TERMS USED IN THIS REPORT:

VOC	volatile organic compound
PCE	tetrachloroethylene
TCE	trichloroethylene
cis-1,2DCE	*cis*-1,2-dichloroethene
ppm	parts per million [In this report, ppm is equivalent to milligrams per liter]
ppb	parts per billion [In this report, ppb is equivalent to micrograms per liter]
yr	year
min	minute
DNAPL'S	dense non-aqueous phase liquids
VC	vinyl chloride
TOC	total organic carbon
PID	photoionization detector
PVC	polyvinyl chloride
CFC	chlorofluorocarbon
ARPD	absolute relative percent difference
RPD	relative percent difference
MTBE	methyl *tert*-butyl ether
Eh	In this report Eh is field Eh or oxidation-reduction potential (orp)
QA/QC	quality assurance/quality control
L/min	liters per minute
m	meter
mm	millimeter
mL	milliliter
mg/L	milligrams per liter
cm	centimeter
NTU	neophelometric turbidity units
R^2	coefficient of determination

Well identification

obswell	observation well
airwell	soil vapor extraction well
sparwell	soil sparge well
injwell	recharge well
extrawell	extraction well

The following abbreviations are used in well names:

Suffix		Prefix	
S or A	shallow cluster well	SVE	soil vapor extraction well
M or B	medium cluster well	SP	soil sparge well
D or C	deep cluster well	IW	interior wall extraction well
R	bedrock well	EW	exterior wall extraction well
		PW or B or MI or MW	observation wells
		RW	recharge wells
		P	piezometer

Lithology abbreviations

f	fine
m	medium
c	coarse
Wx	weathered

Testing and Application of Water-Diffusion Samplers to Identify Temporal Trends in Volatile-Organic Compounds

By Philip T. Harte, Michael J. Brayton, Wayne Ives[1], Sharon Perkins[1], and Carroll Brown Jr.[1]

Abstract

Methods for ground-water sampling have evolved over time. This evolution has been driven by changing theories on how to obtain representative aquifer water samples. Passive sampling is a fairly recent method that relies on the natural flushing capacity of a well to obtain representative samples. The use of water-diffusion samplers is one method of passive sampling that works well under certain conditions.

As part of a 2-year study to determine the temporal variability and trends in concentrations of volatile organic compounds (VOCs) from a primary source area of a large ground-water plume (0.5 mi^2 area) in a glacial-drift aquifer, results of VOC analyses of samples collected with diffusion bag samplers were compared with those collected with other types of samplers. Diffusion bag samplers, because of their ease of use, offered a mechanism to help collect relatively inexpensive VOC samples and thus aided in the temporal analysis of the plume within the source area. The primary source area is located adjacent to a river that looses flow and recharges the aquifer. Here, ground-water flow is relatively rapid (up to several feet per day) and responds quickly to recharge events.

A total of 20 coupled diffusion and peristaltic-pump samples were collected from 7 wells completed in high-permeability glacial-drift. The concentrations of VOCs, primarily tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2-dichloroethene (*cis*-1,2DCE), in samples collected with diffusion samplers show a strong positive linear correlation (root-mean square of 0.94 and above) with concentrations from purged samples following low-flow sampling procedures. Sample results from a peristaltic pump were used to validate sample results from diffusion samples because peristaltic pumps had been used at the site by the New Hampshire Department of Environmental Services, the state agency responsible for remediation of the site. The accuracy of peristaltic pumps to collect VOC samples at the site was evaluated as part of this study and the results are presented within this report.

The mean concentration of PCE in the diffusion samples was 1,152 parts per billion (ppb) and the mean from the peristaltic-pump samples was 1,119 ppb. The standard deviations also were similar. The mean concentrations of TCE were slightly higher in diffusion samples (89.2 ppb) than peristaltic-pump samples (75.4 ppb). The mean concentration of *cis*-1,2DCE in diffusion samples (95.0 ppb) was virtually identical to the mean in peristaltic-pump samples.

Although VOC concentrations changed dramatically at several wells over the sampled period, trends in VOCs detected using diffusion samplers corresponded with trends in VOCs detected using other low-flow sampling methods. For example, at two wells where coupled diffusion and peristaltic-pump samples were collected, VOC concentrations varied by a half order of magnitude over a two-month period. Although the diffusion sampler was installed and left in the well for the entire period, VOC concentrations in the diffusion sampler at the time of retrieval generally matched samples collected with the peristaltic pump on the same day as retrieval, suggesting relatively rapid equilibration of the diffusion sampler to VOC concentrations in the well.

[1] New Hampshire Department of Environmental Services.

The use of diffusion samplers allowed for an improved understanding of contaminant transport conditions at the study site because it allowed for an increase in the frequency of sampling without an associated increase in labor cost. For example, spatially variable declines in PCE concentrations were identified over the two-year study that are related to spatial variations in sediment lithology and the location of the plume within the ground-water flow system. Wells screened in coarse-grained gravel layers and located along the northern part of the plume, close to the river boundary, showed the largest decline in concentrations of PCE. At several wells, concentrations of TCE and *cis*-1,2DCE increased, suggesting that small scale biodegradation is occurring. Temporary increases in concentrations of the primary VOCs followed several large recharge events, suggesting that VOCs are being desorbed from the aquifer matrix.

INTRODUCTION

The Savage Well Superfund Site, named after the former Savage municipal water-supply well for the Town of Milford, is underlain by a large (0.5 mi^2) plume of volatile organic compounds (VOCs) (figs. 1 and 2). The area is underlain by a highly transmissive sand and gravel aquifer. A discontinued tool manufacturing facility, has been identified as the primary source (HMM Associates Inc., 1989, 1991) of volatile organic compounds (mostly tetrachloroethylene (PCE)) that led to contamination of the Savage well. The State of New Hampshire Department of Environmental Services (NHDES) and the U.S. Environmental Protection Agency (USEPA) have constructed a remedial system for the primary source area (fig. 3). The remedial system includes a barrier wall, which surrounds the highest concentrations of dissolved PCE and most likely some dense non-aqueous phase liquids (DNAPL's), and various injection and extraction wells (vapor and water) to capture and treat the dissolved contaminant plume. The barrier wall was constructed from July to November 1998. Remedial operations of wells were tested between December 1998 to March 1999 but full operation started in May 1999.

The U.S. Geological Survey (USGS), in cooperation with NHDES and USEPA Region 1, has established a detailed monitoring system for the source area that includes (1) continuous observations of ground-water levels and physical water properties, (2) manual measurements of ground-water levels to complement the continuous network, and (3) a geochemical and water-quality sampling program. Furthermore, a solute-transport model of the glacial-drift aquifer has been constructed and used to simulate the remedial system.

The main purpose of the geochemical and water-quality sampling program is to document the rate of clean-up of the VOC plume. The sampling program began in May 1997, using low-flow sampling procedures (described in a later section of this report). To facilitate the sampling program, passive diffusion sampling began in 1998 when the frequency of sample collection was increased to coincide with the start of remedial operations. Passive diffusion sampling, using the method described in U.S. Patent No. 5,804,743, is an easy and inexpensive approach to sampling.

Passive diffusion sampling offers time-saving advantages over purged sampling following low-flow procedures. During this study, diffusion sampling was conducted in 1/5th the time of low-flow sampling; therefore, in an equivalent amount of time, five times as many samples were collected with diffusion samplers than with low-flow procedures. Previously, the frequency of VOC data collection in ground water was usually low because of the labor-intensive nature of sampling. Ground-water-quality sampling is typically conducted on a quarterly per annum time basis (Wiedemeier and others, 1998, p. 52) partly because of the expense of more frequent sampling. A quarterly or longer sampling frequency, however, may be insufficient to characterize time trends. For example, seasonal variability of ground-water flow can be a mechanism that increases the transverse dispersion of contaminants in the aquifer and will complicate analysis of long-term trends. Furthermore, anthropogenic factors in the study area, such as construction and operation of the remedial system, also cause short- and long-term changes in VOC concentrations. The lower cost of diffusion sampling allows for more frequent measurements thereby facilitating the identification of short- and long-term trends.

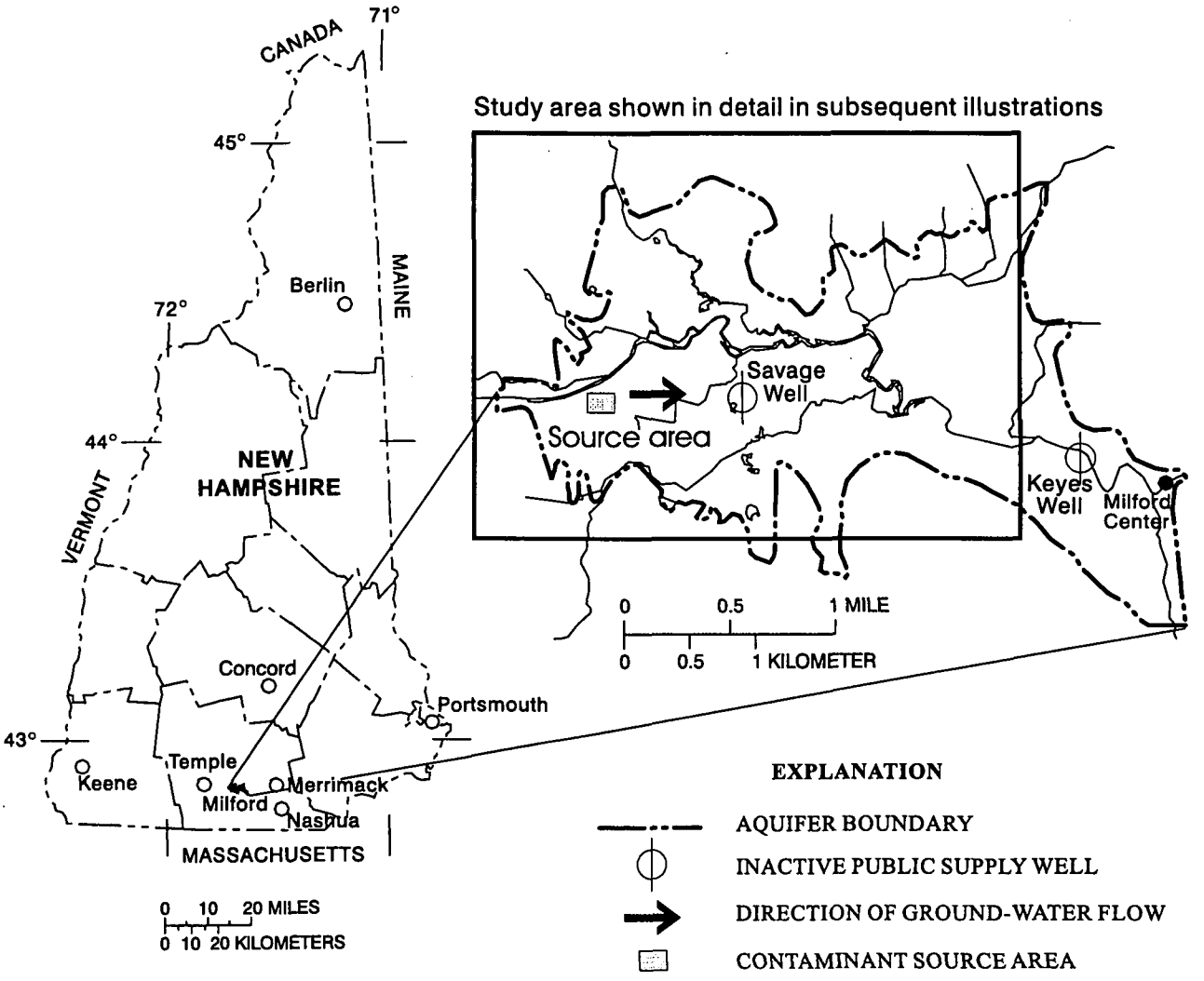
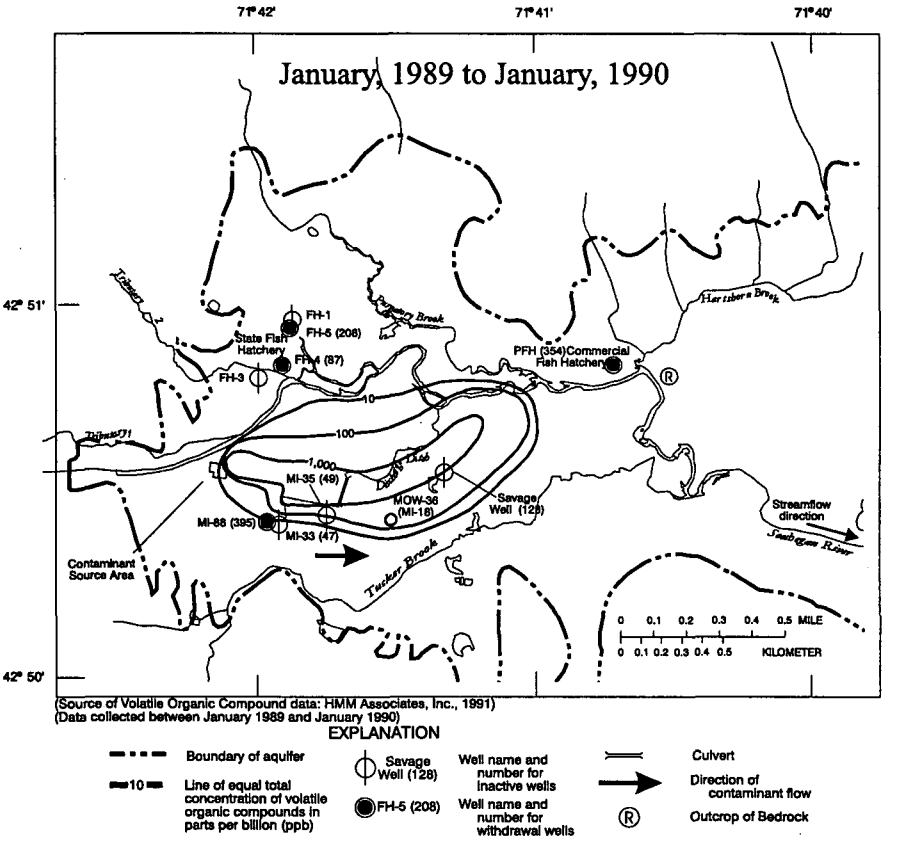


Figure 1. Location of the Milford-Souhegan Glacial-Drift aquifer, Milford, New Hampshire.

(A)



(B)

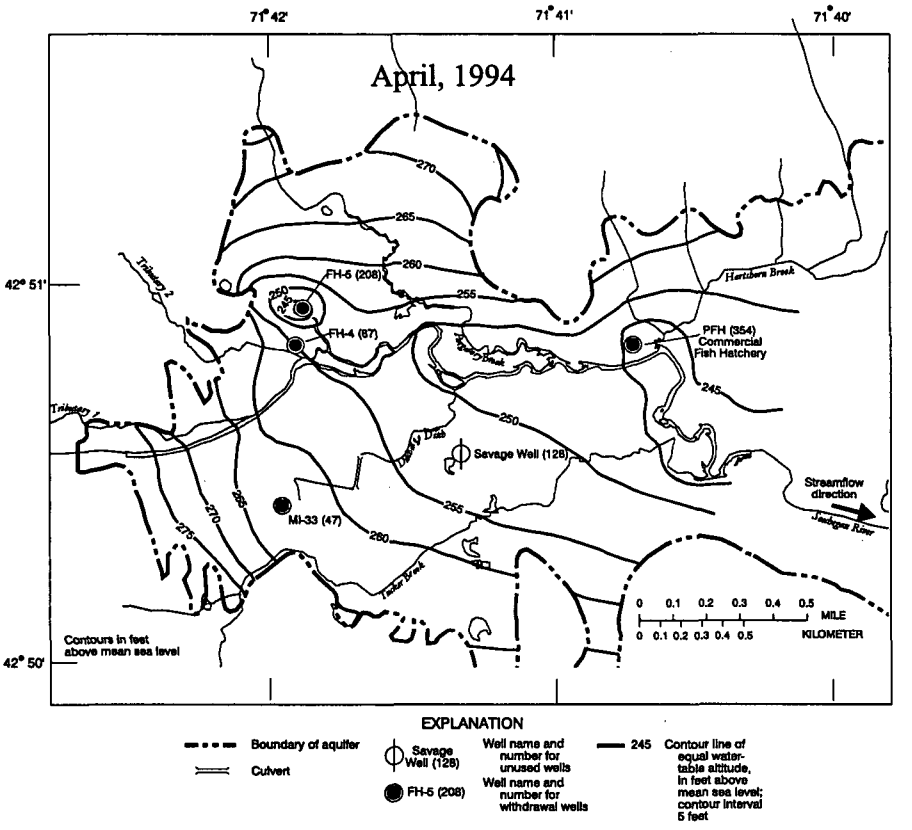


Figure 2. Extent of contaminant plume of total volatile organic compounds (A) and ground-water head contour map (B) in the Milford-Souhegan Glacial-Drift aquifer, Milford, New Hampshire.

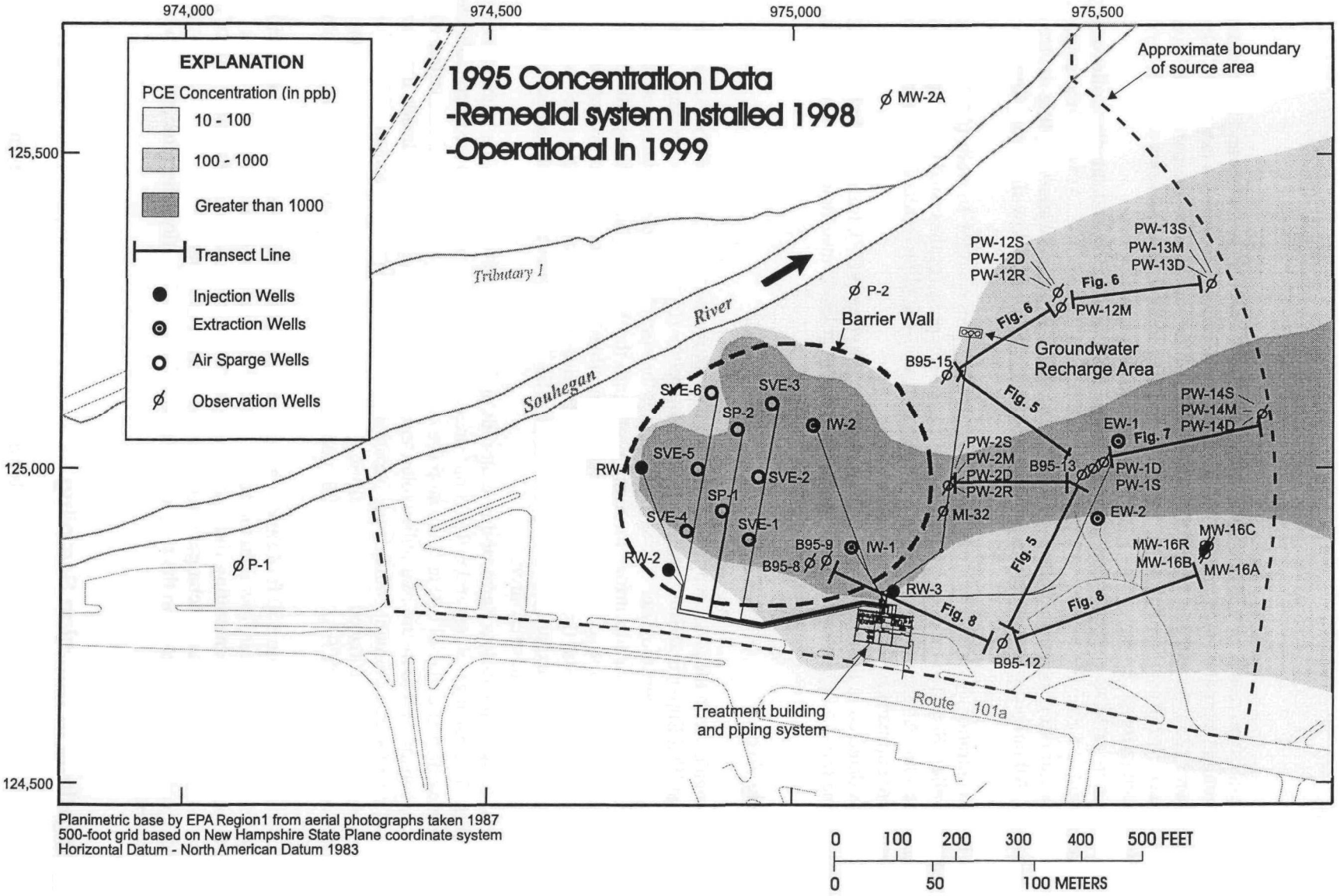


Figure 3. Remedial system, contaminant plume in source area, and monitoring wells at source area of the Savage Superfund Well Site, Milford, New Hampshire. (See table 3 for well construction information; see abbreviations page for well type)

Purpose and Scope

This report summarizes the results of a 2-year data collection effort (1997-99) to understand the temporal variability of VOCs in ground water at an area previously identified as the primary source of a large VOC plume. The report describes general geologic and geochemical characteristics of the source area, compares VOC concentrations in samples obtained by diffusion samplers and by other sampling methods, and presents an analysis of time trends of VOC concentrations.

Comparisons of results of VOC concentration in samples from passive samplers and samples collected by purged methods are presented for seven wells completed in unconsolidated, glacial drift. At two of the seven wells, testing of diffusion sampling included comparisons with more than one purged water-sampling device on more than one occasion. All purged water samples were collected following USEPA low-flow sampling procedures.

Time trends in concentrations of VOCs from diffusion samplers are presented for 16 wells (14 glacial-drift wells and two bedrock wells). Seven of the sixteen wells had diffusion-sampling results tested by comparing with purged water-sampling results. At one other well, a bedrock well, diffusion-sampling results from a vertical string of diffusion samplers were compared to one purged sample.

The primary VOCs detected in the study area include tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2-dichloroethene (*cis*-1,2DCE). Other VOCs were detected but at levels insufficient for comparison.

Description of Study Area

The study area coincides with the area identified as the primary source area of VOCs (HMM Associates, 1989, 1991) to the Savage Well Superfund Site in Milford, New Hampshire (figs. 2 and 3). It is located in the western part of the Savage Well Superfund Site. The source area was the site of a now discontinued tool company where solvents were discharged into the subsurface for many years until the early 1980s. Although discharges have ceased, the underlying contaminant-soaked sediments and immiscible solvents continued to contaminate ground water flowing easterly underneath the site and created a large plume until a barrier wall was constructed. This large plume continues to threaten existing ground-water usage at State and commercial fish hatcheries (fig. 2) and restricts the full beneficial use of this resource.

The barrier wall is constructed of low permeability materials and is designed to contain the highest concentrations of contaminants. The barrier wall encircles 0.008 mi^2 area. The wall fully penetrates the unconsolidated glacial drift (both stratified drift and glacial till) and sits atop the bedrock. Various injection and extraction wells (fig. 3 and table 1) were constructed to insure hydraulic isolation and reduce contaminant mass inside the barrier wall and to capture and treat the contaminants outside the barrier wall. PCE is the primary contaminant and it's maximum concentrations range from 100,000 parts per billion (ppb) inside the wall to 10,000 ppb outside the wall. Secondary VOC contaminants (TCE and *cis*-1,2DCE) concentrations are typically 1-2 orders of magnitude less than those of PCE.

The study area is underlain by up to 100 ft of sands and gravels, and a discontinuous till overlying a biotite granite and gneiss bedrock. Ground-water flow is to the east at velocities of up to several feet per day in the unconsolidated sediments. A partially penetrating river, the Souhegan River, bounds the northwestern part of the source area. Here the river looses flow and recharges the aquifer on average of about 4 ft^3/s. The ground-water flow system responds quickly to recharge from the river or infiltration from precipitation; therefore, the flow system is highly transient.

Previous Investigations of Diffusion Sampling

Methods for ground-water sampling continue to evolve over time. This evolution is driven by advances in understanding of ground-water flow and chemical transport in aquifers and wells, improvements in equipment,

Table 1. Well screen data and geology for selected wells in the study area

[All data in feet; altitude in feet above mean sea level, NGVD29; Aquifer code: S&G = sand and gravel, f-c= fine to coarse, G&S = gravel and sand, rk=bedrock, --, no data available; site type names explained in abbreviation section of report; all wells shown in figure 3 except PW-3, PW-4, PW-6, PW-8, and PW-10 cluster wells]

Well name	Well No.	Easting	Northing	Site type	Altitude of land surface	Top of opening below land surface	Bottom of opening below land surface	Depth to bed-rock below land surface	Screen material
B95-09	404	975039.81	124825.60	obswell	270.31	10.0	20.0	--	S&G
B95-12	407	975343.81	124724.70	obswell	269.45	55.0	60.0	76	G&S
B95-13	408	975490.62	125002.0	obswell	267.01	60.0	65.0	90.5	S&G
B95-15	409	975254.0	125149.40	obswell	269.61	85.0	95.0	96.5	G&S
EW-1	565	975535.23	125046.05	extrawell	266.88	63.55	93.55	--	S&G
EW-2	566	975492.89	124936.25	extrawell	267.05	51.22	81.22	81.5	S&G
IW-1	567	975105.37	124871.14	extrawell	272.4	78.32	108.32	108.3	Sand
IW-2	568	975037.83	125068.37	extrawell	277.03	78.32	108.32	--	S&G
MI-32	46	975247.2	124933.7	obswell	270.2	30.0	75.0	95	S&G
MW-2A	310	975148.9	125591.3	obswell	266.6	29.0	39.0	--	S&G
MW-16A	233	975671.2	124863.1	obswell	267.5	16.9	26.9	--	S&G
MW-16B	321	975671.0	124868.6	obswell	267.6	39.6	49.6	--	Sand,f-c
MW-16C	344	975678.1	124877.1	obswell	267.4	73.2	83.2	87.5	S&G
MW-16R	345	975670.8	124875.2	obswell	266.5	88.0	138.0	87.5	rock
P-1	335	974088.3	124847.5	obswell	276.6	13.9	14.9	--	S&G
P-2	336	975100.9	125281.9	obswell	268.6	17.0	18.0	--	S&G
PW-1D	531	975507.1	125010.99	obswell	266.88	84.48	94.48	94	Till/rk
PW-2R	535	975254.74	124973.56	obswell	268.92	113.9	133.93	102	rock
PW-3S	536	975059.0	125239.0	obswell	269.83	19.76	29.76	--	S&G
PW-3D	537	975059.1	125239.1	obswell	269.84	84.85	94.85	94.5	S&G
PW-4M	538	974970.0	124767.0	obswell	271.81	31.87	41.87	--	S&G
PW-4D	539	974970.1	124767.0	obswell	272.01	62.0	72.0	70	S&G/rk
PW-6S	543	975016.0	124942.0	obswell	276.65	23.63	33.63	--	S&G
PW-6M	544	975016.1	124942.1	obswell	276.37	40.39	50.39	--	S&G
PW-6D	545	975016.2	124942.2	obswell	276.98	87.6	97.6	94	S&G/rk
PW-6R	546	975016.3	124942.3	obswell	276.32	101.04	111.04	95	rock
PW-8M	549	974856.2	125140.4	obswell	273.34	31.37	41.37	--	S&G
PW-10M	551	975152.0	125127.0	obswell	273.98	50.15	60.15	--	S&G
PW-10D	552	975152.1	125127.1	obswell	273.80	94.71	104.71	--	S&G
PW-12S	555	975432.0	125281.0	obswell	265.73	18.1	28.1	--	S&G
PW-12M	556	975437.17	125255.65	obswell	265.81	57.8	68.0	--	S&G
PW-12D	557	975432.20	125281.20	obswell	265.69	87.0	97.0	--	Sand
PW-12R	558	975432.30	125281.30	obswell	265.66	113.9	134.0	100	rock
PW-13S	559	975682.00	125294.00	obswell	267.68	20.3	30.3	--	S&G
PW-13M	560	975682.10	125294.10	obswell	267.86	59.8	70.0	--	S&G
PW-13D	561	975682.20	125294.20	obswell	267.55	94.3	104.35	103	Gravel/rk
PW-14S	562	975765.00	125085.00	obswell	266.76	20.03	30.03	--	S&G
PW-14M	563	975765.10	125085.10	obswell	266.76	60.0	70.0	--	Sand,c-f
PW-14D	564	975765.20	125085.20	obswell	266.77	102.71	112.71	111.5	Sand,c-f/rk
RW-1	569	974751.80	125000.52	injwell	273.67	31.65	41.65	--	Gravel
RW-2	570	974799.44	124838.74	injwell	273.38	22.04	32.04	--	S&G
RW-3	571	975168.45	124805.82	injwell	269.96	18.450	28.450	--	Gravel
SP-1	572	974885.08	124935.83	Sparwell	274.45	60.66	65.66	66.8	Sand
SP-2	573	974910.85	125063.90	Sparwell	275.34	59.71	64.71	--	Sand
SVE-1	574	974927.14	124888.11	airwell	274.99	8.37	23.36	--	--
SVE-2	575	974946.49	124988.03	airwell	276.25	9.41	24.41	--	--
SVE-3	576	974966.91	125106.60	airwell	273.38	12.34	27.34	--	--
SVE-4	577	974828.74	124901.85	airwell	274.02	12.66	27.66	--	--
SVE-5	578	974846.81	125001.08	airwell	274.76	7.870	23.87	--	--
SVE-6	579	974870.28	125128.88	airwell	273.7	12.39	27.39	--	--

and efforts to reduce sampling costs. Water-quality data-collection practices at Superfund sites offer an example of the evolution in ground-water sampling. Retrieval of ground-water samples have utilized decreasingly smaller volumes and lower rates of pumpage since the advent of contaminant sampling. In the early to mid 1980s, samples (for analysis) were commonly collected only after the purging of large volumes of water at high pumping rates. Typically, a minimum of three casing volumes of water were extracted from the well prior to sampling as an attempt to obtain representative water samples. High turbidity in the water samples, a common effect of large volume pumping, was reduced by filtering. Continuing research in contaminant transport found that high rates and volumes of pumping resulted in a number of undesirable effects—such as problems in disposing of contaminated water, and mobilization of particulates surrounding the well as witnessed by high turbidity. The presence of particulates in sampled water can elevate concentrations of contaminants even if filtration is used and potentially leads to an exaggeration of the magnitude of contaminant transport because these particles are mobilized only locally around a well under high pumping stresses.

With the advent of low-flow and low-volume sampling methods (Pohlmann and others, 1994; McFarlane, 1996), less stressful approaches have been developed that seek to minimize the mobilization and entrainment of particulates suspended in the water sample. An extension of this low-flow, less stressful strategy is the passive (no purge) sampling approach and specifically, diffusion sampling (Vroblesky and Hyde, 1997). Diffusion sampling and(or) samplers, as the name implies, works on the principle of diffusion: the movement of chemical compounds as a consequence of concentration gradients. Water-diffusion samplers consist of deionized, contaminant-free water enclosed in polyethylene bags (fig. 4), which are suspended in wells in a mesh sleeve or section of slotted pvc pipe. Contaminants in the well water, such as chlorinated VOCs and aromatic VOCs, are able to diffuse through the polyethylene bag into the previously contaminant-free water until the concentrations in the bag water and well water equilibrate.

Two types of passive-diffusion samplers have been used in previous studies—a vapor-diffusion sampler and a water-diffusion sampler (used for this study). The vapor-diffusion sampler consists of a 40 mL glass vial enclosed in a water-free sealable polyethylene bag. Concentrations of VOCs in the vapor phase can range from 0.27 to 27.3 times higher than in the water phase (Mullaney and others, 1999). Therefore, it is difficult to infer a correlation between concentrations in vapor-diffusion samplers and water-diffusion samplers. For this reason, vapor diffusion method should not be used to quantify water concentrations.

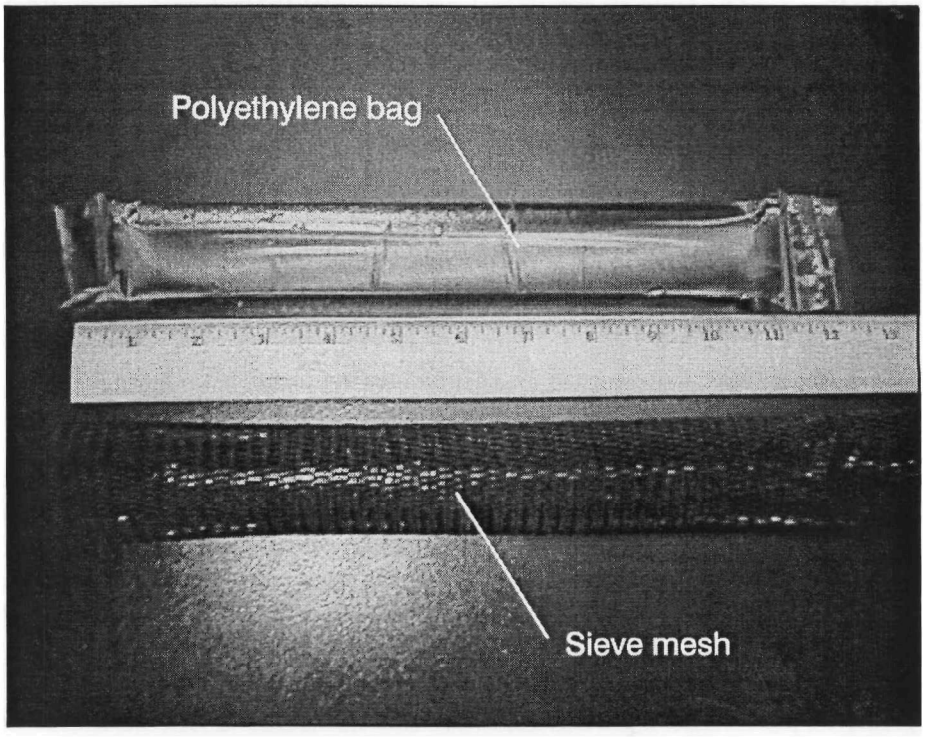
Vapor-diffusion samplers were used by Vroblesky and Robertson (1996) to collect time-series VOC data and to monitor changes in VOC concentrations of ground water discharging to surface-water bodies. Previous studies using water-diffusion samplers include work at several Air Force Bases [Hanscom Air Force Base in Massachusetts (Forest Lyford, U.S. Geological Survey, oral commun., 1999); and McClellan Air Force Base in California (Parsons Engineering Science, Inc., 1999)]. In both those studies, VOC concentrations from diffusion samplers compared favorably to VOC concentrations from purged water samples collected in accordance with low-flow procedures. Vroblesky and Hyde (1997) found that the concentrations of VOCs (primarily PCE, TCE, *cis*-1,2DCE, *trans*-1,2-dichloroethene (*trans*-1,2DCE), 151-DCA, and vinyl chloride (VC)) in water-diffusion samples retrieved at five wells during one-round of sampling were within 10 percent of concentrations in samples retrieved by submersible and bladder pumps and bailers.

Water-diffusion sampling may not be an effective sampling method for all VOCs. VOCs with low vapor pressures and(or) extremely high solubilities may not reach equilibrium between the water column and the contents of the sampler within a reasonable time frame (Paul Hare, General Electric Company, written commun., 1999). For example, acetone was observed not to reach equilibrium after 10 days, while most of the chlorinated solvents reached equilibrium within several days.

Acknowledgments

This study, conducted as part of the remedial effort for the Savage Well Superfund Site, is a collaborative effort between Federal, State, and local governments, and private companies and individuals. The authors wish to express thanks to Richard Goehlert, site remedial project manager of the U.S. Environmental Protection Agency,

(A)



(B)

Figure 4. Diffusion sampler (A) and well identifier (B) used to label wells.

Region 1; Richard Willey, lead hydrogeologist, U.S. Environmental Protection Agency, Region 1; Thomas Andrews of the New Hampshire Department of Environmental Services; and Joseph Newton of Camp, Dresser, and McKee, Inc., for their cooperation and support. Methane data were analyzed by Cindy Mosedale and Dean Moosavai of the University of New Hampshire. Total organic carbon data were analyzed by Dr. William McDowell also of the University of New Hampshire. The majority of the VOC analyses and geochemical analyses were done by the New Hampshire Department of Environmental Services Laboratory. Lou Barinelli of New Hampshire Department of Environmental Services assisted in analysis of laboratory precision levels. Scott Clifford of the U.S. Environmental Protection Agency, Region 1, also performed additional VOC analyses with the U.S. Environmental Protection Agency, Region 1 Mobile Laboratory for a purge test in April 1999.

HYDROGEOLOGIC SETTING

The unconsolidated sediments beneath the study site consist of up to 100-ft thick deposits of predominantly sand and gravel. Borehole geophysical logs (natural gamma and electromagnetic conductivity) and lithologic logs from wells along a north to south transect of the site (figs. 3 and 5) and west to east transect (figs. 6-8) show the sand and gravel sequences are interspersed with discontinuous finer grained sands at depths of 40 ft and 70 ft. Coarse-grained deposits (cobbles and gravels) occur at the uppermost layer near the water table (at a depth of 6-14 ft), at around 60 ft, and at the base of the unconsolidated sediments at 90 ft. Till, which discontinuously mantles the bedrock, is thickest to the west (not shown on figures) and thins to the east.

The stratigraphy appears to be deposited by a sequence of multiple glacial advances. The deep, coarse-grained deposits at 85-90 ft below land surface (figs. 5-8) suggest that subglacial meltwater may have contributed to deep erosion into the bedrock from the glacier. The remaining deposits suggest meltwater deposition in the form of deltas, outwash, and lastly a glacial outburst deposit as evidenced by the coarse cobble zone near the uppermost sequence.

Ground water flows easterly through the study area and receives recharge from the Souhegan River, which loses streamflow at an average rate of approximately 4 ft^3/s to the aquifer. The proximity of the study area to the Souhegan River causes transient variability in the ground-water-flow system (Harte and others, 1997). Water-table maps from pre- and post-wall construction indicate that construction of the low-permeability barrier wall has not impeded recharge from the Souhegan River (fig. 9). The direction and magnitude of maximum ground-water gradients computed from a three-point planar solution (Johnston and Harte, 1998) for the downgradient side of the site shows that completion of the barrier wall in November 1998, coupled with operation of extraction wells (EW1 and EW2, fig. 3) since mid-May 1999, have moderated variations in direction of gradients as the result of transient hydrologic conditions (fig. 10a) and increased the maximum gradients (fig. 10b).

GEOCHEMISTRY OF WATERS

The geochemistry of ground water is an important factor in assessing the potential for biodegradation of chlorinated aliphatic compounds like PCE and will therefore affect analysis of time trends. Processes such as reductive dechlorination occur when electron donors are available and competing electron acceptors are eliminated (Wiedemeier and others, 1998). The principal electron donor in the absence of anthropogenic sources is organic carbon in the aquifer. Electron acceptors include oxygen, nitrate, iron, and sulfate.

The sampled waters at the site are characterized by low total organic carbon (TOC) (less than 2 mg/L). A listing of median concentrations of key geochemical parameters, grouped by uncontaminated and contaminated wells and by depth of well (shallow, medium, and deep) is given in table 2. TOC ranges from 0.83 to 1.67 mg/L. Dissolved oxygen decreases with depth and is lower in contaminated wells than in uncontaminated wells. Whereas oxygen levels appear to be reduced in the contaminated parts of the aquifer, other electron acceptors show no appreciable difference between uncontaminated and contaminated wells. Chloride concentrations are affected at the site by road-salting along the southern part of the plume, which skews comparisons between

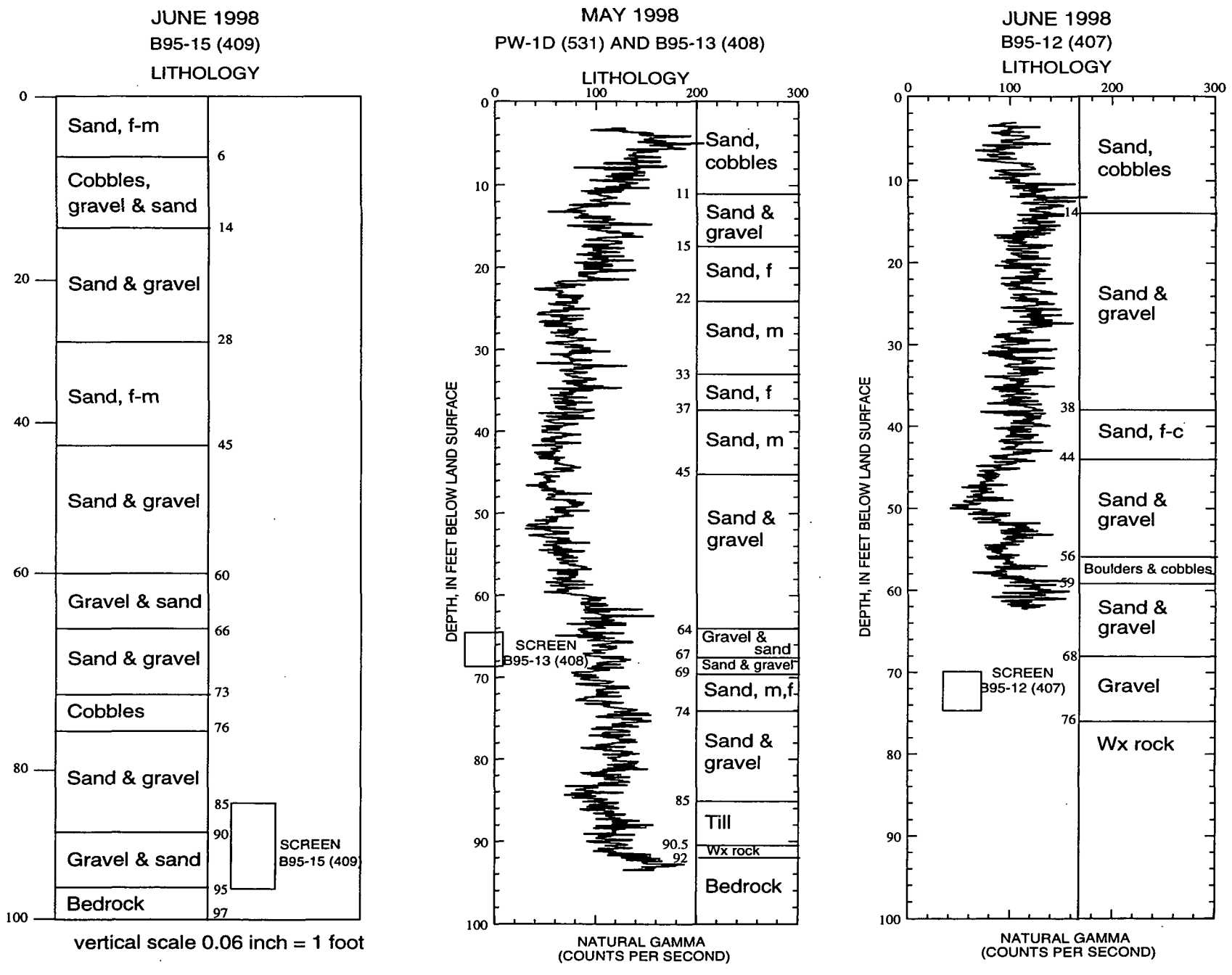


Figure 5. Lithologic and borehole logs for wells in the source area along a north to south transect, including wells B95-15, B95-13, and B95-12. (See abbreviations page)

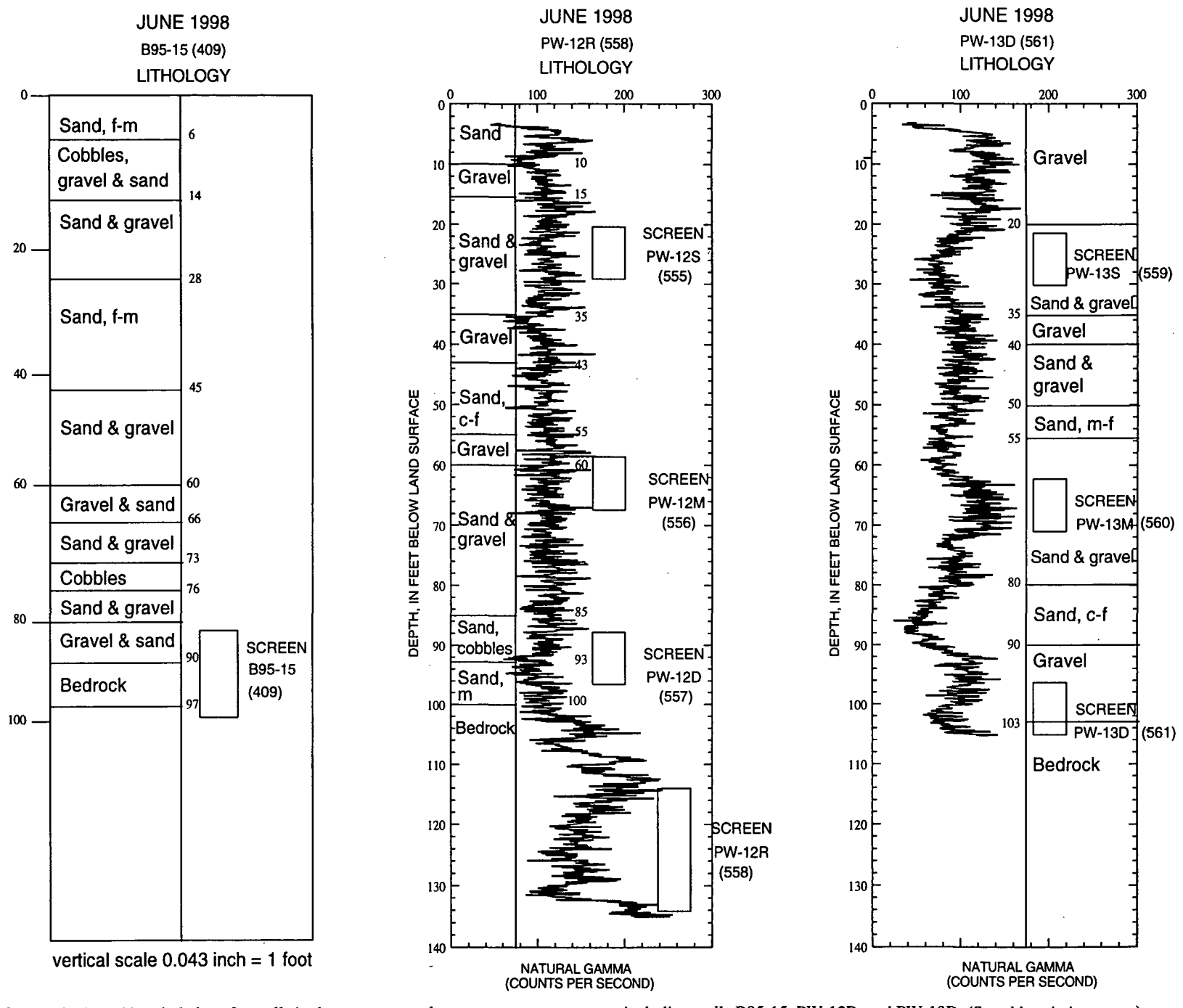


Figure 6. Lithologic and borehole logs for wells in the source area along a west to east transect, including wells B95-15, PW-12R, and PW-13D. (See abbreviations page)

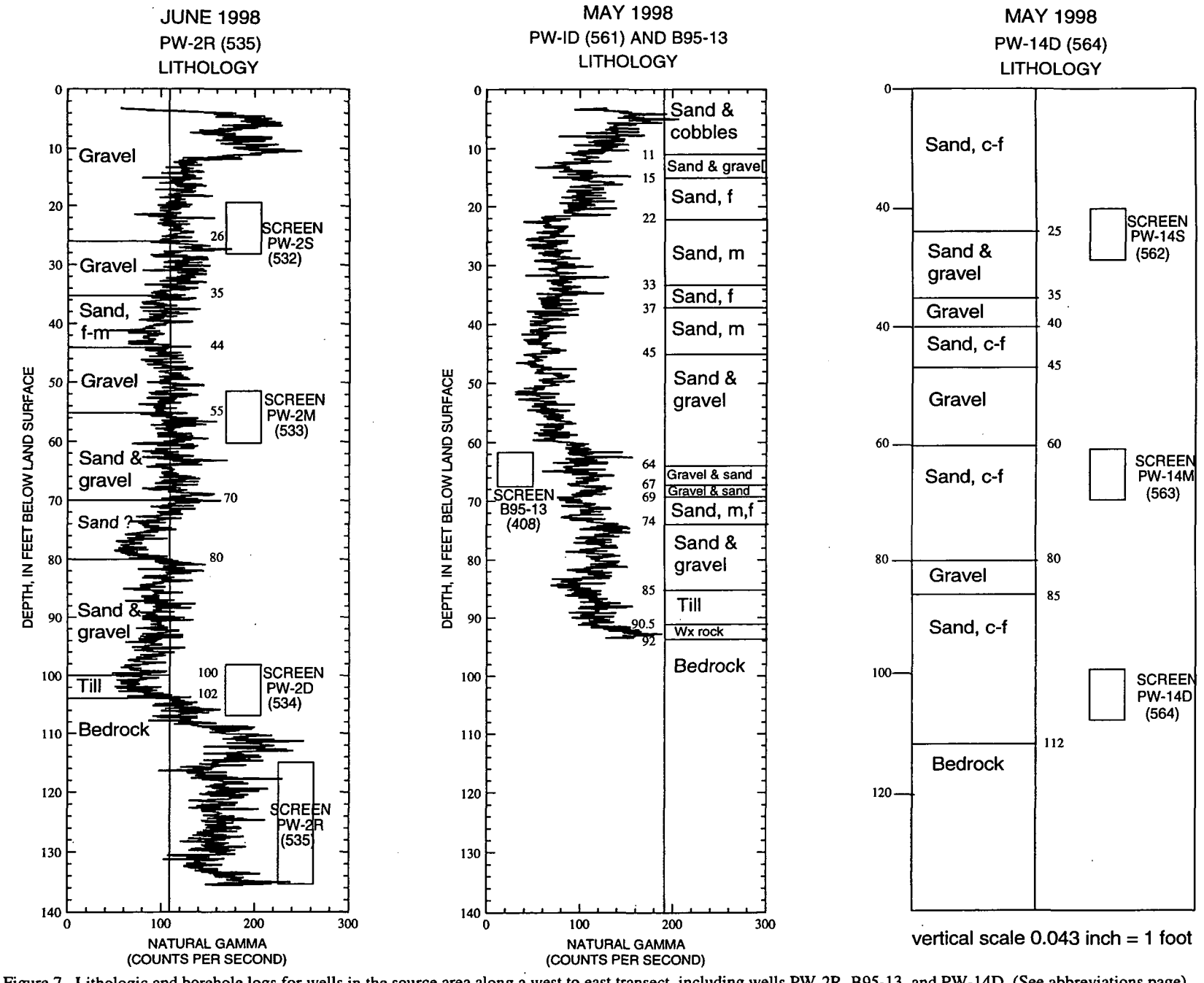


Figure 7. Lithologic and borehole logs for wells in the source area along a west to east transect, including wells PW-2R, B95-13, and PW-14D. (See abbreviations page)

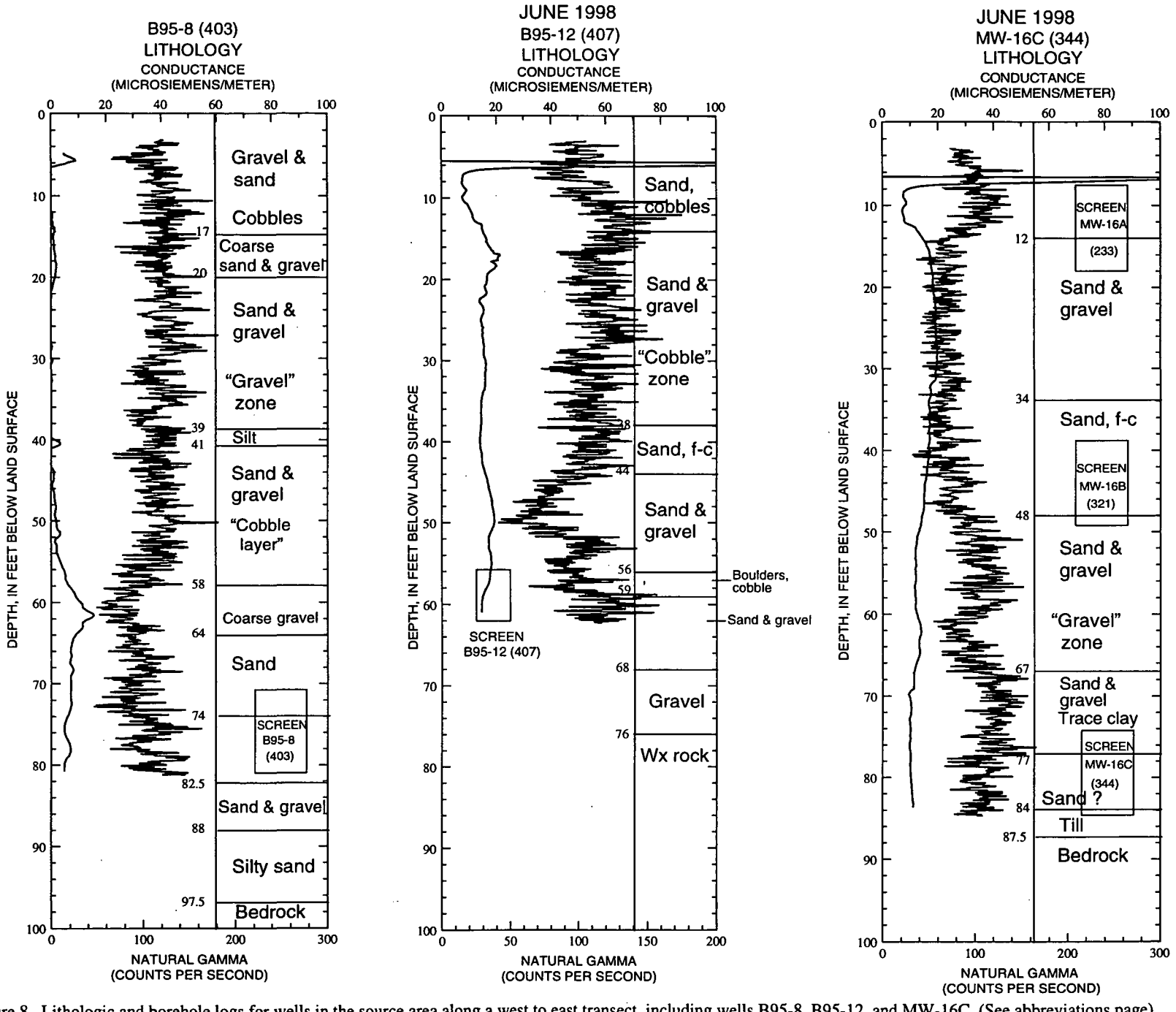
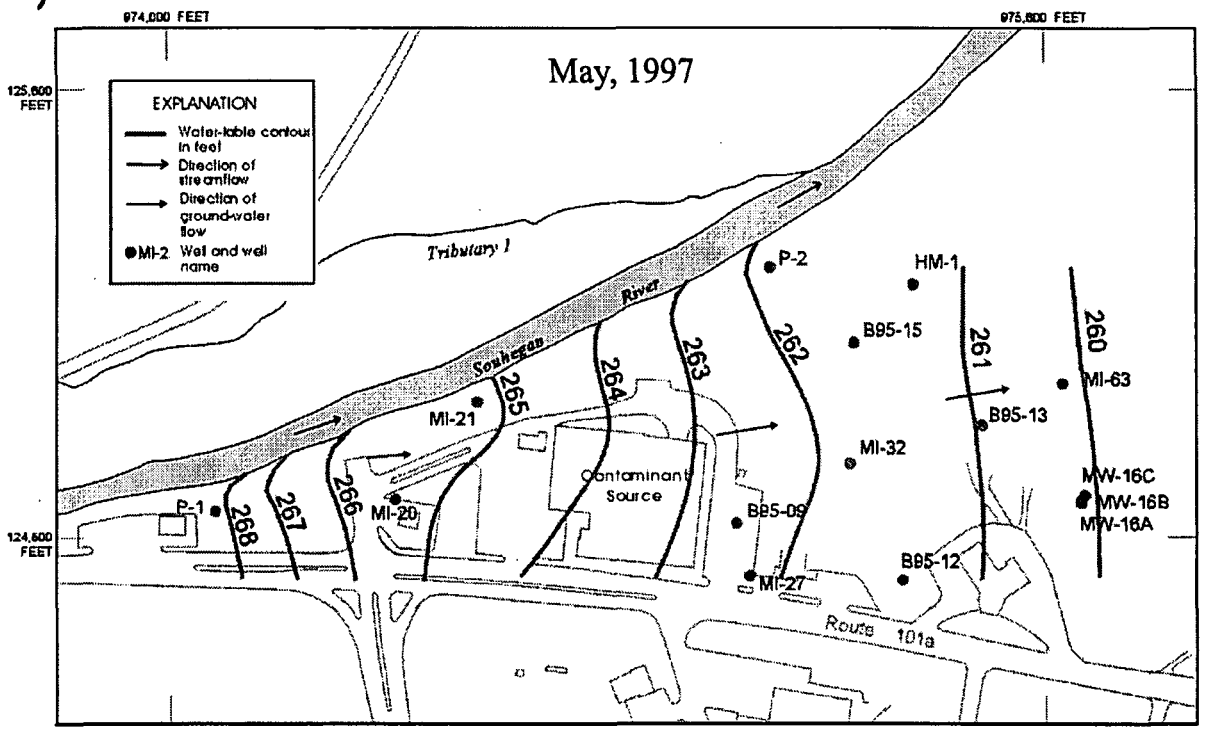
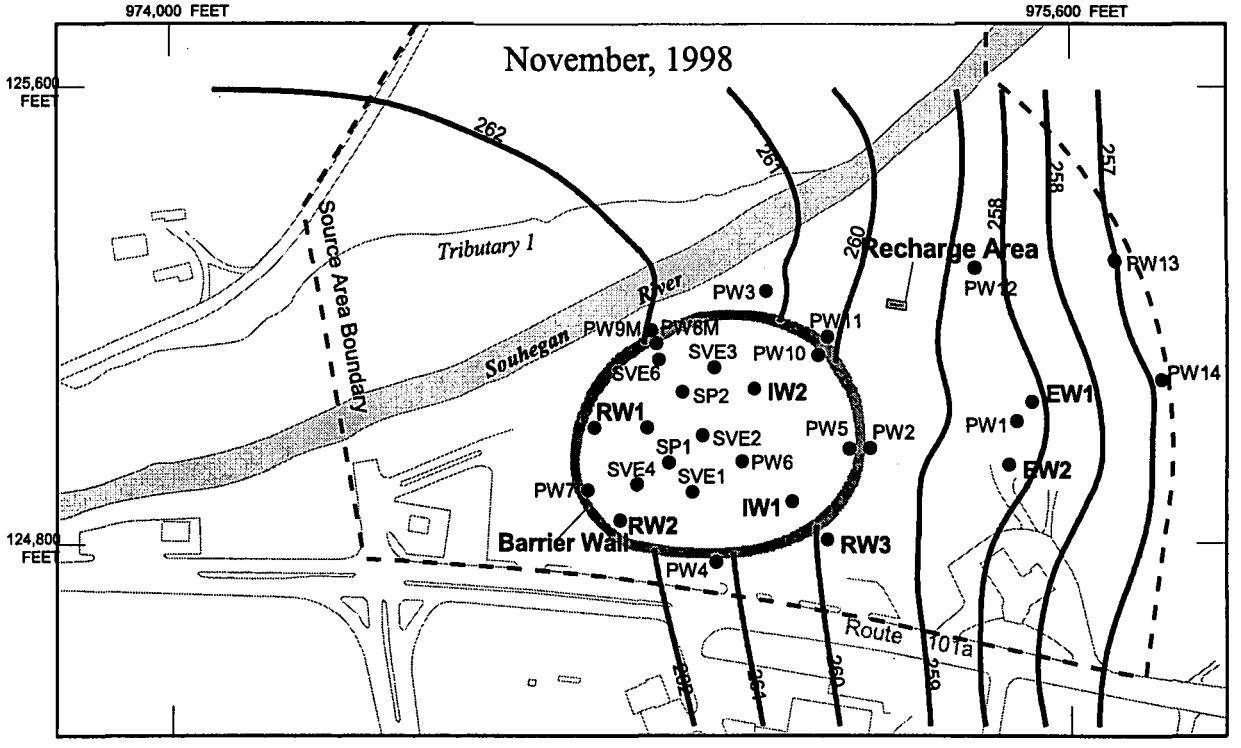


Figure 8. Lithologic and borehole logs for wells in the source area along a west to east transect, including wells B95-8, B95-12, and MW-16C. (See abbreviations page)

(A)



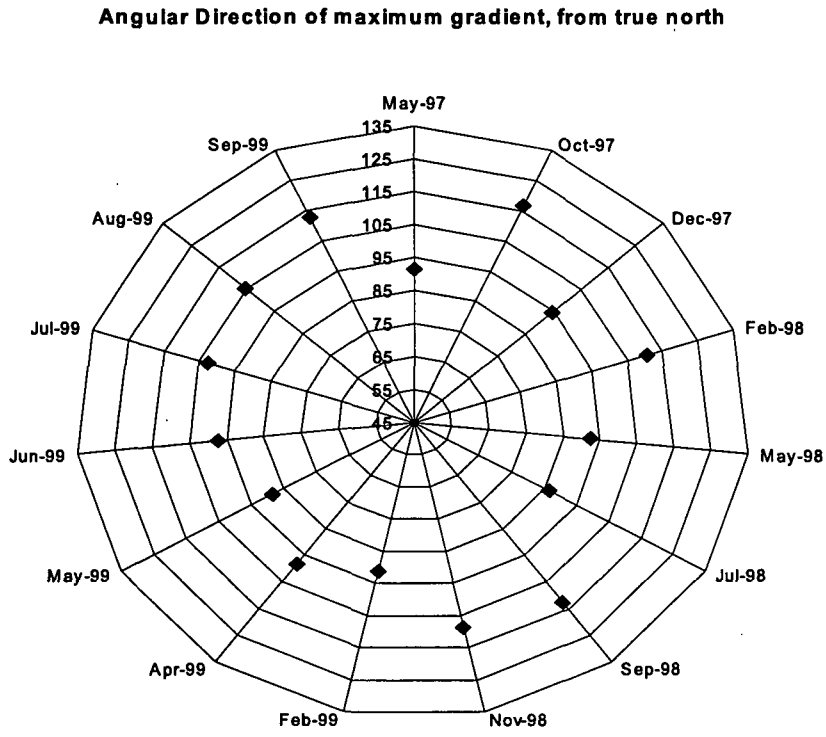
(B)



Planimetric base by EPA Region 1 from aerial photographs taken 1987
Remedial construction data from Camp, Dresser, and McKee Inc., 1999

Figure 9. Water-table surface for pre-remedial construction (May 1997) (A) and post-remedial construction (November 1998) (B).

(A)



(B)

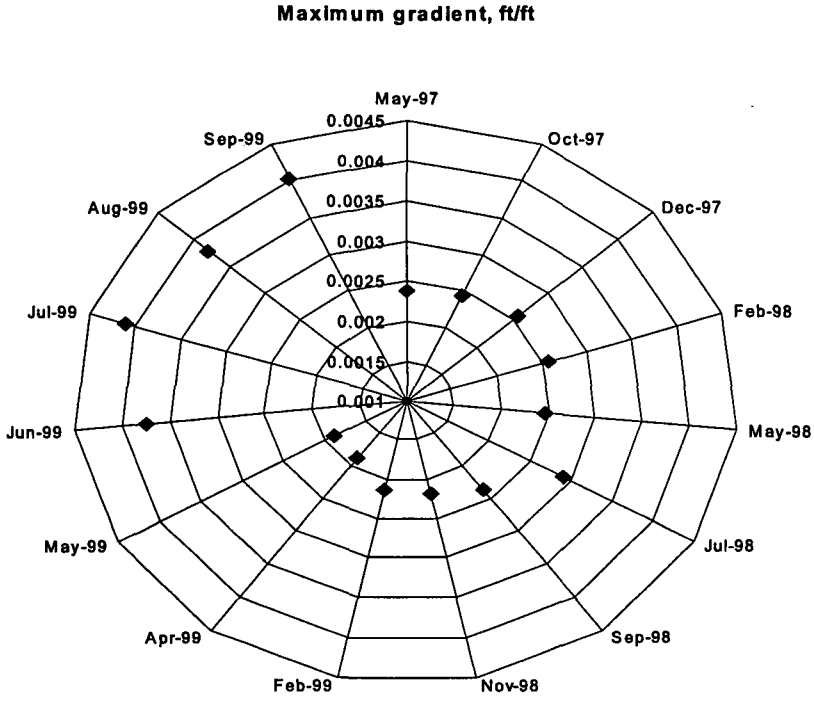


Figure 10. Angular direction of maximum ground-water gradient from true north (A) and gradient (B) computed from three-point planar solution from wells B95-12, B95-15, and B95-13.(Well locations shown in figure 3)

Table 2. Median concentrations of key geochemical parameters in uncontaminated and contaminated ground water with volatile organic compounds from the study area

[Deep wells greater than 80 feet; Medium wells from 40-80 feet; Shallow wells are from 0-40 feet below land surface; mg/L means milligram per liter; ppm means part per million; < means less than; data from May 1997 to April 1999; pH, Eh, and water temperature measured from flowthrough cell; Dissolved oxygen, carbon dioxide, and ferrous iron measured from chemical kits (see table 3) and sampled from purged water from discharge tube; All other constituents sampled from discharge tube and analyzed by methods described in table 3.]

	Deep wells		Medium wells		Shallow wells	
	Uncontaminated	Contaminated	Uncontaminated	Contaminated	Uncontaminated	Contaminated
Number of samples	5	10	17	12	15	4
pH	6.3	7.11	5.83	5.86	5.9	5.8
Eh	214	0	279	292	194	230
Dissolved oxygen (mg/L)	0.4	0.55	3	0.7	2	0.8
Carbon dioxide (mg/L)	15	18.8	20.5	25	23.5	30
Water temperature (degrees celsius)	11.5	13.6	12.1	11.1	11	11.4
Ferrous iron (mg/L)	0	0	0	0	0	0
Methane (ppm)	3.5	3.0	1.79	3.15	1.91	6.1
Total organic carbon (mg/L)	0.83	0.94	1.13	0.86	1.67	0.9
Alkalinity (mg/L as $CaCO_3$)	17.5	58.4	9.2	14.8	13.5	15
Nitrate (mg/L)	<0.05	0.32	0.34	0.55	0.12	1.03
Nitrate+nitrite (mg/L)	<0.05	0.72	1.3	0.55	0.27	1.79
Sulfate (mg/L)	9	12	13	10	11	24.5
Chloride (mg/L)	9	29	13	21	20.5	22.5

background and contaminated areas. In general, the geochemical data suggest that ground waters underneath the site are not conducive to widespread biological degradation of PCE at rapid rates (such as with degradation half lives of 1 year or less) over a large part of the source area.

METHODS OF DATA COLLECTION

Well data are referenced by local name as assigned by driller or principal investigative party. Well data are also referenced in several locations by a project number to allow for cross-referencing in this report, as well as with previous reports of the area. For example, well B95-15 is the principal local name and well number 409 is the number assigned by the project. Only the principal local name will be used in the report after the first cross reference.

Description of Chemical-Monitoring Program

From May 1997 to April 1999, water samples were collected bimonthly at a minimum of 2 wells (B95-15 (well number 409) and B95-13 (well number 408) and a maximum of 6 wells (B95-15, B95-13, B95-12 (well number 407), PW-13M (well number 560), PW-14M (well number 563)(fig. 3)). Samples were collected by multiple methods including diffusion samplers and low-flow purged samplers: peristaltic, bladder, and Voss pumps. Additional wells were sampled using low-flow sampling techniques on several occasions including May 1997, June 1997, December 1997, May 1998, July 1998, September 1998, November and December 1998, and April 1999. From May 1999 to September 1999 samples were collected with diffusion samplers.

A list of constituents analyzed, methods of analysis, and detection limits is provided in table 3. Measured constituents are subdivided by field and laboratory methods. Samples for analysis of volatile organic compounds were collected in 40 mL septum vials and analyzed within 2 weeks of sample collection by USEPA method 8260B (U.S. Environmental Protection Agency, 1996a). Samples were analyzed by State of New Hampshire Department of Environmental Services Laboratory. During a detailed sampling test in April 1999, a USEPA, Region 1 mobile laboratory was used to analyze samples. Aqueous samples were analyzed using USEPA, Region 1, standard operating procedures for head-space screening for VOCs with a Shimadzu Gas Chromotogram 14A equipped with a 30 m, 0.53 mm DBPS-624 column and a photoionization detector (PID). Concentrations were calculated using the external standard technique (Clifford, Scott, U.S. Environmental Protection Agency, written commun., 1999).

Sampling Methods and Techniques

Ground-water samples for VOC analysis were collected by four different sampling techniques: diffusion sampler, peristaltic pump, Voss sampler, and bladder pump. Samples were collected at wells where validation of sample methods were tested (seven wells in all) in order of increasing cumulative volume purged[1] in the following sequence: diffusion, Voss, peristaltic, and bladder. All samples, which were collected for the purpose of comparing sampling methods, were extracted from the same interval in the well, typically at the mid-point of the well opening or screen. The diffusion sampler, which was installed a minimum of 7 days prior to retrieval, was retrieved first from the well. After diffusion sampler retrieval, a Voss pump (on one occasion) or a peristaltic tube (on all occasions) was lowered into the well and its intake was set at the previous midpoint location of the diffusion sampler. After sample collection from the Voss pump or peristaltic tube, the apparatus was retrieved from the well. Finally, a bladder pump was lowered to the previously used midpoint location and samples were collected. The bladder pump was then retrieved and a new diffusion sampler was installed for the next round of sampling. For the peristaltic and bladder pumps, samples were collected according to USEPA, Region 1, Standard Operating Procedures (SOP) for low-flow purging and sampling (U.S. Environmental Protection Agency, 1996b). Purged samples using pumps were collected on the same day immediately after diffusion samplers were retrieved except for one purge sample (B95-13, April 1999) that was collected 7 days latter because of equipment installation problems. The specific methods of each technique are described below.

Diffusion-bags samples were created from a sealed polyethylene bag filled with VOC-free-deionized water. Bags were enclosed in either a mesh screen or a short section of polyvinyl-chloride (PVC) screen and suspended in the well with teflon coated wire and a stainless steel weight. Diffusion-bag samples were placed at the midpoint of a well screen from a typical period of 2 weeks to 2 months. After retrieval of the bags from the well, a small hole is cut in the bag and contents are poured into a 40-mL septum vial. The steps involved in the preparation, installation, and retrieval of diffusion samplers are described in appendix 1.

A Voss sample was collected one time at one well. A Voss sampler is a modified bailer approach to sampling. An inflatable bladder above the bailer separates the water in the well casing from the water in the well screen. A pump inside the bailer extracts water from the volume below the bladder and discharges water above the bladder. Bladder integrity can be monitored by the rise in water levels in the sealed water column above the bladder. After extracting a minimum of one volume of water from the sample interval (the amount of water in the well casing below the bladder seal), the pump is shut off and the bailer removed to the surface where water samples are drawn from the bailer. For the well sampled, the top of the Voss sampler was lowered to 1.0 ft above the top of the well screen. At this depth, the sampler intake is at the midpoint of the well screen and the bladder is at 0.8 ft above the top of the screen. Purging lasted for 7 minutes at a rate of 0.71 L/min or 1.4 volumes of water from the sample interval. Because no water discharges to the surface, no field parameters were monitored during purging. The Voss sampler was then withdrawn and the contents of the sampler were poured into a 40-mL septum vial.

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[1]The effect of increases in volume of water purged from a well on concentrations of PCE and TCE from samples were evaluated in a separate sample comparison test and is discussed under the section "Comparison of Purge Samplers."

Table 3. Instruments used, instrumentation method code, and method detection limits for analyses of water samples

[A complete listing of constituent names are provided in appendix 2; cm mean centimeter; mg/L means milligrams per liter; ppm means part per million; NTU means neophelometric turbidity units; EPA means Environmental Protection Agency]

Location of analysis	Constituent	Instrument or method code	Method detection limit or range
Field	Temp	YSI Model 54A Oxygen Meter	1.0 degrees Celsius
	SC	Hach Model 44600 Conductivity/TDS Meter	0.1 micro-seimens/cm
	pH	Orion 915600 combination pH probe	0.02 pH units
	DO	YSI Model 54A Oxygen Meter	0.1 mg/L
	DO	Chemetrics kit 7501,7512	0-1 ppm,1-10 ppm
	CO_2	Chemetrics kit K1910	10-100 ppm
	Fe^{2+}	Hach kit #26672	0.0-10.0 mg/L
	Turbidity	Hach 2100P turbidimeter	0.01-1000 NTU
	Eh	Orion 9678BN ion selective probe	millivolts
Laboratory	NH^{4+}	EPA 350.1	0.25 mg/L
	S_{2-}	EPA 376.2	0.1 mg/L
	Cl-	EPA 325.2	2 mg/L
	SO_4^{2-}	EPA 300.0	1 mg/L
	NO_2- and NO_3-	EPA 353.2	0.05 mg/L
	NO_3-	EPA 353.2	0.05 mg/L
	NO_3-	Chemetrics R6923 after 12/98	0-70 mg/L
	NO_2-	EPA 353.2	0.05 mg/L
	PO_4^{3-}	EPA 365.3	0.001 mg/L
	CA^{2+}	EPA 200.7	1 mg/L
	Fe total	EPA 200.7	0.05 mg/L
	Mg^{2+}	EPA 200.7	0.1 mg/L
	Mn^{2+}	EPA 200.7	0.01 mg/L
	K+	EPA 200.7	0.4 mg/L
	Na+	EPA 200.7	1 mg/L
	CH_4	Methods described by McAuliffe (1971) and Crill and others (1988)	0.01 mg/L
	TOC	EPA 415.1	2 mg/L
	Br-	Orion 9635BN ion selective probe	0.001 mg/L
	$CaCo_3$	Titration to 4.5 endpoint using Hach digital titrator	0.1 mg/L
	Volatile organic compounds	EPA Schedule 8260	0.002 to 0.250 mg/L

A peristaltic pump was used to collect samples because it was being used for routine monitoring as the site by New Hampshire Department of Environmental Services. Therefore, this method was employed to help validate results of diffusion samplers. Peristaltic-pump samples were collected by inserting a dedicated 3/8-inch polyethylene tube for each well at the midpoint of the well screen, attaching the tube to the pump, and purging water following low-flow sampling procedures. Purge rates from the peristaltic pump ranged from 0.1 to 0.5 L/min. Field parameters including water level, pumping rate, specific conductance, pH, Eh, dissolved oxygen, water temperature, and turbidity were monitored during purging. Most parameters, except turbidity, were measured in a flow-through chamber (specific conductance, pH, Eh, dissolved oxygen, and water temperature). Downhole measurements of dissolved oxygen and water-temperature were made at about 20 percent of the wells. Downhole probes were placed directly below the purge intake for comparison with readings made at land surface with the flow-through chamber (appendix 2a). Samples for VOC analysis were collected in 40-mL septum vials after field parameters stabilized. Criteria for parameter stabilization followed USEPA (1996), Region 1 Standard Operating Procedures.

Bladder-pump samples were collected on five dates by placing a bladder pump at the midpoint of the well screen and withdrawing water through 1/4-inch copper tubes. Copper tubes were used because of their ability to prevent degassing of chemicals, particularly chlorofluorocarbons (CFC's), which were collected during this study (but not included in this report). The bladder pump and lines were not dedicated to specific wells but were cleaned before use at each well according to standard operating practices (Koterba and others, 1995), which included using nutrient-free detergent, methanol, and deionized washes. Water was purged following low-flow sampling procedures. Purge rates from bladder pumps ranged from 0.5 to 1.0 L/min. Samples were collected in 40-mL septum vials after field-parameter stabilization.

Quality Assurance and Control

Ground-water samples were collected in cooperation with NHDES. Selected constituents were analyzed at the NHDES laboratory and at the USGS office in Pembroke, N.H. Field-parameter data were collected by NHDES and USGS field personnel. Specific analytical methods used for particular constituents are listed in table 3.

On all VOC sampling dates, a trip blank accompanied the sampling party to and from the collection site. Samples were delivered to the NHDES laboratory and transferred with a chain of custody form after visual inspection by receiving laboratory personnel. Project method protocols included the use of method (equipment) blanks, trip blanks, field duplicates, and split samples. Equipment blanks were collected for diffusion samplers by methods described in appendix 1.

Equipment blanks were contaminated on four out of ten sample dates. This contamination could have occurred during blank sample preparation and transport or during handling at the analyzing laboratory. Three of the four equipment-blank samples showed detectable levels of acetone on September 30, 1998, February 8, 1999, and April 15, 1999, but no detection of primary constituents (PCE, TCE, and *cis*-1,2DCE). Acetone was not detected in ground-water samples for those dates. PCE was detected in one of the four equipment blanks on February 19, 1998, but the concentration (3.5 ppb) was only marginally greater than the detection limit (2 ppb) and was insignificant in relation to the PCE concentrations of ground-water samples (ranging from 830 to 4,100 ppb). No VOCs were detected in the trip blanks.

Differences between duplicates and split samples were evaluated by use of the Absolute Relative Percent Difference (ARPD) formula:

$$ARPD = \frac{|x_1 - x_2|}{\frac{x_1 + x_2}{2}} \times 100, \qquad (1)$$

where

x_1 is original sample, and

x_2 is replicate sample.

Differences between samples collected by different methods (for example, low-flow and diffusion) were evaluated by use of the Relative Percent Difference (RPD) formula:

$$RPD = \frac{x_1 - x_2}{\frac{x_1 + x_2}{2}} \times 100, \tag{2}$$

Duplicate VOC field samples were analyzed by the NHDES Laboratory following USEPA schedule 8260B. Laboratory standard-operating procedures included the use of the following steps: initial instrument calibration, check sample, laboratory blanks, matrix spikes, matrix duplicates, and laboratory fortified blanks (which include five of the primary expected VOC constituents). Approximately 3.5 percent of 350 total VOC samples were analyzed as field duplicates. The mean ARPD of duplicates with positive detections was 4.5 percent for PCE, 4.8 percent for TCE, and 4.1 percent for *cis*-1,2DCE. Standard deviations of ARPD between duplicates were less than 5 percent. The maximum ARPD of a duplicate was 10.9 percent and occurred for PCE and *cis*-1,2DCE (appendix 6).

Chemical analyzes were done on nine matrix spikes and matrix spike duplicates for five compounds (1,1-dichloroethene, benzene, trichloroethylene, toluene, and chlorobenzene by the NHDES Laboratory (Lou Barinelli, New Hampshire Department of Environmental Services, written commun., 2000). The average ARPD ranged from 2.44 to 3.93 percent for the five compounds. All results were within control limits (three standard deviations). Precision levels from matrix spikes and matrix spike duplicates are comparable to precision levels from the field duplicates and indicate that the average level of precision from the NHDES Laboratory is within 5 percent.

Detailed testing of the effect of volume, flow rate, and pump type on PCE and TCE concentrations was done at well B95-13 on April 14, 1999. Two pump types were used, bladder and peristaltic, in a sequentially higher purge rate and volumetric order of sampling. The USEPA mobile laboratory was used to analyze results. Two split samples were analyzed with the NHDES laboratory. One split sample was collected using a peristaltic pump and yielded an 20.3 percent ARPD in PCE concentration and a 13.6 percent ARPD in TCE concentration. The other split sample was collected with a bladder pump and yielded an 16.7 percent ARPD in PCE concentration and a 17.2 percent APRD in TCE concentration. Three sets of duplicate samples were analyzed by the USEPA mobile lab for samples collected using a peristaltic (two sets) and a bladder pump (one set). In addition, a laboratory duplicate was done on a peristaltic sample. The laboratory duplicate yielded a ARPD of 11.7 percent for PCE and a ARPD of 4.9 percent for TCE. The peristaltic field duplicates had a ARPD of 13.3 and 14.3 percent for PCE and a 1 and 7 percent APRD for TCE. The bladder duplicate had a ARPD of 2 percent for PCE and a ARPD of 13.8 for TCE. Averaging the above results, an average level of precision for the USEPA mobile laboratory is 13 percent for PCE and 8.8 percent for TCE.

A split sample was shared with members of the USGS New England Coastal Basins National Water Quality Assessment Program (NAWQA). Samples were sent for analyses to the USGS National Water-Quality Laboratory and NHDES laboratory and analyzed for major ions, metals, and VOCs (data are on file at the Pembroke, N.H. office). The USGS national laboratory analyzes approximately 15 more VOC constituents than the NHDES laboratory. Constituent concentrations of less than 15 percent ARPD resulted except for magnesium, which varied by more than 50 percent. The only positive detection for VOCs occurred for methyl tert-butyl ether (MTBE), which had a ARPD of 13 percent.

Field-parameter data collection by the USGS followed water-quality sampling methods and criteria in the USGS National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, 1998). Field techniques of USGS personnel trained to make water-quality measurements are verified annually by participation in the National Field Quality Assurance Program, which sends unknown samples to participants to test parameters such as pH, alkalinity, and specific conductance. Field probes and instruments are calibrated using known

standards. Laboratory analysis conducted by USGS include testing for bromide, alkalinity, and nitrate. Bromide testing was conducted on approximately 160 samples from October 1997 to September 1999, using an ion-specific probe. Ten percent of these samples were duplicate samples with matching concentrations of less than 15 percent ARPD. Alkalinity titrations were performed on 196 samples from May 1997 to September 1999, following USGS national water-quality procedures (U.S. Geological Survey, 1998). Five percent of these samples were duplicate samples with matching concentrations of less than 5 percent ARPD. Nitrate testing using colorimetric kits in the laboratory was performed from November 1998 to September 1999 on 90 samples. Nine percent of these samples were duplicate samples with generally less than 25 percent ARPD.

Additional field parameters tested for quality assurance and control included carbon dioxide, ferrous iron, and dissolved oxygen. Field-testing equipment are listed in table 3. Approximately five to ten percent of measurements were duplicates with generally less than 20 percent ARPD for carbon dioxide and ferrous iron and less than 5 percent ARPD for dissolved oxygen.

CONCEPTUALIZATION OF CONTRIBUTING AREA OF WATER SAMPLES

Understanding the differences in the volume of aquifer contributing to a specific water sample may help explain variations in water-sample concentrations. Both passive (diffusion sampling) and low-flow sampling methods sample water from a relatively small volume of the aquifer around the well opening. Although the zone of aquifer interrogated is small for both methods, small variations in these zones can lead to differences in results because the concentrations of VOCs can vary over short distances.

In diffusion sampling there is no drawdown and the sample represents an equilibrium condition between water in the diffusion sampler and ground water flowing through the well under natural flow conditions. Therefore, the natural flushing rate of the well is an important mechanism in collecting representative diffusion samples. The natural flushing rate can be relatively large and approach rates of several liters per minute in properly constructed wells tapping high-permeability aquifers.

Assuming that the natural flushing rate of the well is sufficient to allow ample flow into the well and that circulation of water within the well allows enough water to come in contact with the diffusion sampler, the volume of water in contact with the diffusion sampler will be controlled by the deployment time of the sampler, rates of ground-water flow in the aquifer, and the variability of ground-water flow due to transient conditions. Figure 11a is a conceptual diagram showing horizontal contributing areas of water in contact with the diffusion sampler for various deployment times. Theoretically, as the duration of deployment increases, the contributing area of water also will increase. This is shown in figure 11a as the near vertical lines delineating the outer extent for several weeks of deployment. The lateral extent of the contributing area will be controlled by the angular variation of flow due to transient conditions. A static or near steady-state-flow system will most likely have a narrower lateral extent than a highly transient-flow system.

The water the sampler effectively samples also will be controlled by the rate of equilibration between the sampler and the chemical compound in the well water. The equilibration time may actually constrain the contributing area so that the area that influences the concentration in the sampler is controlled by a combination of deployment time and rate of equilibration. Therefore, there will be a difference between the contributing area of the water in contact with the sampler and the contributing area of the water sampled with that sampler.

In low-flow sampling, water samples are collected in a relatively short amount of time (hours) compared to diffusion sampling. The zone of aquifer sampled is largely dependent on drawdowns during purging and sample collection. Drawdown can range from negligible amounts (less than 0.01 ft) to large amounts (more than 10 ft). For the case of negligible drawdowns, the horizontal area contributing water is primarily upgradient from the well. For large drawdowns, the horizontal contributing area also will encompass areas downgradient of the well if drawdowns extend beyond the wellbore. Sampled waters also may include borehole water, as well as aquifer water, if the aquifer is not transmissive enough to recharge the purged water. The effect of drawdown on the size and configuration of the horizontal contributing area is shown in figure 11b for a simplified case as semi-elliptical areas around the well.

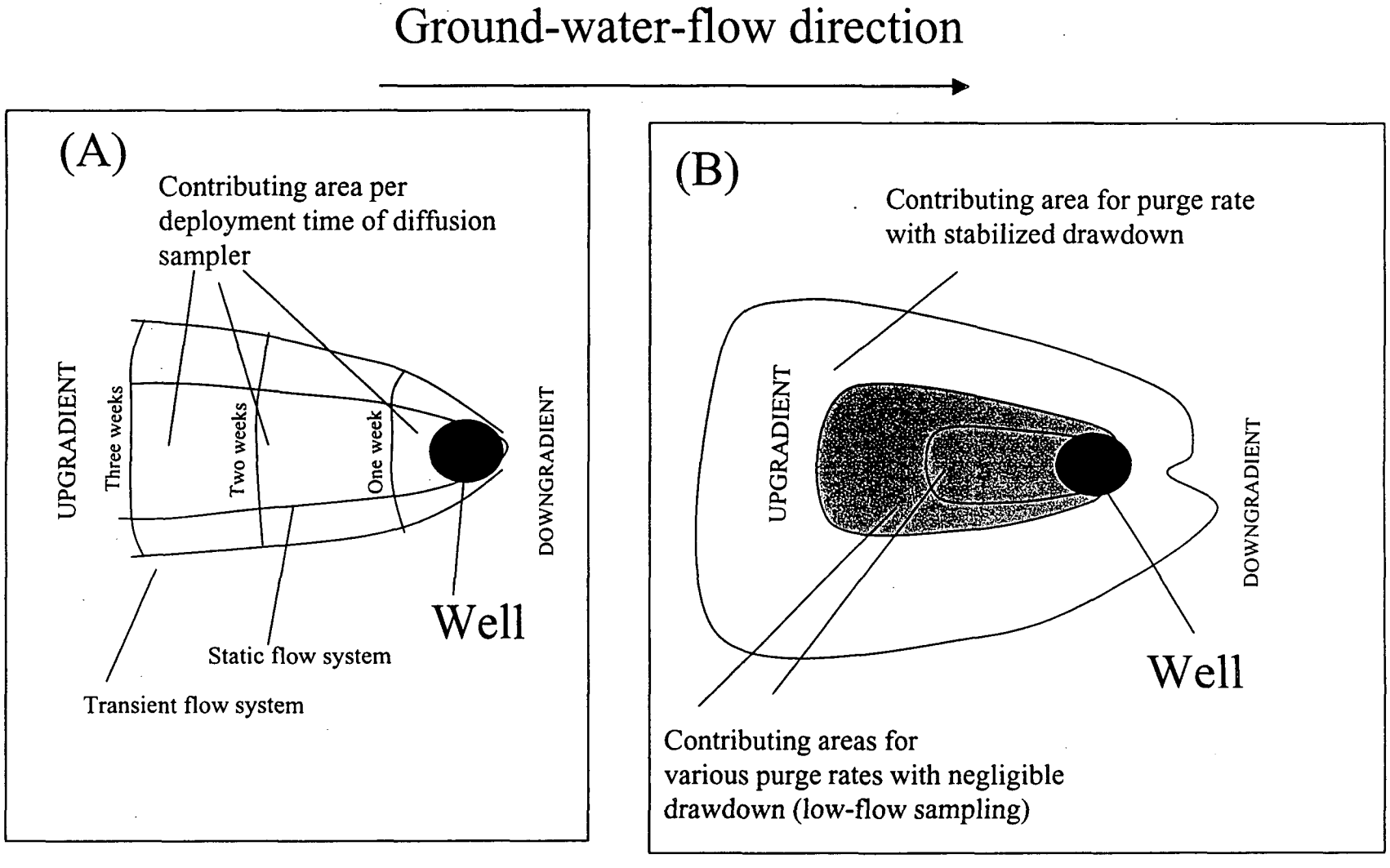


Figure 11. Conceptual diagram showing horizontal contributing areas to a well for various deployment time of diffusion sampler (a) and for various purge rates (b).

The vertical contributing area also will affect the horizontal contributing area. Purged low-flow samples may interrogate relatively short radial distances over the full screen length or large lateral distances for a fraction of the screen length.

RESULTS OF TESTING

Testing of diffusion samplers involved comparing results of VOC analyses of samples collected from diffusion samplers with those collected after purging operations. Similarity of results with standard low-flow methods suggest that diffusion samplers are suitable for use in sampling ground water for VOCs. However, differences in results between the two approaches also may suggest an acceptable validation test given the potential differences in contributing areas associated with the two methods. For example, water samples from purged methods may originate from a longer vertical length of the well opening than waters from diffusion samples. Therefore, because of vertical heterogeneity of contaminant concentrations in the aquifer, variations in contributing areas of waters will affect sample concentrations producing dissimilar results between diffusion and purged methods. The fact that the results are different does not necessarily imply that diffusion sampling is less reliable than purge sampling. Evaluation of diffusion sampling as a viable alternative sampling method must be made in consideration of these inherent differences in the contributing area of the sample and on a well by well basis.

Comparison of Diffusion Samplers with Other Samplers

The list of VOCs analyzed (USEPA schedule 8260B) and comparison of detections between peristaltic and diffusion, and bladder and diffusion samples are given in tables 4 and 5. For the bladder and diffusion comparison, which consist of only three samples, there is exact agreement of VOCs detected. For the peristaltic and diffusion comparison, which consists of twenty samples, three compounds other than the primary VOCs (PCE, TCE, and *cis*-1,2DCE) were detected. These compounds include 1,1,1-trichloroethylene and carbon disulfide, which were detected in the peristaltic samples but not in the diffusion samples, and methylene chloride, which was detected in the diffusion sample but not in the peristaltic sample. All VOCs detected by only one of the two methods have relatively high vapor pressures (more than 100 mm of mercury at 25 degrees Celsius). Therefore, differences in diffusion rates may not be the primary mechanism in causing positive detections in only one of the methods. The primary mechanism is more likely analytical precision, because the detected concentrations were all just slightly greater than the detection level (table 4).

PCE concentration results from the two primary wells in which multiple sample methods were utilized and waters withdrawn for comparison (wells B95-13 and B95-15) are shown in figures 12 and 13. Diffusion samplers provided results comparable to samples obtained with a peristaltic pump (see well B95-15 and B95-13 results in appendix 3). VOC concentrations in samples obtained using bladder pumps were higher than concentrations in samples from the diffusion bags and peristaltic pumps (see well B95-13 results in appendix 4). Differences in VOC concentrations reported in appendix 4 between bladder and diffusion samples are attributed to variations in contributing areas of sampled waters. Concentrations of VOCs from this well (B95-13) have a tendency to increase with increasing purge rate (see fig. 15b) and the increasing purge rate probably induces flow into the sample intake area from a different contributing area.

The repeated similarity between VOC concentrations in purged peristaltic samples and concentrations in diffusion samples indicates that diffusion samples provide results effectively contemporaneous to the time of retrieval. For example, diffusion samplers were installed at the end of the previous sampling round (anywhere from 2 weeks to 2 months) yet, the concentrations of contaminants in the diffusion sampler reflect the concentration of the water passing through the well at the time of retrieval because VOC concentrations compare to VOC concentrations in the purged samples collected within hours of diffusion bag retrieval. This point is illustrated by the November 1998 sample at well B95-15 (fig. 13). Water collected from the diffusion sampler (which had been

Table 4. Volatile-organic compounds analyzed and detected in water samples collected by peristaltic pump and diffusion samplers from wells in Milford, New Hampshire, from May 1998 to July 1999

[Detected compounds are in boldface type; ppb means parts per billion; RDL means reporting detection limit]

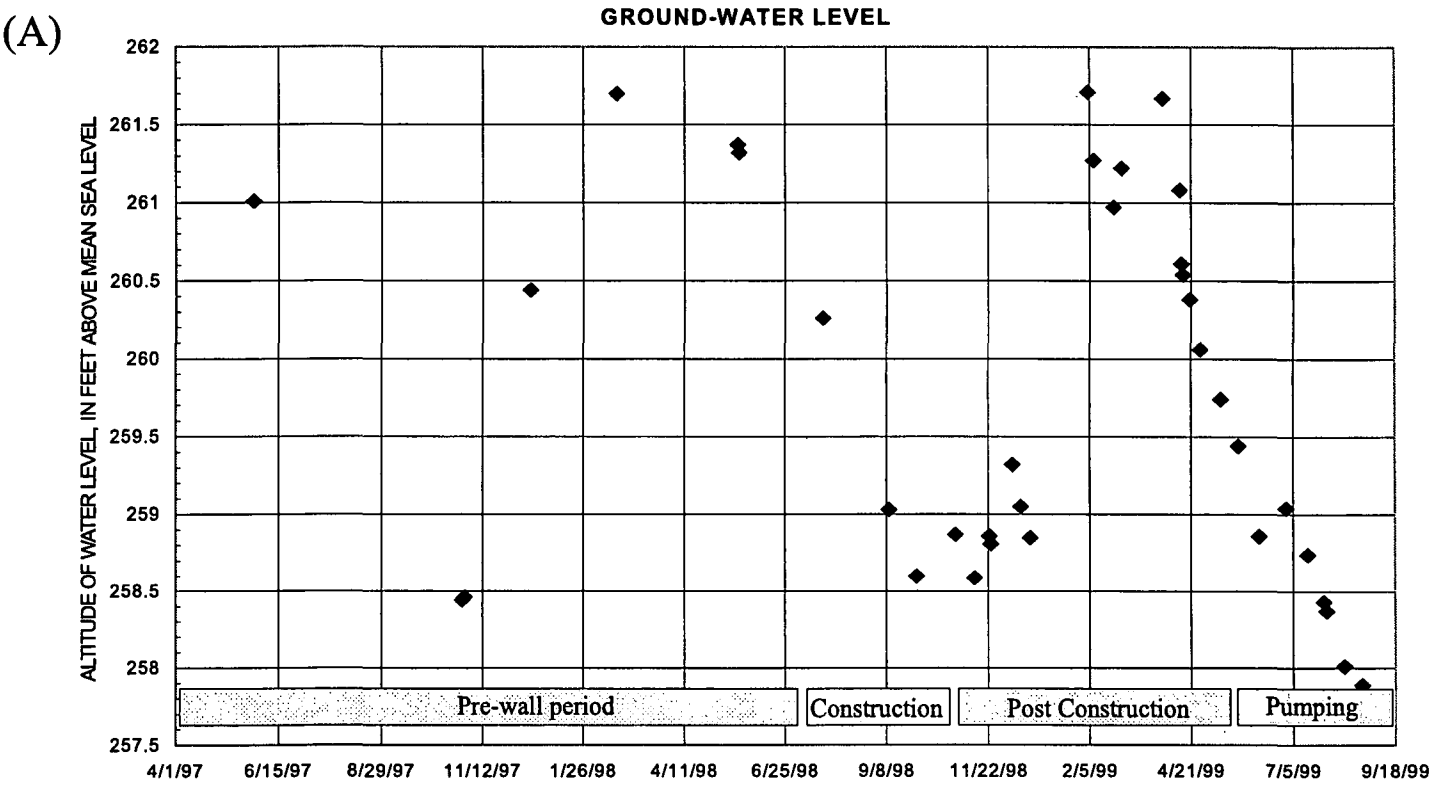
Compound name	Fraction of detects to total number of samples	
	Peristaltic	Diffusion
1,1,2,2-Tetrachloroethane	0/ 20	0/ 20
1,1,1,2-Tetrachloroethane	0/ 20	0/ 20
[1]1,1,1-Trichloroethane	1/ 20	0/ 20
1,1-Dichloroethylene	0/ 20	0/ 20
1,1-dichloroethene	0/ 20	0/ 20
1,1,2-Trichloroethane	0/ 20	0/ 20
1,1-Dichloropropene	0/ 20	0/ 20
1,2,4-Trimethylbenzene	0/ 20	0/ 20
1,3,5-Trimethylbenzene	0/ 20	0/ 20
1,2-Dibromo-3-chlororpropane	0/ 20	0/ 20
trans-1,2-Dichloroethene	0/ 20	0/ 20
trans-1,3-Dichloropropene	0/ 20	0/ 20
1,2,3-Tricholoropropane	0/ 20	0/ 20
1,3-Dichloropropane	0/ 20	0/ 20
1,2-dichloroethene	0/ 20	0/ 20
1,2-Dichloropropane	0/ 20	0/ 20
1,2-Dichlorobenzene	0/ 20	0/ 20
1,2,3-Trichlorobenzene	0/ 20	0/ 20
1,2,4-Trichlorobenzene	0/ 20	0/ 20
2,2-Dichloropropane	0/ 20	0/ 20
cis-1,2-Dichloroethene (*cis*-1,2DCE)	20/20	20/20
2-Butanone (MEK)	0/ 20	0/ 20
2-Hexanone	0/ 20	0/ 20
4-Methyl-2-Pentanone (MIBK)	0/ 20	0/ 20
Acetone	0/ 20	0/ 20
Bromobenzene	0/ 20	0/ 20
Benzene	0/ 20	0/ 20
Bromochloromethane	0/ 20	0/ 20
Bromoform	0/ 20	0/ 20
Bromomethane	0/ 20	0/ 20
n-Butylbenzene	0/ 20	0/ 20
sec-Butylbenzene	0/ 20	0/ 20
tert-Butylbenzene	0/ 20	0/ 20
Carbon tetrachloride	0/ 20	0/ 20
[2]Carbon disulfide	1/ 20	0/ 20
o-Chlorotoluene	0/ 20	0/ 20
p-Chlorotoluene	0/ 20	0/ 20
Chloroethane	0/ 20	0/ 20
Chloromethane	0/ 20	0/ 20
Chloroform	0/ 20	0/ 20
Chlorobenzene	0/ 20	0/ 20
Dibromomethane	0/ 20	0/ 20
Dibromochloromethane	0/ 20	0/ 20
Dichlorobromomethane	0/ 20	0/ 20
Dichlorodifluoromethane	0/ 20	0/ 20
Diethyl ether	0/ 20	0/ 20
Ethylene dibromide	0/ 20	0/ 20
Ethylbenzene	0/ 20	0/ 20
Hexachlorobutadiene	0/ 20	0/ 20
Isopropylbenzene	0/ 20	0/ 20
Methyl-*tert*-butyl ether (MTBE)	0/ 20	0/ 20
[3]Methylene chloride	0/ 20	1/20
Naphthalene	0/ 20	0/ 20
Para-isopropyltoluene	0/ 20	0/ 20
n-Propylbenzene	0/ 20	0/ 20
Styrene	0/ 20	0/ 20
Tetrachloroethylene (PCE)	20/20	20/20
Tetrahydrofuran (THF)	0/ 20	0/ 20
Trichlorofluoromethane	0/ 20	0/ 20
Trichloroethylene (TCE)	20/20	19/20
Toluene	0/ 20	0/ 20
Vinyl chloride	0/ 20	0/ 20
Xylenes (total)	0/ 20	0/ 20

[1]Detected value 12 ppb (RDL 10 ppb).
[2]Detected value 2.7 ppb (RDL 2.0 ppb).
[3]Detected value 21 ppb (RDL 20 ppb).

Table 5. Volatile-organic compounds analyzed and detected in water samples collected by bladder pump and diffusion samplers from wells in Milford, New Hampshire, from May 1998 to April 1999

[Detected compounds are in boldface type]

Compound name	Fraction of detects to total number of samples	
	Bladder	Diffusion
1,1,2,2-Tetrachloroethane	0/ 3	0/ 3
1,1,1,2-Tetrachloroethane	0/ 3	0/ 3
1,1,1-Trichloroethane	0/ 3	0/ 3
1,1-Dichloroethylene	0/ 3	0/ 3
1,1-dichloroethene	0/ 3	0/ 3
1,1,2-Trichloroethane	0/ 3	0/ 3
1,1-Dichloropropene	0/ 3	0/ 3
1,2,4-Trimethylbenzene	0/ 3	0/ 3
1,3,3-Trimethylbenzene	0/ 3	0/ 3
1,2-Dibromo-3-chlororpropane	0/ 3	0/ 3
trans-1,2-Dichloroethene	0/ 3	0/ 3
trans-1,3-Dichloropropene	0/ 3	0/ 3
1,2,3-Tricholoropropane	0/ 3	0/ 3
1,3-Dichloropropane	0/ 3	0/ 3
1,2-dichloroethene	0/ 3	0/ 3
1,2-Dichloropropane	0/ 3	0/ 3
1,2-Dichlorobenzene	0/ 3	0/ 3
1,2,3-Trichlorobenzene	0/ 3	0/ 3
1,2,4-Trichlorobenzene	0/ 3	0/ 3
2,2-Dichloropropane	0/ 3	0/ 3
cis-1,2-Dichloroethene (*cis*-1,2DCE)	3/ 3	3/ 3
2-Butanone (MEK)	0/ 3	0/ 3
2-Hexanone	0/ 3	0/ 3
4-Methyl-2-Pentanone (MIBK)	0/ 3	0/ 3
Acetone	0/ 3	0/ 3
Bromobenzene	0/ 3	0/ 3
Benzene	0/ 3	0/ 3
Bromochloromethane	0/ 3	0/ 3
Bromoform	0/ 3	0/ 3
Bromomethane	0/ 3	0/ 3
n-Butylbenzene	0/ 3	0/ 3
sec-Butylbenzene	0/ 3	0/ 3
tert-Butylbenzene	0/ 3	0/ 3
Carbon tetrachloride	0/ 3	0/ 3
Carbon disulfide	0/ 3	0/ 3
o-Chlorotoluene	0/ 3	0/ 3
p-Chlorotoluene	0/ 3	0/ 3
Chloroethane	0/ 3	0/ 3
Chloromethane	0/ 3	0/ 3
Chloroform	0/ 3	0/ 3
Chlorobenzene	0/ 3	0/ 3
Dibromomethane	0/ 3	0/ 3
Dibromochloromethane	0/ 3	0/ 3
Dichlorobromomethane	0/ 3	0/ 3
Dichlorodifluoromethane	0/ 3	0/ 3
Diethyl ether	0/ 3	0/ 3
Ethylene dibromide	0/ 3	0/ 3
Ethylbenzene	0/ 3	0/ 3
Hexachlorobutadiene	0/ 3	0/ 3
Isopropylbenzene	0/ 3	0/ 3
Methyl-*tert*-butyl ether (MTBE)	0/ 3	0/ 3
Methylene chloride	0/ 3	0/ 3
Naphthalene	0/ 3	0/ 3
Para-isopropyltoluene	0/ 3	0/ 3
n-Propylbenzene	0/ 3	0/ 3
Styrene	0/ 3	0/ 3
Tetrachloroethylene (PCE)	3/ 3	3/ 3
Tetrahydrofuran (THF)	0/ 3	0/ 3
Trichlorofluoromethane	0/ 3	0/ 3
Trichloroethylene (TCE)	3/ 3	3/ 3
Toluene	0/ 3	0/ 3
Vinyl chloride	0/ 3	0/ 3
Xylenes (total)	0/ 3	0/ 3



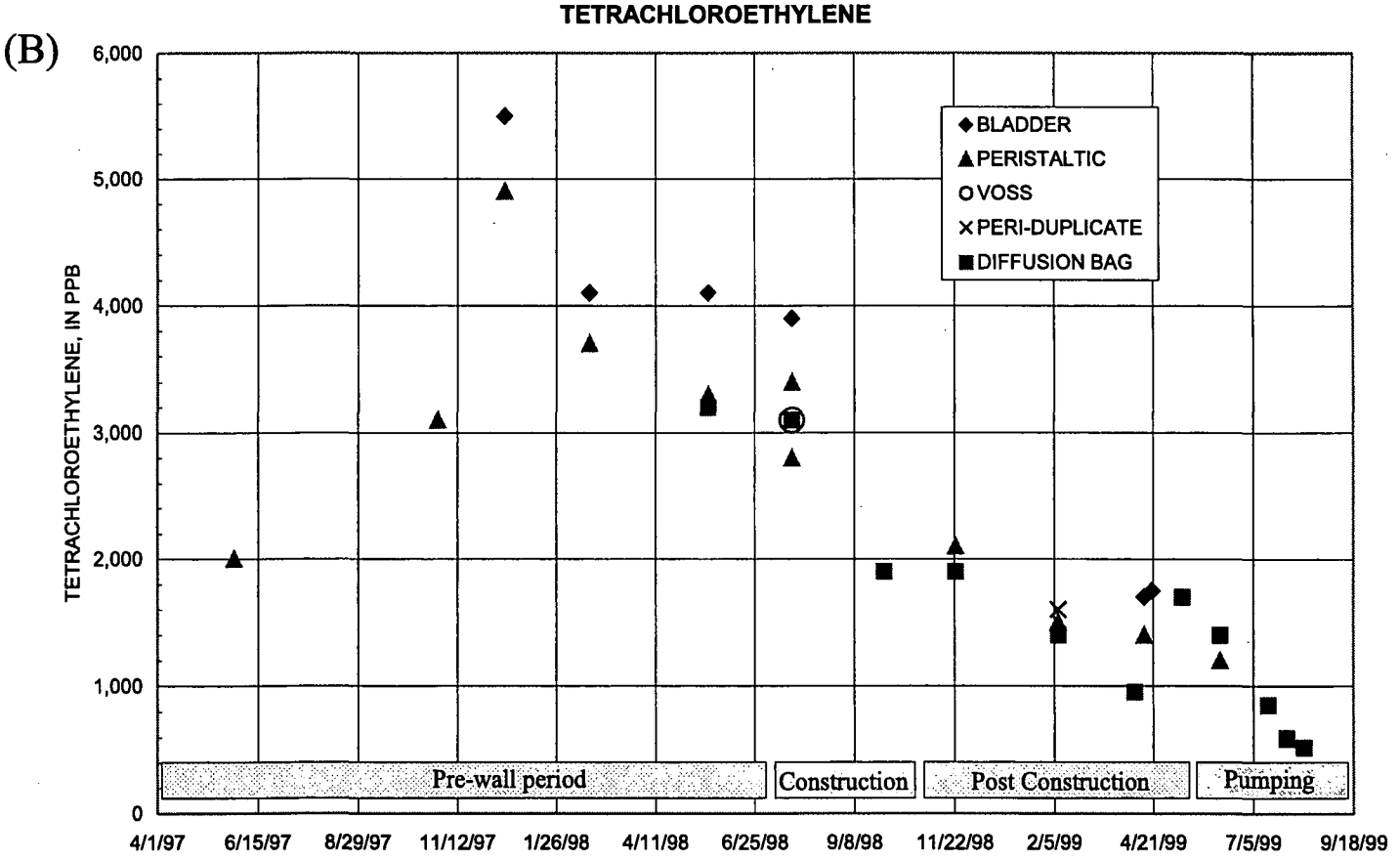
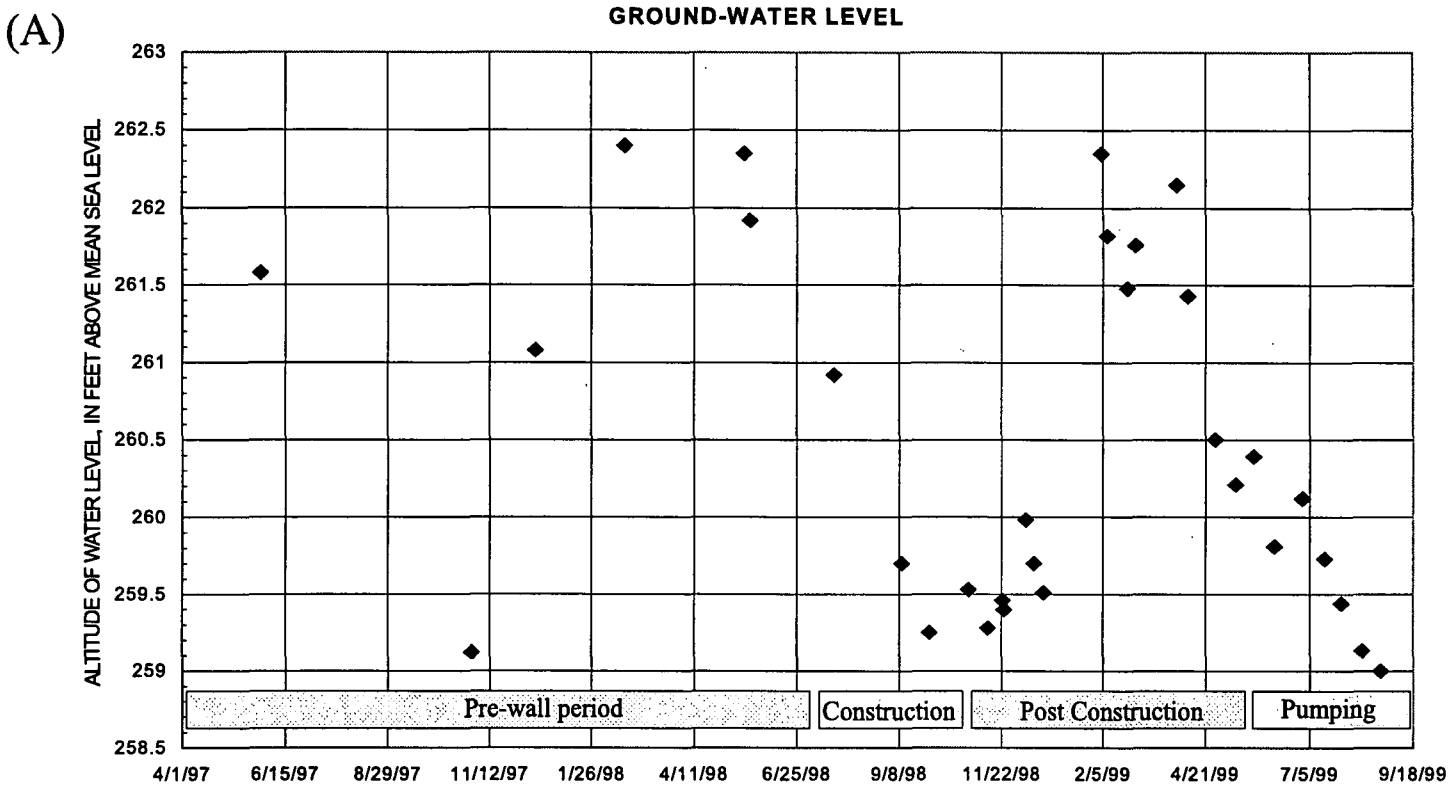


Figure 12. Ground-water levels (A) and concentration of tetrachloroethylene (PCE) in samples collected by various methods (B) for well B95-13.



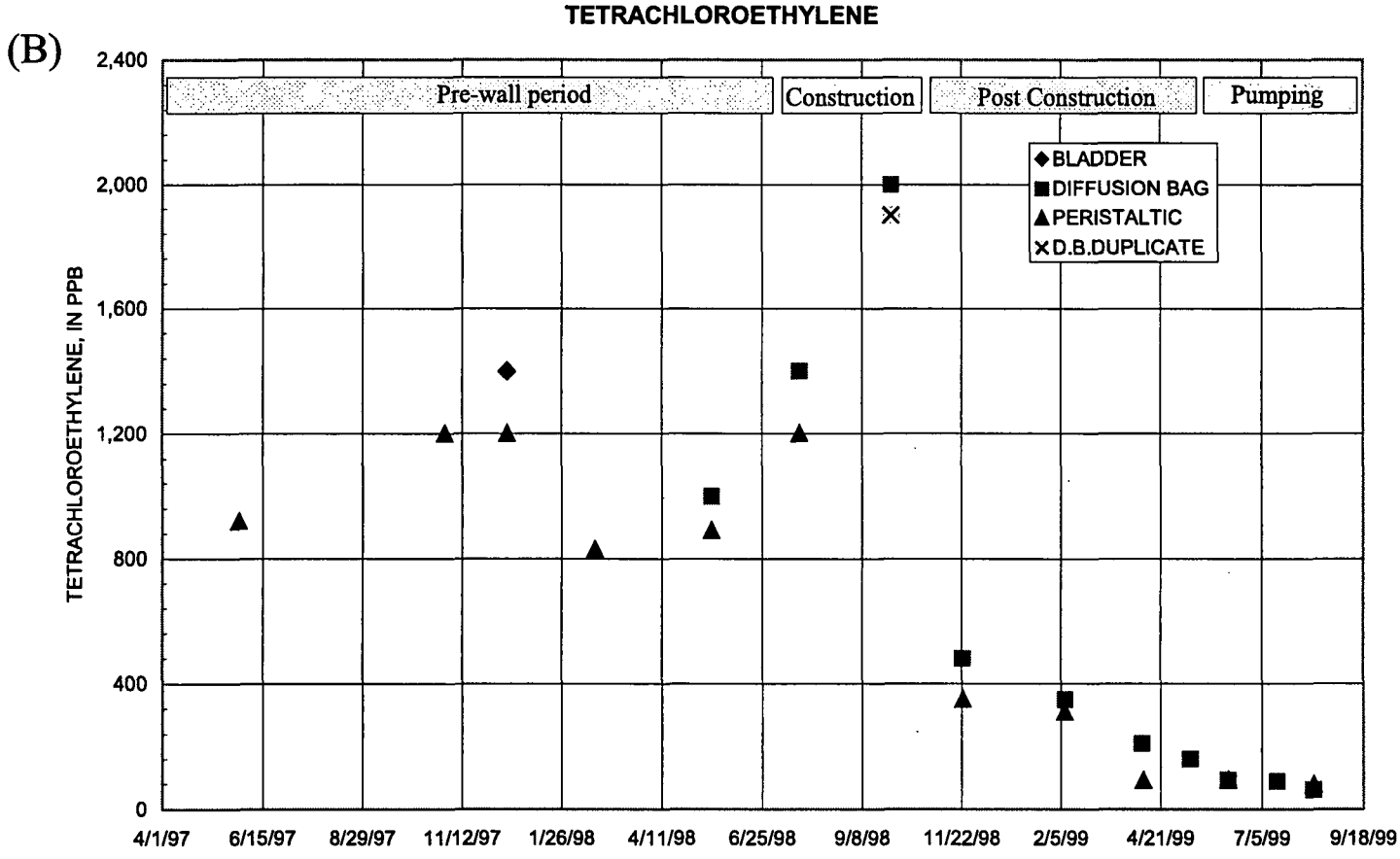


Figure 13. Ground-water levels (A) and concentration of tetrachloroethylene (PCE) in samples collected by various methods (B) for well B95-15.

installed in September when PCE concentrations were 2,000 ppb) in November yielded a concentration of 500 ppb of PCE, a concentration comparable to the 375 ppb of PCE detected in the peristaltic sample also in November.

Concentrations of VOCs in 20 samples collected by diffusion samples in 7 glacial-drift wells[2] correlate well with concentrations from low-flow peristaltic samples from the same wells (fig. 14). The linear regressions produce root-mean squares of 0.966 for PCE, 0.942 for TCE, and 0.979 for *cis*-1,2DCE. The PCE and *cis*-1,2DCE regression lines are virtually identical to the 1:1 line. The TCE regression line shows that TCE concentrations for the diffusion samples are greater than concentrations for the peristaltic samples.

The mean PCE concentration for diffusion samples is 1,152 ppb and the mean from the peristaltic samples is 1,119 ppb (table 6). The standard deviations also are similar. A two-tailed students t-test of equal variance between the two data sets indicates a 96-percent probability that the means are from the same population. Comparison of results for other VOCs also shows excellent agreement. The mean TCE concentration for diffusion samples is slightly higher than the mean concentration for peristaltic samples, whereas, the means for *cis*-1,2DCE are identical for both methods.

Relative Percent Differences (RPD) of VOC concentrations between peristaltic and diffusion samples indicate that diffusion samples provide "on average" higher concentrations than peristaltic samples (table 7). The mean RPD for PCE was -13.42 percent (negative concentration indicates concentration from diffusion sample is greater than concentration from peristaltic sample), the RPD for TCE was -16.3 percent, and the RPD for *cis*-1,2DCE was -3 percent. Compared to duplicate results that show much smaller differences (except for *cis*-1,2DCE), diffusion sample results are larger than differences associated with analytical precision. This is an important point and indicates that concentrations from diffusion samples had a tendency (although not statistically proven) to provide higher concentrations than concentrations from peristaltic samples. Because of the potential for VOCs to degas during peristaltic pump sampling (Imbrigiotta and others, 1988), it seems reasonable to expect these differences. The accuracy of peristaltic pumps to collect representative samples is discussed in the section "Comparison of Purge Samplers."

The effects of deployment time on VOC concentration from diffusion samplers were evaluated by plotting the measured concentration differences between the diffusion samples and peristaltic samples against deployment time of diffusion samplers. A plot of linear scatter (fig. 15a) of the data shows a wide spread of data relative to the y-axis and thus a poor linear correlation (R^2 of 0.15). The percent difference in differential concentrations also were plotted (fig. 15b) and also shows a wide scatter of data. In figure 15b a linear regression also was fitted to the data but a poor fit (R^2 of 0.15) resulted as well. In both graphs, the effect of deployment time is not observable and the wide scatter of data points suggest differences are caused by factors other than the time required for equilibration, such as differences in contributing areas of sampled water.

In the deployment time plot shown in figure 15a, as well as the linear regression plots shown in figure 14, the largest difference in results between diffusion samplers and peristaltic samples occurred for sample B95-13 in April 1999, which is the only comparison set that was not sampled on the same day (sample number 6 in appendix 5). This suggest that the difference in sample time probably affected results of the validation and emphasizes the importance of contemporaneous comparison of sample methods.

The evidence discussed in this section indicates that whereas diffusion samples provide VOC concentrations that are slightly higher than concentrations from peristaltic samples, the differences are not statistically different at a 96 percent probability. The mean concentration of VOCs, the RPD's, and graphical illustrations all show a tendency for slightly higher concentrations from diffusion samples than peristaltic-pump samples. In general, the diffusion samplers provided excellent results that were validated against purged-type sample methods.

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[2]Results from bedrock wells were not corroborated against purged samples due to limitations on the scope of the project.

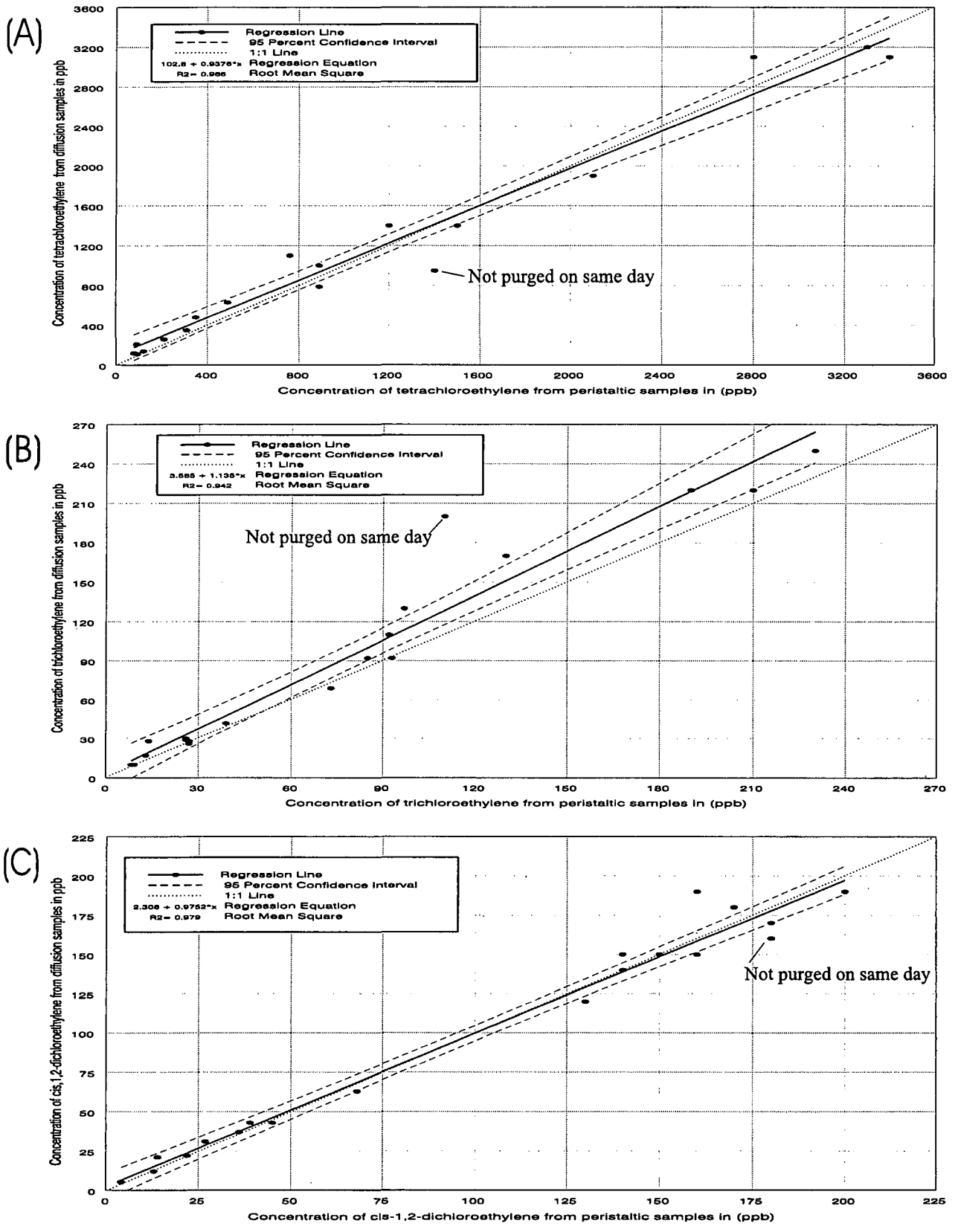

Figure 14. Linear regression of concentrations from peristaltic and diffusion samples for tetrachloroethylene (PCE) (A) , trichloroethylene (TCE) (B), and *cis*-1,2-dichloroethene (*cis*-1,2DCE) (C).

Table 6. Statistical summary of concentrations of volatile-organic compounds from peristaltic and diffusion samples

[ppb means part per billion]

	Tetrachloroethylene (PCE)		Trichloroethylene (TCE)		*cis*-1,2-dichloroethene (*cis*-1,2DCE)	
	Peristaltic	Diffusion	Peristaltic	Diffusion	Peristaltic	Diffusion
Number of samples	20	20	20	20	20	20
Mean, in ppb	1,119.1	1,152.	75.4	89.2	95.0	95.0
Median, in ppb	890	975	56	55.5	99	91.5
Standard deviation of sample, in ppb	1,048.4	1,000.3	69.7	81.5	70.5	69.5
Maximum, in ppb	3,400.	3,200.	230	250	200	190.
Minimum, in ppb	78	110	8.4	10	4.2	5.2

Table 7. Summary of absolute relative percent differences (ARPD) between laboratory duplicate samples and relative percent difference (RPD) between peristaltic samples and diffusion samples

[PCE, Tetrachloroethylene; TCE, Trichloroethylene; *cis-1,*2DCE, *cis*-1,2-dichloroethene; negative values indicate that sample concentrations from diffusion sampler were greater than those from the perstaltic pump; % means percent; see appendix 5 for individual calculation of RPD; see appendix 6 for individual calculation of ARPD; only duplicate results from NHDES laboratory which include all three primary constiuents (PCE, TCE, and *cis*-1,2DCE) are considered for ARPD calculations]

	Duplicate samples	Method samples	Duplicate samples	Method samples	Duplicate samples	Method samples
	ARPD PCE	RPD PCE	ARPD TCE	RPD TCE	ARPD *cis*-1,2DCE	RPD *cis*-1,2DCE
Mean	4.50%	-13.42%	4.81%	-16.30%	4.10%	-3.00%
Median	4.32%	-15.38%	4.20%	-12.60%	4.30%	0.00%
Standard deviation	4.04%	24.40%	4.18%	18.49%	1.74%	12.53%
Number of samples	10	20	6	20	5	20
Maximum	10.91%	38.30%	10.91%	5.63%	5.41%	11.76%
Minimum	0.00%	-79.07%	0.00%	-66.67%	1.16%	-40.00%

Vertical Variations

Heterogeneity and stratification of chemical concentrations in aquifers and wells is common. Vertical variations in concentrations of VOCs were detected in strings of diffusion samplers installed in two wells (B95-13 and MW-16R (well number 345, table 8) in July 1999. The first string of samplers consisted of three bags with a 2-ft spacing and installed in a 5-ft long, 2-inch-diameter screen (well B95-13) in sand and gravel. The uppermost diffusion sampler was placed 1/2 ft below the top of screen and the lowermost sampler was 1/2 ft above the bottom of screen. Concentrations of PCE were one-third lower in the sample from the uppermost sampler, set near the top of the screen, than concentrations from the middle and lowermost samplers. The uppermost sampler is adjacent to a slightly finer grained sand layer, whereas the middle and lowermost samplers are adjacent to a coarser grained layer of sands and gravels. The variation in concentrations of TCE and *cis*-1,2DCE was much smaller than the variation in concentrations of PCE.

The second string of samplers consisted of four bags with a 6-ft spacing installed in a 38-ft long, 6-inch-diameter open borehole in bedrock well MW-16R (well number 345). Two of the four samplers were placed side by side at the midpoint between upper and lower samplers to test the effects of different enclosures (mesh sleeve versus a pvc-slotted pipe) on water flow and diffusion to the diffusion bag. PCE concentrations differ vertically and also between enclosure types. TCE concentrations show little difference vertically or between types of enclosures. *Cis*-1,2DCE concentrations increase with depth and show little differences between enclosure types.

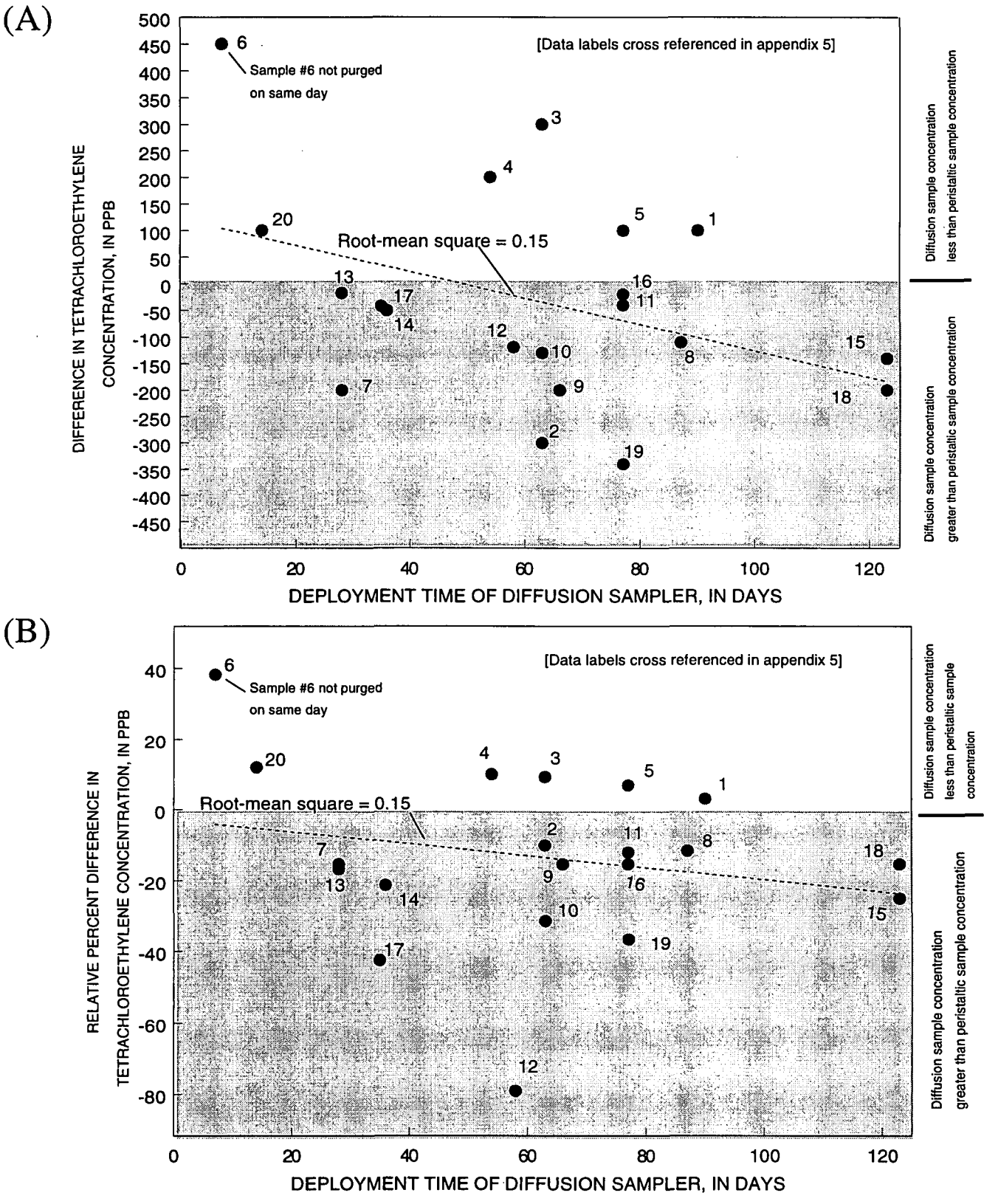

Figure 15. Comparison between deployment time of diffusion sampler and difference of measured concentrations of tetrachloroethylene (PCE) from diffusion and peristaltic-pump samples (A) and comparison of percent difference (B).

Table 8. Variations in concentrations of PCE, TCE, and *cis*-1,2DCE in vertical strings of diffusion samplers, in July and October 1999 and from purge sample from well MW-16R in October 1999

[Residence times for July sample was 14 days; residence times for October sample was 49 days; tetrachloroethylene (PCE), trichloroethylene (TCE); *cis*-1,2-dichloroethene (*cis*-1,2DCE); ppb means parts per billion; mesh means polyethylene mesh holder; -- means no data; pvc means polyvinyl chloride holder]

Well name and number (fig. 3)	Open interval, in feet below land surface	Location of midpoint of sampler, in feet below land surface	Type of sample enclosure or sample	July 30, 1999			October 28, 1999		
				PCE, in ppb	TCE, in ppb	*cis*-1,2 DCE, in ppb	PCE, in ppb	TCE, in ppb	*cis*-1,2 DCE, in ppb
B95-13 (well number 408)	60-65	60.5	mesh	290	40	100	--	--	--
		62.5	mesh	590	40	100	--	--	--
		64.5	mesh	590	40	110	--	--	--
MW-16R (well number 345)	100-138	108.5	pvc	78	25	32	270	37	43
		114.5	pvc	180	32	35	340	83	110
		114.5	mesh	110	29	38	310	66	98
		114.5	peristaltic	--	--	--	260	56	140
		120.5	pvc	110	49	110	630	98	190

The string-of-samplers test was repeated in bedrock well MW-16R in October 1999 because of the differences in PCE concentrations between enclosures in July. The results of the October test show a much smaller difference in PCE concentrations between the enclosures, with a nine percent APRD as opposed to a 48 percent APRD for the July test. Recall that the mean ARPD from duplicates is 4.5 percent for PCE (table 7) and that the standard deviation is 4.0 percent. The upper control limits for analytical precision of a compound is typically 3 times the standard deviation and is, consequently, 12 percent for PCE (at the 99.9 percent confidence interval) based on the analyses of duplicates. Therefore, concentrations of PCE from the different enclosures in the second test are statistically similar.

Vertical variations in concentrations of PCE were larger in the October 1999 test than in the July test. PCE concentrations differ by more than 100 percent and increase with depth in the October 1999 test. In addition, vertical variations in concentrations also were measured for TCE and *cis*-1,2DCE in October, unlike July concentrations that indicated small differences except for *cis*-1,2DCE concentrations.

A single purge sample was taken in October 1999 at MW-16R to compare concentrations from diffusion samples to purge samples. The tube intake for the peristaltic sample was set at the same vertical depth as the middle horizon of the vertical string test (114.5 ft below land surface). PCE and TCE concentrations were lower from the peristaltic sample than the two diffusion samples taken at the same depth. The RPD was -17.5 percent and -16.6 percent (negative indicating diffusion sample concentration from mesh enclosure was higher than the peristaltic sample concentration) for PCE and TCE, respectively. Concentration of *cis*-1,2DCE was higher from the peristaltic sample than the two diffusion samples. The RPD was 35.3 percent for *cis*-1,2DCE (positive indicating diffusion sample concentration from mesh enclosure was lower than the peristaltic sample concentration).

Pumpage of water in boreholes and wells induces vertical circulation of water. The large difference in concentrations of *cis*-1,2DCE between peristaltic and diffusion samples for the middle interval could result from the peristaltic sample inducing some water circulation from the lowermost sample interval where concentrations in VOCs are greater than the upper sample intervals.

Results of the vertical string test show there are large vertical differences in concentrations of VOCs in the two tested wells. Diffusion samplers were shown to have the ability to identify chemical stratification of VOCs in the tested wells and thus the use of additional vertical-string tests would be useful to help identify the vertical source of water from purged samples and whether additional vertical sampling is needed.

Comparison of Purge Samplers

Because most of the diffusion-sample results were compared to results from samples collected with a peristaltic pump, an additional test was performed at well B95-13 to evaluate differences in PCE and TCE concentrations between samples retrieved by bladder and peristaltic pumps. The test was designed not only to evaluate differences in concentration of samples retrieved by these pumps, but also to investigate differences in concentrations with changes in purge rates and volume. Nine samples were collected at ascending and then descending purge rates (table 9). Samples are labeled in table 9 (column 1) by pump type, purge rate, and whether the samples were collected during a forward sequence (ascending rate of purge) or reverse sequence (descending rate of purge). For example, samples p.25f and p.48f denote samples collected with the peristaltic pump, during an ascending purge rate, 0.25 and 0.48 L/min, respectively. Under all cases, drawdowns were negligible (less than 0.06 ft) during the test.

The pump test and sampling was designed to minimize differences between collection of samples with peristaltic and bladder pumps. A 1/4-inch polyethylene tube (for use with a peristaltic pump) and a bladder pump were lowered to the same interval, at the midpoint of the well screen, and set several days before the start of the pump test to avoid disturbing the water column inside the well. A 1/4-inch copper[3] tube was used to deliver water from the bladder pump because this type of tube was used previously for other bladder-pump samples.

The sequence of pumping followed the listing of samples reported in table 9. First, the peristaltic pump was operated at a rate of 0.25 L/min for 100 min and VOC samples were collected (sample p.25f). Next, the peristaltic pump was operated at a rate of 0.48 L/min for 59 min and samples were collected at 159 min into the test (sample p.48f). The peristaltic pump and the bladder pump were simultaneously turned off and on and the bladder pump was operated at a rate of 0.45 L/min for 245 min and samples were collected at 404 min into the test (sample b.45f). The bladder pump was increased to a rate of 0.97 L/min and operated for 76 min and samples were collected at 480 min into the test (sample b.97f). The pump rate of the bladder was then decreased to 0.5 L/min while simultaneously turning on the peristaltic pump and operating it at a rate of 0.5 L/min to yield a combined rate of 1.0 L/min. Dual pumping occurred for 85 min. Samples from the peristaltic pump were collected at 65 min into the dual operation period (545 min into the test, sample p.1+) and samples from the bladder pump were collected at 85 min into the dual operation period (565 min into the test, sample b.1+). The peristaltic pump was shut off and the bladder pump continued to operate at it's same rate for another 17 min and samples were collected 583 min into the test (sample b.5r2). The bladder pump and peristaltic pump were simultaneously turned off and on and the peristaltic pump was operated for another 18 min and the sample collected at 595 min into the test (sampled p. 49r2). Finally, the peristaltic pump rate was decreased to 0.33 L/min and samples were collected at 625 min into the test (sample p.33r). This sequence of pumping allowed for continuous purging of the well and evaluation of the effect of purge type, purge rate, and sequence of sampling on VOC concentrations.

Figure 16 shows the results from analyses of PCE concentration of samples. Precision (error) bars are shown with results and span 13 percent of the reported PCE concentration. The 13 percent precision for PCE is the average ARPD of splits, field duplicates, and lab duplicates from samples during this test and represents the level of precision of reported concentrations for PCE. The average ARPD for TCE is 8.8 percent. Results from quality assurance and control measurements are discussed in the preceding section of this report.

A sequential plot (fig. 16a) of PCE concentrations shows an increase in concentration during the ascending rate of purging and a small decline during the descending rate of purging, which indicates that purge rates affect PCE concentrations more than the cumulative volume purged. A plot of purge rate in relation to concentration shows a moderate trend toward higher concentrations with higher purge rates (fig. 16b). The type of pump also appears to effect the PCE concentration. Three of the four bladder samples had higher PCE concentrations than the five peristaltic samples (table 9).

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[3]Reynolds and others (1990) report that low-density polyethylene tubing may adsorb PCE more readily than rigid tubing such as cooper tubing. They found that a diffusive transport model correctly represented loss of PCE from various tubing materials. Following this approach, PCE concentrations in our case may decrease by as much as 2 percent when pulling water through the polyethylene tubing compared to the cooper tubing.

Table 9. Water-quality results from test comparing peristaltic and bladder pumps at well B95-13, April 14, 1999

[Elapsed time for an individual sample is the difference between the preceding cumulative time and the current cumulative time. min=minute, l=liters, ppb= part per billion, mg/L = milligrams per liter, ppmv=parts per million, umhos/cm=micromhos per centimeter mv=millivolts, ntu=neophelometric turbidity units, -- means no data, >, greater than]

Sample name[1]	Pump type (p=peristaltic, b=bladder)	Time, in hours and minutes	Cumulative time, in minutes	Purge rate, in L/min	Cumulative volume purged[2], in liters	Equivalent volume of water purged, in volumes of casing	Tetrachloroethylene (PCE), in ppb	Trichloroethylene (TCE), in ppb	Dissolved oxygen, in mg/L	Carbon dioxide, in mg/L	Methane, in ppmv	pH	Water temperature, in degrees Celsius	Total organic carbon, in mg/L	Specific conductance, in umhos/cm	Field Eh, in mv	Turbidity, in ntu
p.25f	p	1326	100	0.26	26	0.7	1,685	100	0.2	25	--	--	10.6		145	253	0.55
p.48f	p	1425	159	0.48	54.32	1.5	1,717	96	0.1	22	14.36	--	10.9	0.84	124	270	0.59
b.45f	b	1611	404	0.45	87.17	2.4	2,010	101	0.5	25	14.84	6.61	10.7	1.33	138	245	0.99
b.97f	b	1725	480	0.97	151.19	4.2	2,006	99	1.	22	13.18	6.98	10.5	--	126	247	>10
p.1+	p	1830	545	1.08	221.39	6.1	1,877	113	0.7	19	15.49	6.82	10.2	--	128	246	2.2
b.1+	b	1850	565	1.08	243	6.7	2,032	118	0.2	19	14.28	6.58	9.8	--	--	242	0.36
b.5r2	b	1908	583	0.5	252	6.9	1,738	105	--	--	--	6.55	9.7	--	127	372	--
p.49r2	p	1920	595	0.49	257.9	7.1	1,841	98	0.6	20	--	7.14	10	--	128	165	1.88
p.33r	p	1950	625	0.33	267.8	7.4	1,783	104	0.4	18	--	7.13	9.8	--	128	156	0.97

[1]Sample names are denoted by pump type, purge rate, and whether sampled during an ascending purge rate sequence (f) or descending (r). The symbols + indicates that two pumps were actively purging, in this case the peristaltic (p.1+) and bladder (b.1+). Therefore, the combined rate is listed in the purge rate.

[2]Cumulative volume purged is computed as follows as shown for the value reported for p.48f (54.32 L): the differential in time between sample p.48f and the preceding sample b.45f is 159 min-100 min = 59 min at purge rate of 0.48 L/min (purge rate for p.48f), which is equal to 28.32 L; this is combined with the volume from the preceding sample (p.25f), which is 100 min at 0.26 L/min or 26 L to yield a cumulative volume of 54.32L (28.32+26).

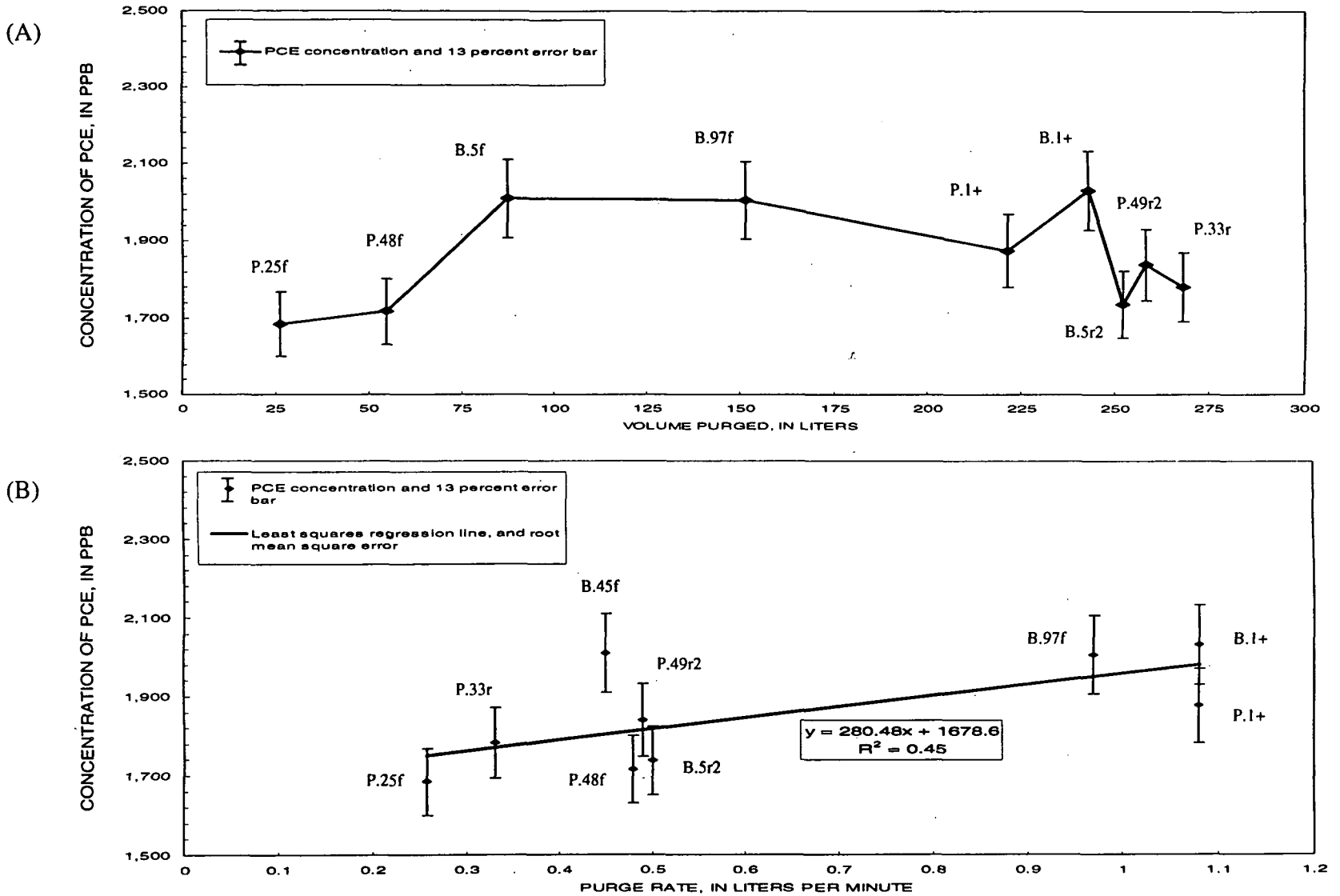

Figure 16. Concentrations of tetrachloroethylene (PCE) from tests comparing peristaltic and bladder pumps, for PCE and volume purged (A), and PCE and purge rate (B), April 14, 1999 (data point labels denote pump type, purge rate and sequence of pumping; P = peristaltic, B = bladder, f = ascending purge rate, r = descending purge rate, + = pumps both operating, 2 = duplicate).

Table 10. Summary statistics comparing concentrations of tetrachloroethylene (PCE) and trichloroethylene (TCE) grouped by pump type from samples collected at well B95-13 (well number 408), April 14, 1999

[L/min means liter per minute; ppb means part per billion; % means percent; -- means no data]

	All samples		Comparable purge rates (excluding b.97, p.25f, and p.33r samples; table 9)	
	Bladder pump	Peristaltic pump	Bladder pump	Peristaltic pump
Number of samples	4	5	3	3
Mean purge rate, in L/min	0.75	0.53	0.68	0.68
Mean concentration of PCE, in ppb	1,947	1,781	1,927	1,812
Standard deviation of sample	139.5	80.8	163.8	83.9
95% confidence interval	2,065-1,829	1,844-1,718	2,078-1,776	1,890-1,734
p-value from students t-test (two-tailed)	0.06	--	0.34	--
Mean TCE, in ppb	105.8	102.2	108.	102.8
Standard deviation of sample	7.4	6.0	7.3	6.6

Sample statistics indicate that PCE concentrations of bladder-pump samples are generally greater than concentrations from peristaltic-pump samples but not statistically different at the 95 percent confidence level (table 10). The computed [4]p-values from the students two tailed t-test are greater than the confidence level of 0.05 indicating that the bladder results are statistically similar to the peristaltic results. The difference in mean concentrations between bladder and peristaltic results is larger, although not statistically different, when all samples are analyzed then when only samples of similar purge rates are compared. The p-value from the student's two-tailed t-test for all samples is much smaller (0.06) than the p-value for samples with similar purge rates (0.34). This large difference suggests that purge rates affect PCE concentrations more than pump type. The mean TCE concentrations also are generally greater for bladder-pump samples than peristaltic-pump samples (table 10) but at the levels detected, differences are within the margin of analytical precision.

The effect of purge rate on PCE concentrations is a consequence of the physical and chemical heterogeneity of the plume. Imbrigiotta and others (1988) reported similar results and hypothesized that sampled observation wells, which showed increases in contaminants for high purge rates, were screened in low concentration zones adjacent to high concentration zones. Therefore, during high purge rates, water was pulled from the high to low concentration zones.

While PCE concentrations from bladder-pump samples are not statistically different than PCE concentrations from peristaltic-pump samples, the observed PCE concentrations are higher from the bladder-pump samples than the concentrations from peristaltic-pump samples. The chemical field parameters of waters withdrawn by different types of pumps suggest that the higher PCE concentrations from bladder-pump samples are neither the result of increased turbidity in the bladder samples, nor conversely, decreased concentrations of dissolved gases like oxygen or carbon dioxide, but probably the result of degassing[5] of samples collected with the peristaltic pump. Turbidity concentrations from peristaltic samples were similar to bladder samples (except for sample b.1). Dissolved oxygen and carbon dioxide concentrations also were similar between peristaltic and bladder samples regardless of purge rate. Values of pH, however, were high for peristaltic samples, and indicate some degassing occurred with the peristaltic pump. This may explain the slightly lower VOC concentration in the peristaltic sample compared to the bladder sample.

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[4]The p-value is also called the attained significance level (Helsel and Hirsch, 1992).

[5]Degassing of constituents occurs when water samples are subjected to negative pressures, which can occur with use of peristaltic pumps.

The results of the detailed test comparing sampling with bladder and peristaltic pumps show that PCE and TCE concentrations from samples collected with both pumps are statistically similar for the range in concentrations tested (although concentrations of PCE and TCE from bladder-pump samples were higher than concentrations from peristaltic-pump samples). The RPD of the mean concentration of PCE between bladder and peristaltic samples for similar purge rates (bladder samples, 1,927 ppb, and peristaltic, 1,812 ppb, table 10) is 6.2 percent. This RPD is one-half the RPD of the mean concentration of PCE between peristaltic and diffusion samples (-13.42 percent, table 7). Therefore, because the difference in concentrations of PCE between bladder and peristaltic samples is less than that of peristaltic and diffusion samples, peristaltic samples are considered to be adequate for validation of diffusion sampler results at tested wells. Furthermore, the sequence of sampling at wells where validation of diffusion samplers were tested, also appears not to have adversely affected the validation tests because the pump test at B95-13 showed that cumulative volume did not affect PCE concentrations (fig. 16a). Recall that samples collected for validation were collected in the following sequence: diffusion, Voss, peristaltic, and bladder (see section on Sampling Methods and Techniques).

RESULTS OF APPLICATION TO MONITOR TRENDS

The preceding sections document the evidence supporting the suitability of diffusion samplers in collecting high-frequency time-series data on VOCs if a minimum deployment time of 1 week or more is used. The following section discusses results of this high-frequency sampling, which occurred from November 1998 to October 1999.

Fifteen wells were chosen to collect detailed time-series data of post-wall construction conditions. All of the fifteen wells are located outside of the barrier wall (fig. 3). Trends were analyzed for the concentration of individual primary detected VOCs (PCE, TCE, and *cis*-1,2DCE), the ratios between the concentration of these compounds, and the total VOCs, which were determined by summing the concentration of the three detected VOCs (PCE, TCE, and *cis*-1,2DCE). As in the testing phase, VOCs other than the primary compounds were largely undetected.

PCE was the primary VOC detected prior to construction of the barrier wall. Concentrations of PCE show declines of at least a half order of magnitude at 8 of the 15 wells sampled (figs. 17-21) since the start of barrier wall construction in July 1998 (the barrier wall was constructed from July to November 1998, and remedial operations of wells were tested between December 1998 to March 1999, but full operation started in May 1999). These wells include PW-12M, PW-12D, PW-12R, MW-16R, B95-15, B95-13, PW-13M, and PW-13D. Wells with the largest declines in PCE (PW-12M, B95-15, and PW-13D) are screened in coarse-grained gravel layers and are along the northern flank of the plume where ground-water flow is rapid from recharge of the river. Several wells where small declines in PCE have occurred are screened in slightly finer grained layers of sand, including wells PW-14M and PW-14D, and MW-16B and MW-16C. These wells are in the central to southern flank of the plume. At well B95-13, located adjacent to remedial extraction wells EW-1 and EW-2 (fig. 3), PCE declines appear to have increased after remedial wells were placed into full operation in mid-May 1999.

Several short-term changes in PCE also are evident in addition to the gross overall declines measured over the time of study. Transient declines and rises in concentration, including a sharp decline and rise in PCE at well PW-12S were detected in June and July of 1999 (fig. 18). This well is near a recharge gallery (fig. 3) where treated water is injected back into the aquifer at a rate of approximately 60 gal/min. Many wells show transient rises in PCE in May and September of 1999, which are likely the result of large precipitation events during those months. Large precipitation events, and subsequent recharge to ground water, may help desorb additional contaminants from the aquifer matrix and increase concentrations in the dissolved phase.

Time trends in concentrations of TCE and *cis*-1,2DCE at most of the sampled wells match the trends in concentrations of PCE. At several wells that had large declines in PCE concentration, however, only small declines occurred in TCE and(or) *cis*-1,2DCE concentrations. Furthermore, at three wells (wells PW-12M, PW-12R, and PW-13D), concentrations of *cis*-1,2DCE increased while concentrations of PCE decreased. *Cis*-1,2DCE is primarily formed from the degradation of PCE and TCE and increases in *cis*-1,2DCE at selected

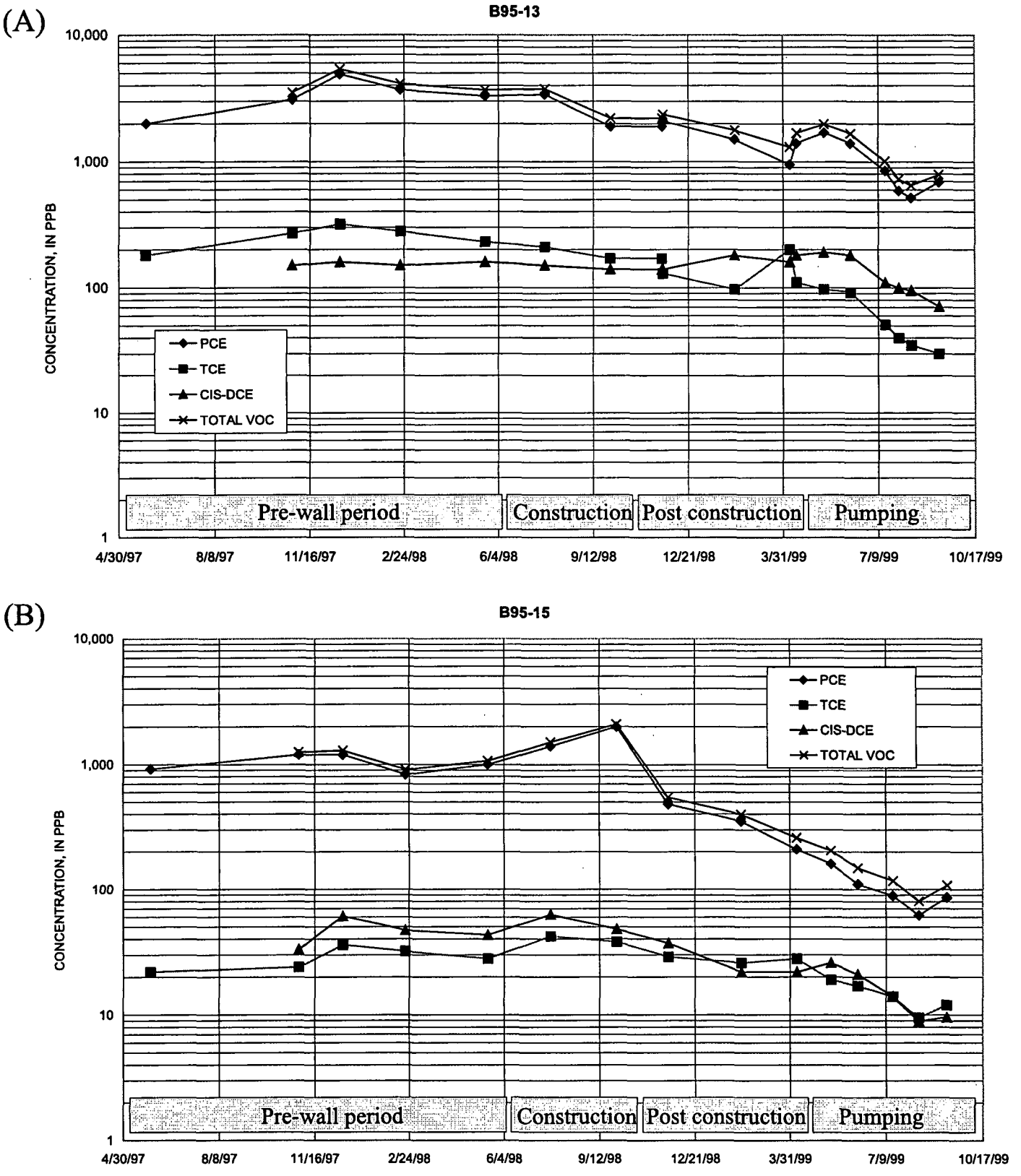


Figure 17. Concentrations of volatile organic compounds (VOC's) (tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2-dichloroethene (*cis*-dce), and total VOC's (totalvoc) from diffusion samplers for wells B95-15 and B95-13. (Well locations are shown in figure 3.)

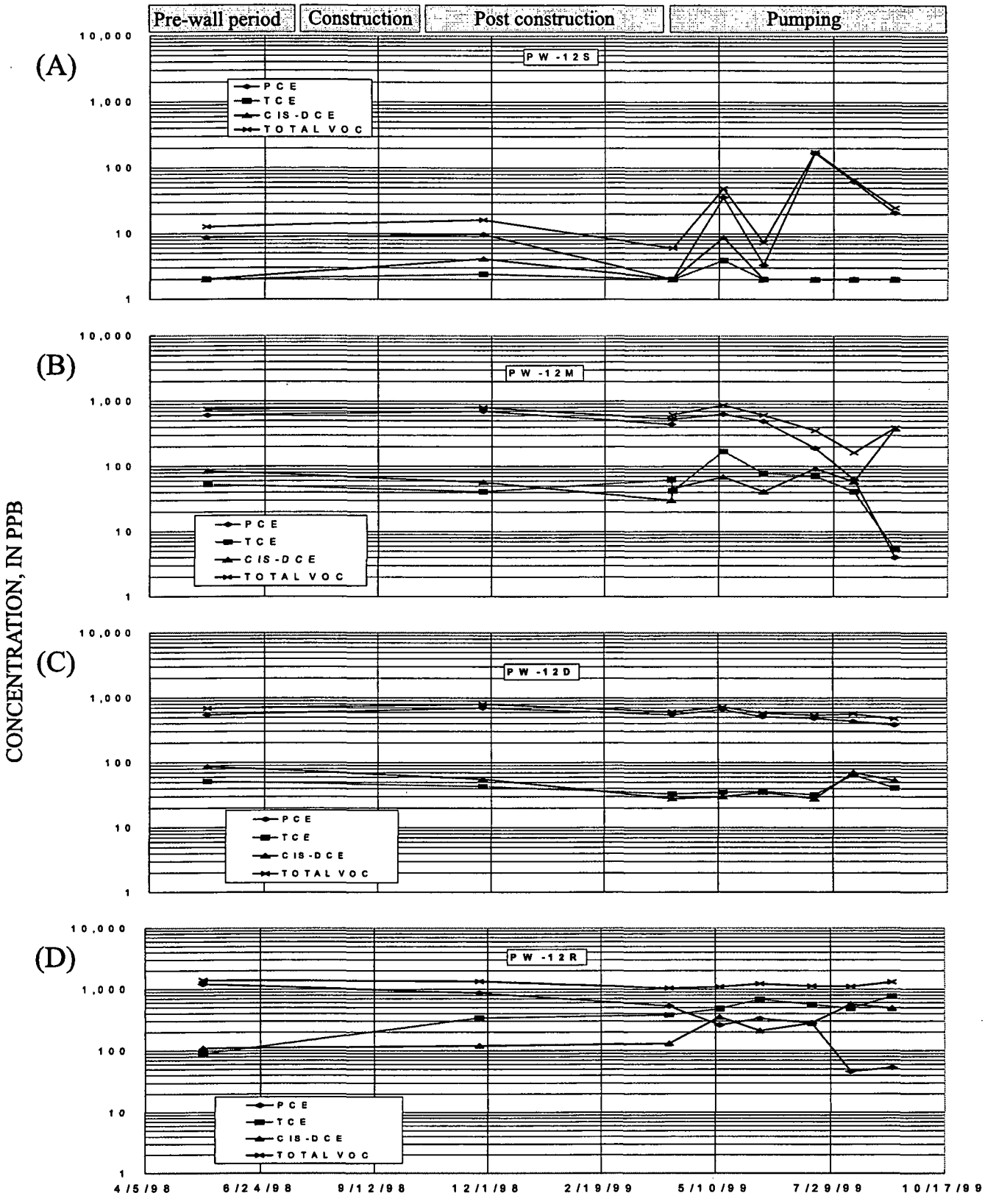


Figure 18. Concentrations of volatile organic compounds (VOC's) (tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2-dichloroethene (CIS-DCE), and total VOC's (TOTAL VOC) from diffusion samplers for PW-12 cluster wells.

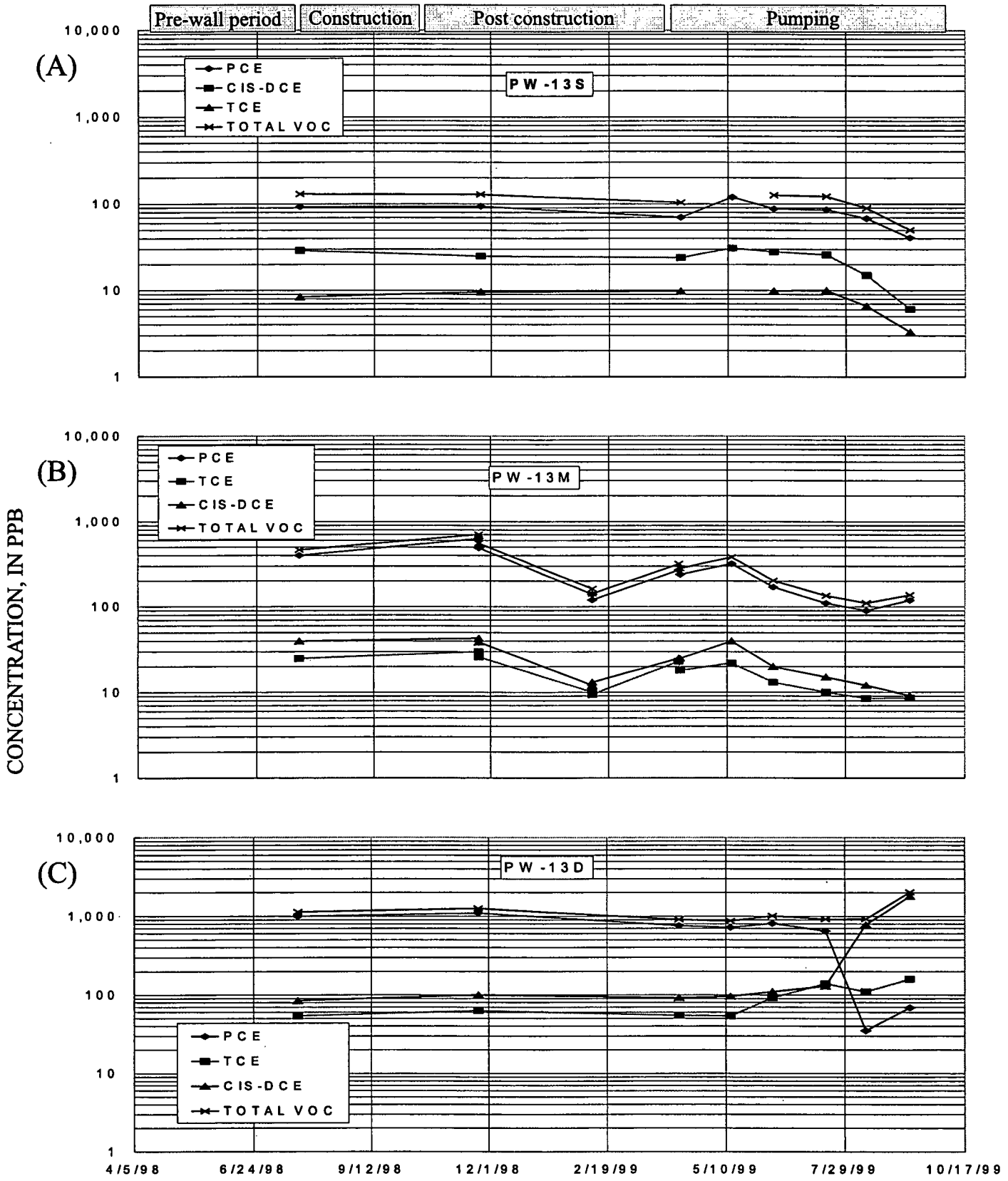


Figure 19. Concentrations of volatile organic compounds (VOC's) (tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2-dichloroethene (CIS-DCE), and total VOC's (TOTAL VOC) from diffusion samplers for PW-13 cluster wells.

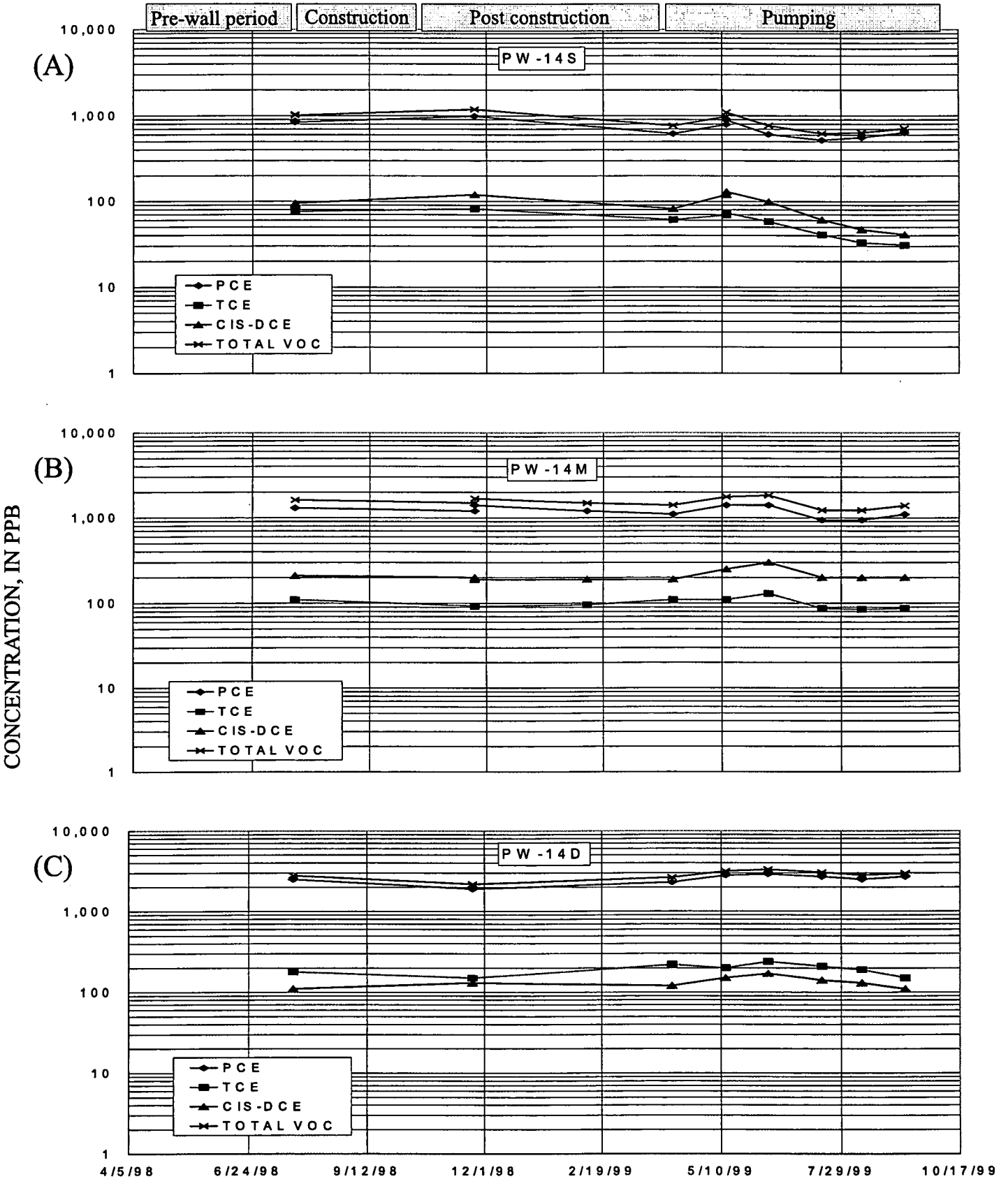


Figure 20. Concentrations of volatile organic compounds (VOC's) (tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2-dichloroethene (CIS-DCE), and total VOC's (TOTAL VOC) from diffusion samplers for PW-14 cluster wells.

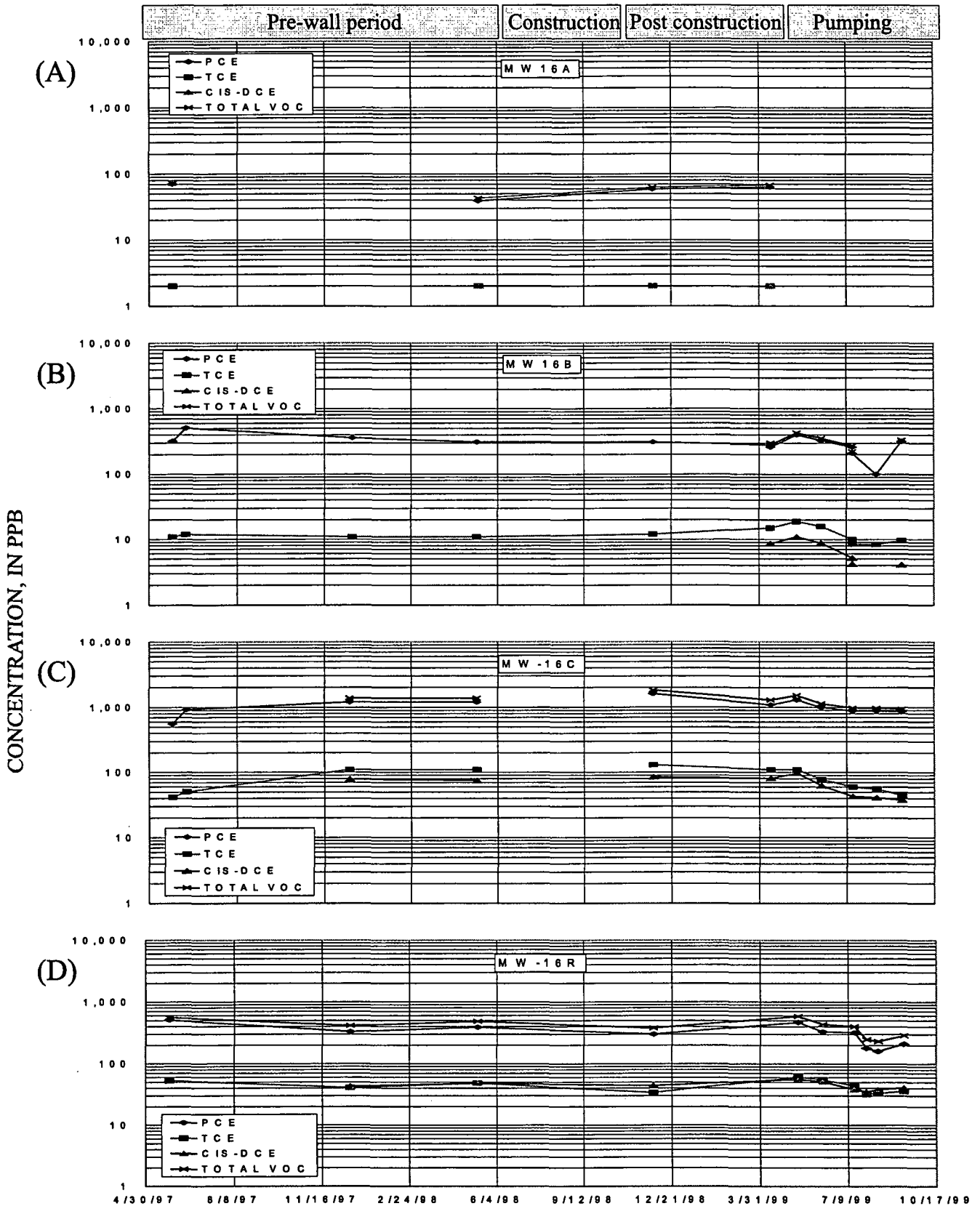


Figure 21. Concentrations of volatile organic compounds (VOC's) (tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2-dichloroethene (CIS-DCE), and total VOC's (TOTAL VOC) from diffusion samplers for MW-16 cluster wells.

wells suggest spatial and temporal variations in rates of biodegradation. Wells PW-12R and PW-13D are fully and partially set in bedrock, respectively, and some bedrock waters show a tendency of higher daughter-to-parent compound ratios than drift waters. In general, because most wells do not show increases in *cis*-1,2DCE, biodegradation is evidently occurring only on a local scale. The increase in *cis*-1,2DCE at three wells since the construction of the barrier wall suggests that the source of PCE probably is isolated by the wall, otherwise PCE concentrations would be higher relative to TCE and *cis*-1,2DCE concentrations.

At several wells where *cis*-1,2DCE has increased, sampled waters contain above-background concentrations of methane. The median methane values for contaminated shallow, medium, and deep wells ranged from 3 to 6.1 ppm. Well PW-12M, which shows increases of more than 1 order of magnitude of *cis*-1,2DCE, had a methane concentration of 9.0 and 7.7 ppm (appendix 2b).

Methane concentrations have increased over time and coincide with increases in *cis*-1,2DCE and TCE at wells where high frequency collection of methane occurred (B95-13 and B95-15). The ratio of *cis*-1,2DCE to PCE and methane (CH_4) for wells B95-13 and B95-15 is shown in figure 22. Methane concentrations have increased from 1997 to maximum levels in November 1998 when the barrier wall was completed. Increases in the ratio of *cis*-1,2DCE to PCE correspond to increases in methane and suggest an increase in biologic activity and methanogenesis in some zones of the aquifer.

VOC decreases in wells downgradient of the source area probably indicate the success of the barrier-wall construction in preventing the migration of contaminants. The average concentration of PCE and total VOCs (PCE, TCE, and *cis*-1,2DCE) have decreased since the completion of the barrier wall in November 1998. The average concentration of PCE in wells at the farthest downgradient part of the source area (PW-13, PW-14, and MW-16 clusters) declined by 23 percent from November 1998 to September 1999; whereas, total VOCs declined by only 5 percent. The slow decline in total VOCs is the result of increases in TCE and *cis*-1,2DCE at several wells.

A first-order exponential equation (Wiedemeier and others, 1998) was used to quantify observed concentration declines at the downgradient wells:

$$C = C_o \exp^{-kt} \tag{3}$$

where

C is concentration at t (time),
C_o is initial concentration at time = 0,
k is the first-order decay constant (1/yr), and
t is time (years).

The average concentration of PCE and total VOCs from sampling rounds in April through October 1999 for wells PW-13, PW-14, and MW-16 clusters were divided by average concentrations from November 1998 (the initial concentration, Co) and plotted on graphs (fig. 23). An exponential function was fitted by least squares method and is shown as the regression line. The 95-percent confidence level was also plotted to bracket trendlines. The results show that the computed exponential slopes for PCE are steeper than for total VOCs. The computed decay constants (k) are 0.4304/yr for PCE and 0.3189/yr for total VOC. After 10 years, the range in C/Co values for PCE is from 0.08 to virtually 0; the range in total VOCs is from 0.2 to 0. As additional data are collected, the exponential trendlines may shift and residual errors also may be reduced, which would result in more representative trends.

The ease of use of diffusion samplers and associated decrease in sampling time allowed for high frequency sampling and detailed analyses of trends, but also allowed for a more instantaneous picture of the plume. For example, depending on the number of wells, it may take 2-3 weeks to sample a round of wells at the site. During that time, sample concentrations can vary because of short-term trends. VOC data collected on July 16, July 30, and August 12, 1999, at well B95-13 (appendix 2c), all at 2-week intervals, show PCE concentrations of 850 ppb, 590 ppb, and 520 ppb. Thus, the analysis of plume concentrations are less likely to be influenced by errors associated with the length of time required to collect a complete round of data at a site.

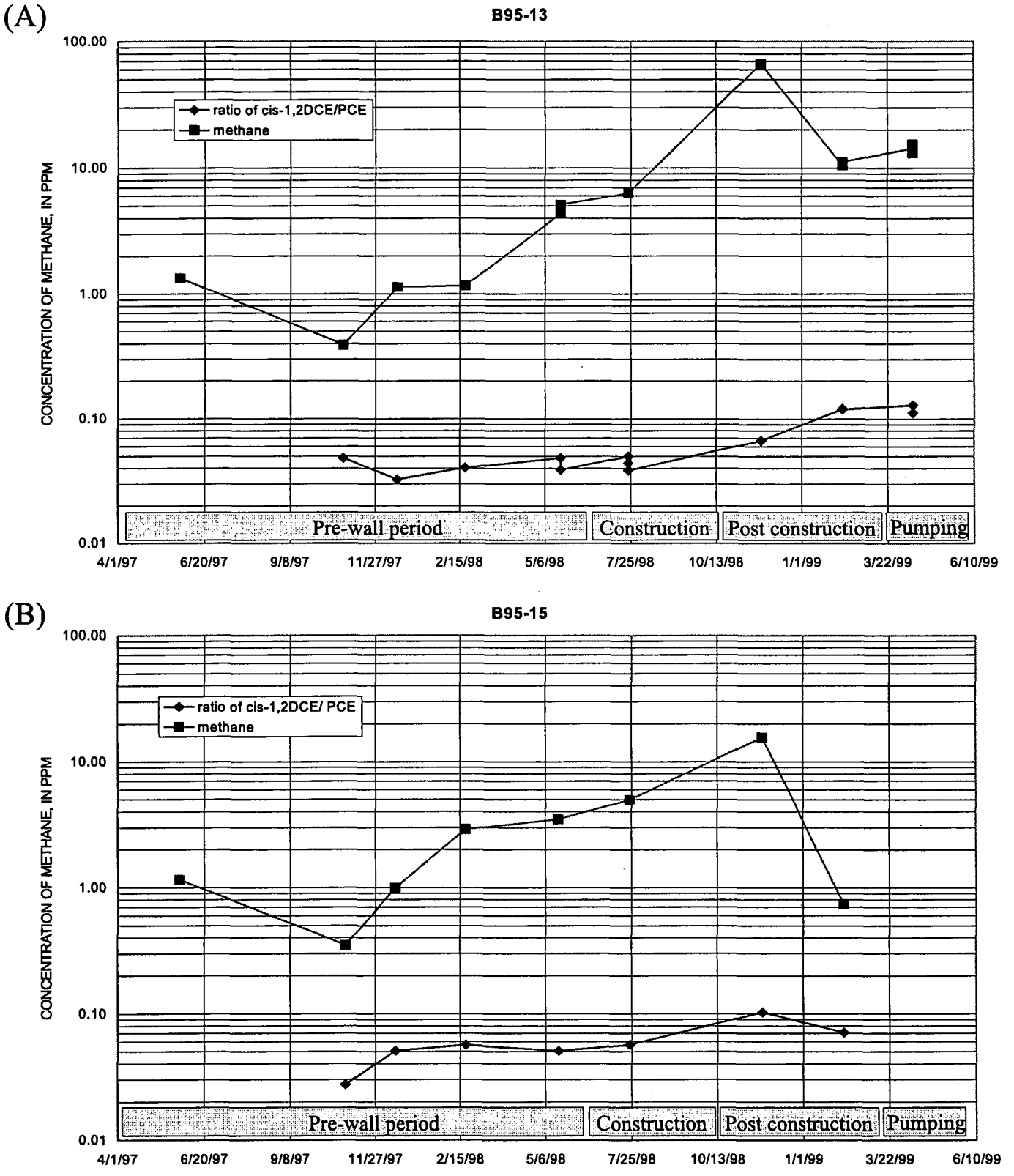
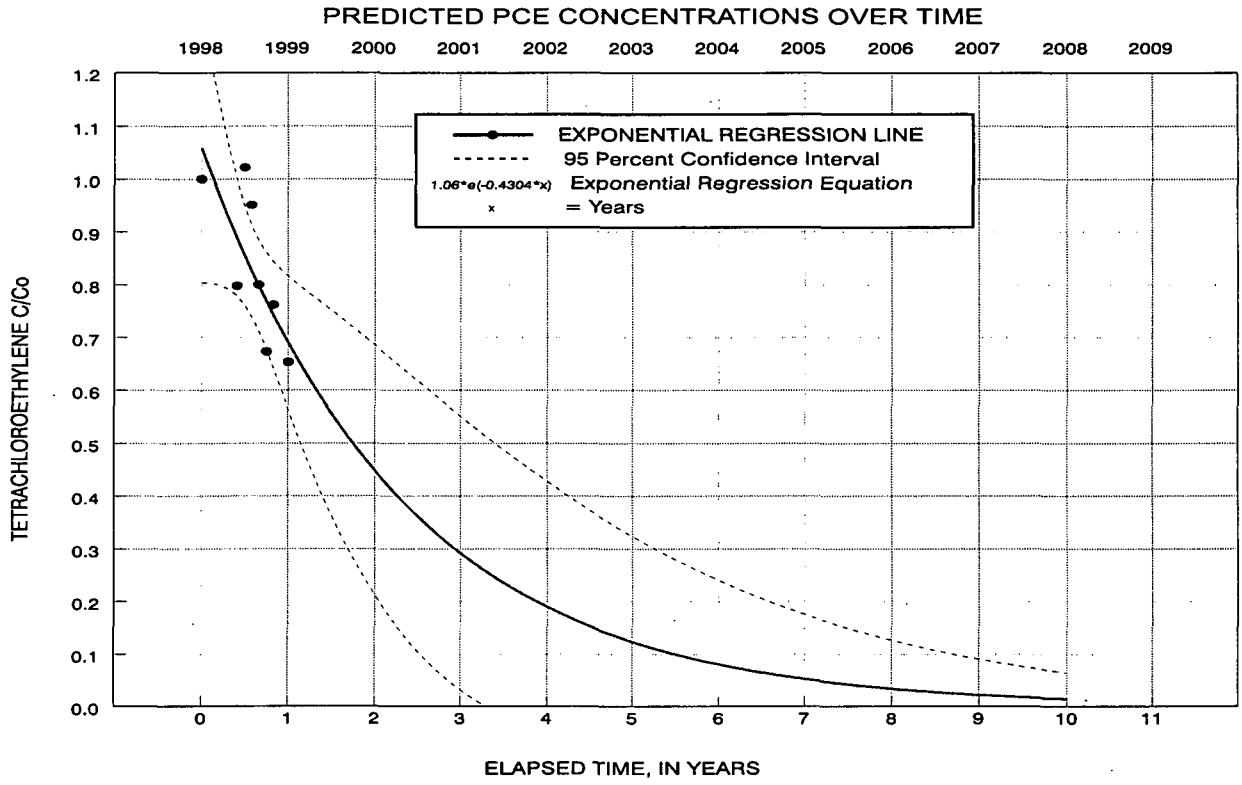


Figure 22. Concentrations of methane (CH_4) and the ratio of *cis*-1,2-dichloroethane (*cis*-1,2DCE) to tetrachloroethylene (PCE) for wells B95-13 (A) and B95-15 (B). (ratio cis/pce means ratio of *cis*-1,2DCE to PCE)

(A)



(B)

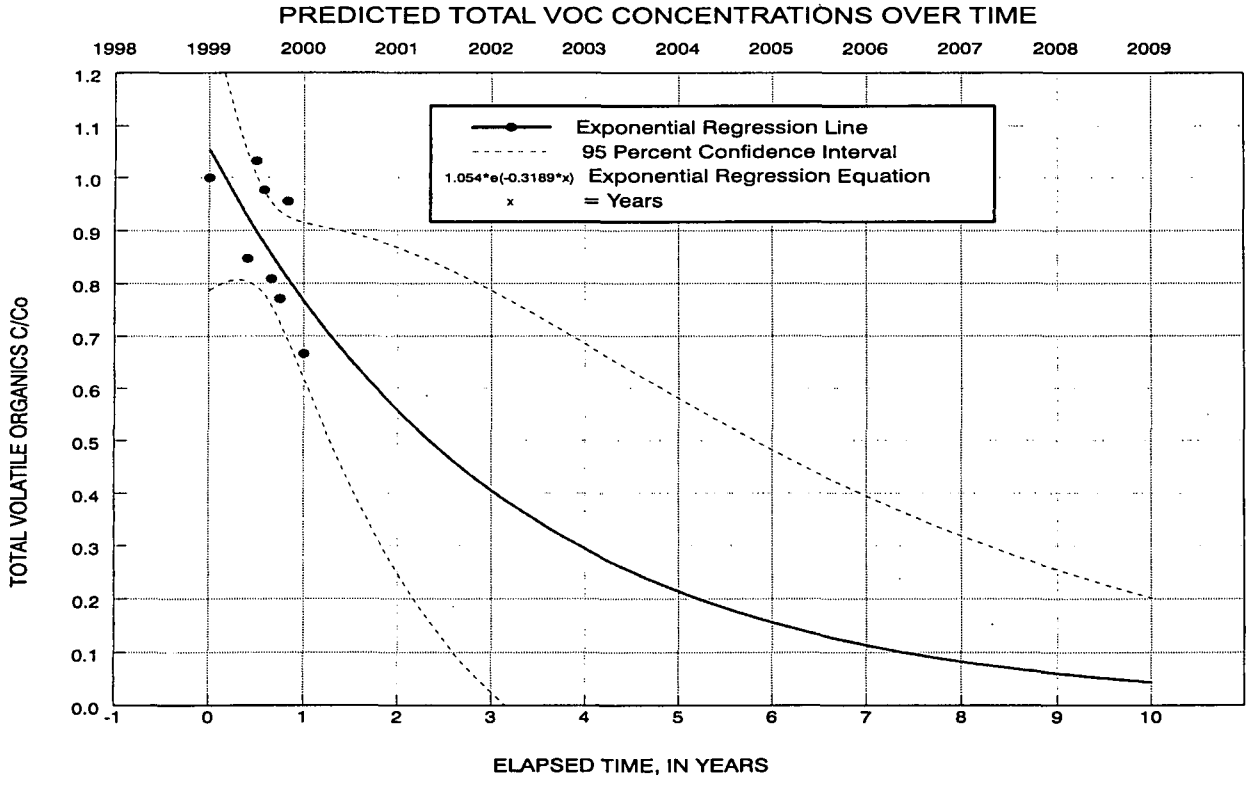


Figure 23. Future time trends in concentration of volatile organic compounds (VOC's) as a ratio of average initial concentrations of tetrachloroethylene (PCE) (A) and total VOC's (B). (C/C_o means concentration divided by initial concentration)

SUMMARY AND CONCLUSIONS

The concentrations of volatile-organic compounds (VOCs), principally tetrachloroethylene (PCE), trichloroethylene (TCE), and cis-1,2-dichloroethene (cis-1,2DCE), in ground-water samples collected with diffusion samplers correlate well with concentrations in samples collected by low-flow purging procedures. Twenty coupled diffusion and peristaltic-pump samples were collected from seven wells completed in glacial drift. Sample results from peristaltic pumps were used to validate sample results from diffusion samples because peristaltic pumps had been used at the site by the New Hampshire Department of Environmental Services. Linear regressions of concentrations from diffusion and peristaltic-pump samples produced root-mean squares of 0.966 for PCE, 0.942 for TCE, and 0.979 for cis-1,2DCE. The PCE and cis-1,2DCE regression lines are essentially identical to the 1:1 line. The TCE regression line shows that TCE concentrations in the diffusion samples tend to be greater than concentrations in the peristaltic samples.

The mean concentration of PCE in diffusion samples was 1,152 parts-per-billion (ppb) and the mean from the peristaltic samples was 1,119 ppb. The standard deviations also were similar. The mean TCE concentration from diffusion samples (89.2 ppb) was slightly higher than the mean concentration from peristaltic samples (75.4 ppb), whereas the means for *cis*-1,2DCE with both sample methods were identical. The Relative Percent Differences (RPD) of PCE, TCE, and *cis*-1,2DCE concentrations between peristaltic-pump and diffusion samples indicate that diffusion samples provide, on average, higher concentrations (3 to 16 percent) than peristaltic-pump samples (although not statistically different). Compared to duplicate results, which show a small difference in concentration (4 percent on average in samples with positive detects), the differences in concentrations between samples collected by different methods are larger than differences in concentrations associated with analytical inaccuracies.

Because of the inherent problems associated with sampling for VOCs with peristaltic pumps, an additional sampling test was performed to evaluate the performance of peristaltic pumps in sampling for VOCs. Concentrations from peristaltic-pump and bladder-pump samples were analyzed and showed a 6.2 percent RPD in concentrations of PCE between bladder-pump (high concentration) and peristaltic-pump samples (low concentrations). The difference was not statistically different and less than the analytical precision level of 13 percent for the test. Therefore, peristaltic-pump samples were considered adequate for the purpose of validating results from diffusion samplers.

Trends in VOCs, which were corroborated by both diffusion samples and purged samples following low-flow procedures, indicate that diffusion samplers equilibrate relatively quickly to concentrations of VOCs in the well water at the time of bag retrieval. Declines in PCE concentration in diffusion samples of several hundred parts-per-billion between consecutive coupled sampling periods matched declines in PCE in purged samples and indicate that water concentrations inside the diffusion samplers were equivalent to concentrations in the purged samples collected the same day as bag retrieval.

The use of diffusion samplers in this setting was a cost-effective alternative to more expensive sampling procedures. Diffusion sampling costs less and can be done in one-fifth the time of low-flow sampling, allowing for more frequent data collection, and resulting in a better understanding of several contaminant transport conditions at the study site.

The most significant contaminant transport condition identified was the spatial variability in declines of PCE at most wells, and the locally observed small increases in TCE and *cis*-1,2DCE at several wells since a barrier wall was constructed. Rates of PCE decline at wells correspond with variations in sediment lithology at the screen interval and location of the well within the plume. Wells screened in coarse-grained gravel layers along the northern flank of the plume showed the largest declines in PCE. At several wells, concentrations of TCE and *cis*-1,2DCE increased, whereas PCE decreased suggesting that small scale biodegradation is occurring. Most wells that showed concentration increases of TCE or *cis*-1,2DCE are partially set in the bedrock. Increased methane concentrations following wall construction point to a short-term increase in methanogenesis, which also may help explain the small scale increases in TCE and *cis*-1,2DCE. Temporary increases in VOCs occurred following recharge events on several occasions, suggesting desorbtion of VOCs from the aquifer matrix.

Vertical variations in VOCs were detected from strings of diffusion samplers installed in one short-screened (5-ft long) well, screened in the glacial drift, and one open-hole (38-ft long) bedrock well. Variations in vertical concentrations were as much as 100 percent, much larger than the maximum RPD between duplicates of 11 percent. Preliminary results indicate the technique may be applied as a screening tool to estimate vertical concentrations.

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Appendix 1. Procedures used in this study for preparation, installation, and collection of - water-diffusion bag samples in wells.

1) Get trip blank from analyzing laboratory. Trip blank water will remain in 40-ml septum vial and will travel with samplers to the field. Septum viles should be stored in a clean laboratory refrigerator and transported in a cooler with ice.
2) Ensure adequate supply and check quality of 40-ml septum vials to be used in the field.
3) **Bag preparation:** Bags should be constructed as close to the deployment time as possible and carefully transported to avoid contamination. Cut off a 13 in. length of 2-in.wide, polyethylene 2-mil thick sleeves. When filled, sleeves (bags) are 1.5 in. diameter. Seal one end of the sleeve multiple times with a heat-impulse sealer. The last seal and first seal should be approximately 2 in. apart. Rinse the inside of the newly created "bag" with VOC-free water several times. Pour VOC-free water into bag opening, filling to a length of 9 inches (approximately 260 mL). Seal open end of bag with heat sealer multiple times with care to minimize air space in the tube. Ideally, the same source of VOC-free water should be used for all blanks and the diffusion bags that will be placed in wells.
4) Create laboratory environment blank bag. This bag will remain in the laboratory, exposed to ambient laboratory conditions until the next sampling round (the next time diffusion bags are created). Laboratory bags are used to identify potential contamination problems during construction of bags.
5) Create equipment blank. This diffusion bag will travel with samplers into the field and represents a check of the sampling device as well as the working environment.
6) Create diffusion bags for the wells. Know in advance how many diffusion bags need to be installed. Make two extra bags in case of accidental puncture.

First Time Installation

Enclosures and associated equipment for installing bags in wells should be assembled and ready for use before the start of sampling. Enclosures are constructed only for the first initial diffusion sampling round at a newly sampled well by this method. Subsequent diffusion sampling at the same well can reuse the enclosure.

Two types of diffusion bag enclosures (shrouds) can be used. Mesh enclosures are ideal for cased and screened wells. PVC pipe enclosures are useful in open- walled rock holes where bag puncture can be an issue. Mesh enclosures are thick netted flexible devices coated with polyethylene materials and of a minimum diameter of 1.5 in.. Diffusion bags will fit inside mesh enclosures. PVC pipe enclosures are 1 3/8 in. inner diameter, and 1.5 in. outer diameter, slotted to allow water contact with bag, and pipe material. Diffusion bags will also fit inside PVC pipe enclosures. Bottom of enclosures should be fitted with a stainless steel weight. All materials should be properly decontaminated before usage.

Verify well depth by sounding with a measuring tape from known measurement point. Take a water-level measurement from same measurement point and compute height of water column above open interval and potential placement of bag inside well. **It is important to fully submerge diffusion bag in water so this step of verifying well**

construction and water levels must be done. For short screens or open holes (less than 5 ft), diffusion bags are typically installed at the midpoint of well opening. For long screens or open holes (more than 5 ft), bags can be installed with several bags in a vertical string (series) up and down opening or at designated locations such as fractures.

Install bag inside enclosure. Tie a spool of teflon line to one end of holder and lower inside the well to the desired depth. Cut off teflon line so as to set the midpoint of the diffusion bag at desired depth and then secure top part of line to a fixed object such as a padlock anchor.

7) Store all bags in a sealed container.
8) Collect laboratory environment sample from previous sampling period by cutting bag open and filling two 40-ml septum vials. This sample has been equilibrating to ambient laboratory conditions for several weeks.
9) Transport all diffusion bags and blanks to the field.
10) Make a water-level measurement from a known point at monitoring wells.
11) Retrieve samples from all wells by hoisting enclosures to the surface. Cut open the top part of the diffusion bag with special care not to spill the bag, and fill two 40-ml septum vial's. If field duplicates or matrix spike duplicates are needed, fill two additional vials or more with the remaining water. Otherwise, remaining water can be poured into a small beaker for purposes of recording water temperature with a small temperature probe. If preservatives are required by laboratory, add preservatives to vial according to analyzing laboratory. USEPA Region 1 (USEPA, 1996b) provides information on protocol to use for collection of VOC's samples.
12) Store collected samples in a cooler with ice.
13) Install newly created clean diffusion bags into enclosure and lower to designated position in well.
14) After last bag is installed, cut open equipment blank diffusion bag and pour contents into two 40-mL septum vials.
15) Fill out chain of custody form and make copies.
16) Transport and submit all samples and blanks to analyzing laboratory.

Appendix 2. Explanation of abbreviations

Source of Data (Collecting Agency)

DES = New Hampshire Department of Environmental Services
USGS = U.S. Geological Survey
EPA = U.S. Environmental Protection Agency

Sample Collection Method

peri = peristaltic pump
GRAB = grab sample in surface water
BL = bladder pump
DB = passive diffusion bag sampler
VOSS = voss bailer pump

Units

mg/L = miligrams per liter
L = liters
min = minutes
ft = feet
cm = centimeter
mv = milivolts
°C = degrees celcius
NTU = neophlemetirc turbidity unit

Chemical Compounds

CO_2 = carbon dioxide
Fe2+ = iron cation, plus two charge
S^{2-} = sulfide anion
NH_4^+ = ammonium
Cl- = chloride anion
SO_4^{2-} = sulfate
NO_3^- = nitrate
NO_2^- = nitrite
PO_4^{3-} = total phosphate
Ca^{2+} = calcium cation
Fe(total) = total iron
Mg^{2+} = magnesium cation
Mn^{2+} = manganese cation
K^+ = potassium cation
Na^+ = sodium cation
CH_4 = methane
TOC = total organic carbon
Br- = bromide
$CaCO_3$ = alkalinity, measured as total calcium carbonate
PCE = tetrachloroethene

TCE = trichloroethene
CIS-DCE = cis-1,2 dichloroethene
111-Tri = 1,1,1-trichloroethene
MTBE= methyl-tertiary-butyl-ether
THF = tetrahydrofuran
Meth.Chl = methylene chloride

Other Explanations

= number
-- = no data
< less than
© = field colorimetric chemical test kit
SC = specific conductance
DO = dissolved oxygen
hole = downhole measuring device
flowthru = flow-through chamber
Temp = temperature
(d) = duplicate sample
SC-lab = specific conductance as measured from sample bottle in the lab
U "x"= undected at a limit of "x" ppb
equip blank (eq.) = equipment blank
lab blank = laboratory blank
umhos/cm = micromhos per centimeter
Eh = redox potential measurement
river = river sample

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
(DB blank)		2/8/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(eq. blank)		9/30/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		5/11/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		5/13/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		5/18/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		5/19/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		5/21/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		7/21/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		7/23/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		9/18/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		9/30/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		10/20/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		11/23/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		11/30/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		12/1/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		12/3/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		12/7/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		12/8/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		12/8/98	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)		2/8/99	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-12	407	5/28/97	DES	peri	0.11	105	11.6	0	665	5.66	--	11.89	--	13.28	3	15	0	0.5	376
B95-12	407	10/28/97	DES	peri	0.5	100	50.0	0	761	5.31	--	--	--	--	4.2	23	--	0.06	--
B95-12	407	12/15/97	DES	peri	0.44	62	27.3	0.02	813	5.2	--	4	--	9	3	25	0	--	273
B95-12	407	2/19/98	DES	peri	0.53	61	32.3	0	869	5.57	3.8	--	11.8	--	3	23	0	0.18	--
B95-12	407	5/18/98	DES	peri	0.52	153	79.6	0.01	732	5.6	5	--	11.8	--	5	35	0	0.25	213
B95-12	407	7/22/98	USGS	peri	0.51	20	10.2	0.01	739	5.73	--	--	--	--	--	--	--	1.4	--
B95-12	407	12/2/98	DES	peri	0.198	50	9.9	0.01	727	5.62	--	4.9	--	12.8	4	30	0	0.18	--
B95-12	407	4/13/99	DES	peri	0.198	112	22.2	0	719	5.58	--	5.23	--	11.5	4	25	0	0.11	308
B95-12(d)	407	5/28/97	DES	peri	0.11	105	11.6	0	665	5.66	--	--	--	--	3	15	0	0.5	376
B95-13	408	5/28/97	DES	peri	0.09	72	6.5	0.02	120	5.53	--	0.09	--	14.84	1	16	0	1.71	318
B95-13	408	10/28/97	USGS	BL	0.45	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	10/28/97	DES	peri	0.49	78	38.2	0.02	194	5.55	1.2	--	--	--	0.5	19	0	0.09	--
B95-13	408	2/20/98	USGS	BL	0.67	75	50.3	0	160	5.73	--	--	--	--	--	--	--	0.7	163
B95-13	408	2/20/98	USGS	peri	0.52	56	29.1	0	158	5.77	1.45	--	11.2	--	0.7	17	0	0.25	303

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
B95-13	408	5/21/98	USGS	BL	0.62	100	62.0	0	154	5.86	--	--	--	--	--	--	--	1.21	--
B95-13	408	5/21/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	5/21/98	DES	peri	0.5	104	52.0	0.01	151	5.86	0.4	--	11	--	0.4	30	0	0.24	292
B95-13	408	7/23/98	USGS	BL	0.88	96	84.5	0.02	185	5.82	--	--	--	--	0.5	--	--	4.39	65
B95-13	408	7/23/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	7/23/98	USGS	peri	0.24	133	31.9	0.01	181	6.11	0.5	--	11	--	0.9	35	0	3.11	193
B95-13	408	7/23/98	USGS	peri	0.5	28	14.0	0.02	181	6.1	0.3	--	11	--	0.9	35	0	1.69	--
B95-13	408	7/23/98	USGS	voss	0.84	9	7.6	0	178	5.88	--	--	--	--	--	--	--	--	--
B95-13	408	9/30/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	11/23/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	11/24/98	DES	peri	0.164	75	12.3	0	132	5.86	--	0.73	--	11.1	0.8	30	0	0.18	--
B95-13	408	2/8/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	2/8/99	USGS	peri	0.49	65	31.9	0.01	127	5.76	--	0.7	--	9.6	0.3	14.5	0	0.53	278
B95-13	408	4/7/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/14/99	USGS/EPA	peri	0.258	100	26.0	0	145	--	--	0	--	10.6	0.2	25	--	0.55	--
B95-13	408	4/14/99	USGS/DES	peri	0.48	159	54.0	0.01	124	--	--	0	--	10.9	0.1	22	--	0.59	--
B95-13	408	4/14/99	USGS/DES	BL	0.45	404	87.0	0.01	138	--	--	0	--	10.7	0.5	25	--	0.99	--
B95-13	408	4/14/99	USGS/EPA	BL	0.97	480	151.0	0	127	--	--	0	--	0	>1	22	--	>10	--
B95-13	408	4/14/99	USGS/EPA	peri	1.08	545	221.0	0.06	128	6.82	--	0	--	10.2	0.7	19	0	2.2	--
B95-13	408	4/14/99	USGS/EPA	BL	1.08	565	243.0	0.06	128	6.58	--	0	--	9.8	0.2	19	--	0.36	--
B95-13	408	4/14/99	USGS/EPA	BL	0.5	583	252.0	0.01	127	6.55	--	0	--	9.7	--	--	--	--	--
B95-13	408	4/14/99	USGS/EPA	peri	0.49	595	258.0	0.01	128	7.14	--	0	--	10	0.6	20	--	1.88	--
B95-13	408	4/14/99	USGS/EPA	peri	0.33	625	268.0	0.02	128	7.13	--	0	--	9.8	0.4	18	--	0.97	--
B95-13	408	4/20/99	USGS/EPA	BL	0.85	45	38.0	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/20/99	USGS/EPA	BL	0.8	65	54.0	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/20/99	USGS/EPA	BL	0.63	75	61.0	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/20/99	USGS/EPA	BL	0.63	85	67.0	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	6/10/99	USGS	peri	0.45	48	21.6	0	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13 (d)	408	2/8/99	USGS	peri	0.49	65	31.9	0.01	127	5.76	--	--	--	--	0.3	14.5	0	0.53	278

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
B95-13(d)	408	4/14/99	USGS/EPA	peri	1.08	545	221.0	0.06	--	--	--	--	--	--	--	--	--	--	--
B95-13(d)	408	4/14/99	USGS/EPA	peri	1.08	545	221.0	0.06	--	--	--	--	--	--	--	--	--	--	--
B95-13(d)	408	4/14/99	USGS/EPA	BL	1.08	565	243.0	0.06	--	--	--	--	--	--	--	--	--	--	--
B95-13(d)	408	4/14/99	USGS/EPA	peri	0.33	625	268.0	0.02	--	--	--	--	--	--	--	--	--	--	--
B95-13(d)	408	4/14/99	USGS/EPA	peri	0.48	159	54.0	0.01	--	--	--	--	--	--	--	--	--	--	--
B95-13(d)	408	4/14/99	USGS/EPA	BL	0.45	404	87.0	0.01	--	--	--	--	--	--	--	--	--	--	--
B95-13-A	408	7/30/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13-B	408	7/30/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13-C	408	7/30/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	5/28/97	USGS	peri	0.12	79	9.5	0.01	71	5.79	--	0.44	--	11.21	<1	15.5	0	0.5	291
B95-15	409	10/30/97	USGS	BL	0.51	15	7.7	--	113	--	--	--	--	--	--	--	--	--	--
B95-15	409	10/30/97	DES	peri	0.48	80	38.4	0	113	6.96	--	0.4	--	--	0.2	19	0	0.05	298
B95-15	409	2/20/98	USGS	peri	0.51	48	24.5	0	110	5.68	0.7	--	10	--	0.7	21	0	0.1	244
B95-15	409	5/18/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	5/18/98	DES	peri	0.49	62	30.4	0	104	5.73	--	--	9.9	--	0.3	35	0	0.19	--
B95-15	409	7/23/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	7/23/98	USGS	peri	0.49	110	53.9	0	110	5.79	1	--	10	--	0.5	27	0	1.57	300
B95-15	409	9/30/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	11/23/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	11/24/98	DES	peri	0.207	60	12.4	0	178	5.8	--	0.3	--	10	0.4	27	0	<1	--
B95-15	409	2/8/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	2/8/99	USGS	peri	0.47	132	62.0	0.01	189	5.79	--	0.9	--	9.2	0.3	25	0	0.12	302
B95-15	409	4/7/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	4/8/99	USGS	peri	0.414	110	45.5	0	152	5.86	--	0.7	--	10.9	0.4	22	0	0.17	281
B95-15	409	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	6/10/99	USGS	peri	0.47	41	19.3	0.02	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	9/10/99	USGS	peri	0.4	60	24.0	0.01	--	--	--	--	--	--	--	--	--	--	--
B95-15(d)	409	9/30/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-3	398	5/29/97	DES	peri	0.08	62	5.0	0	95	5.92	--	0.2	--	14.59	0.5	20	1.5	0.21	250
B95-3	398	6/17/97	USGS	BL	1.37	187	256.2	0.06	102	5.97	--	--	--	--	<0.5	25	1.2	--	183
B95-3	398	12/16/97	DES	peri	0.14	43	6.0	0	89	6.33	--	0.5	--	11	0.5	40	0.8	<1	231

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
B95-3	398	5/12/98	DES	peri	0.18	50	9.0	0	98	5.9	--	0.1	--	11	0.7	--	1	<1	--
B95-3	398	12/3/98	DES	peri	0.206	90	18.5	0.02	91	5.84	--	0.35	--	12.3	0.2	21	1.4	0.17	--
B95-3	398	4/20/99	DES	peri	0.218	50	10.9	0.01	98	5.9	--	0.4	--	11	0.5	16	0.8	<1	124
B95-5	400	6/2/97	DES	peri	0.1	58	5.8	0	88	5.83	--	8.58	--	10.79	5.5	100	0	0.4	230
B95-5	400	12/17/97	DES	peri	0.17	50	8.5	0	71	5.8	--	8	--	11	3	30	0	<1	--
B95-5	400	5/12/98	DES	peri	0.17	53	9.0	0	96	5.8	--	4.3	--	10	4	--	0	<1	--
B95-5	400	12/2/98	DES	peri	0.168	60	10.1	0	65	5.8	--	8.7	--	13	8	17	0	<1	--
B95-5	400	4/21/99	DES	peri	0.19	75	14.3	0	71	6.03	--	8.82	--	10.9	9	20	0	0.43	357
B95-6	401	6/16/97	USGS	BL	1.23	175	215.3	0.02	326	5.72	--	--	--	--	<0.5	20	3.6	--	139
B95-6	401	12/17/97	DES	peri	0.13	48	6.2	0	111	5.99	--	0.52	--	0.9	0.4	23	1	0.17	204
B95-6	401	5/12/98	DES	peri	0.15	62	9.3	0	180	5.9	--	0.54	--	12.2	0.3	--	2.5	0.18	--
B95-6	401	12/2/98	DES	peri	0.202	60	12.1	0	103	5.9	--	0.53	--	12.1	0.3	20	0.8	0.18	--
B95-6	401	4/21/99	DES	peri	0.214	50	10.7	0	104	6	--	0.4	--	11	0.6	23	1.6	<1	96
B95-7	402	12/17/97	DES	peri	0.16	70	11.2	0	385	5.7	--	2.6	--	11	1.5	16	0	<1	--
B95-7	402	1/12/98	DES	peri	0.3	95	28.5	0.02	454	6	--	--	--	--	--	--	--	--	243
B95-8	403	6/16/97	USGS	BL	1.43	218	311.7	0.03	550	5.81	--	--	--	--	3	16	0	--	209
B95-8	403	12/16/97	DES	peri	0.13	50	6.5	0	466	5.72	--	1.98	--	0.3	1.5	13	0	0.92	--
B95-8	403	5/12/98	DES	peri	0.16	40	6.4	0	470	5.82	--	2.71	--	12	3	--	0	0.2	--
B95-8	403	12/7/98	DES	peri	0.21	75	15.8	0	491	5.7	--	2.9	--	16	3	30	0	1	--
B95-8	403	4/22/99	DES	peri	0.234	65	15.2	0.02	482	6	--	3.8	--	12	3	30	0	<1	220
B95-9	404	5/29/97	DES	peri	0.09	40	3.6	0	647	5.7	--	0.12	--	14.94	2	16	0	0.17	292
B95-9	404	12/16/97	DES	peri	0.12	61	7.3	0	595	5.74	--	2.25	--	10	1	40	0	0.17	--
B95-9	404	5/12/98	DES	peri	0.17	50	8.5	0	514	5.79	--	2.6	--	11.5	2	--	0	0.21	--
B95-9	404	12/3/98	DES	peri	0.208	35	7.3	0	366	5.6	--	0.8	--	13	0.9	27	0	<1	--
B95-9	404	4/22/99	DES	peri	0.232	90	20.9	0	295	5.6	--	2.9	--	10	3	18	0	<1	203
B95-9(d)	404	12/16/97	DES	peri	0.12	61	7.3	0	--	--	--	--	--	--	--	--	--	--	--
B95-9(d)	404	5/12/98	DES	peri	0.17	50	8.5	0	--	--	--	--	--	--	--	--	--	--	--
equip blank		2/19/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	4/15/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	5/13/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	7/16/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	7/30/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	8/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
equip blank	0	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-1	565	3/1/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-1	565	7/16/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-1	565	9/10/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-2	566	3/1/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-2	566	7/16/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-2	566	9/10/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-2dup	566	3/1/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HM-1	299	5/29/97	DES	peri	0.09	84	7.6	0.01	103	5.59	--	0.02	--	12.22	0.5	18	0	0.65	101
HM-1	299	12/15/97	DES	peri	0.13	65	8.5	0.03	113	5.95	--	0.4	--	7.8	0.3	>100	.1	0.45	77
lab blank	0	5/13/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	7/15/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	7/30/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MI-19	30	5/30/97	DES	peri	0.07	190	13.3	0.01	220	8	--	0.65	--	14.89	0.8	<10	0	99	253
MI-20	31	5/30/97	DES	peri	0.08	45	3.6	0	206	5.47	--	2.59	--	13.11	2.5	16	0	<1	328
MI-20	31	12/17/97	DES	peri	0.11	98	10.8	0	519	5.35	--	1.78	--	1.8	--	--	0	0.96	--
MI-21	33	5/30/97	DES	peri	0.03	55	1.7	0.02	79	5.6	--	1.02	--	16.46	1	100	0	<1	321
MI-21	33	5/14/98	DES	peri	0.13	50	6.5	0	63	5.9	--	2	--	1	2	--	0	<1	--
MI-22	35	12/16/97	DES	peri	0.05	138	6.9	0	194	7.3	--	1	--	9	1	15.5	0	4	--
MI-22	35	5/13/98	DES	peri	0.06	230	13.8	0.09	187	6.92	--	1.02	--	12.1	1	--	0	82.1	--
MI-23	37	12/16/97	DES	peri	0.13	52	6.8	0	108	5.5	--	2.4	--	9	2	20	0	<1	--
MI-23	37	5/13/98	DES	peri	0.18	55	9.9	0.01	117	5.57	--	0.82	--	9.4	--	--	--	0.48	--
MI-25	40	6/2/97	DES	peri	0.05	195	9.8	0.01	185	7	--	1.03	--	13.75	0.7	100	0.8	147	<90
MI-25	40	12/15/97	DES	peri	0.02	90	1.8	2.09	500	6.27	--	1.59	--	6.3	1	--	0.6	2.25	156
MI-27	42	5/29/97	DES	peri	0.12	65	7.8	0	703	5.71	--	0.14	--	15.4	5	16	0	0.28	387
MI-27	42	12/15/97	DES	peri	0.11	35	3.9	0	747	5.52	--	4.9	--	--	1.5	30	0	<1	--
MI-32	46	6/2/97	DES	peri	0.11	85	9.4	0	140	5.57	--	4.2	--	11.56	--	--	--	3	257
MI-32	46	5/12/98	DES	peri	0.15	153	23.0	0	174	5.7	--	0.7	--	11	1	--	0	5	--
MI-32	46	12/4/98	DES	peri	0.17	125	21.3	0	320	5.7	--	1.3	--	13	1.4	30	0	3	--
MI-32	46	4/20/99	DES	peri	0.194	62	12.0	0	257	5.61	--	0	--	11.9	2	35	0	0.29	286
MI-63	203	5/29/97	DES	peri	0.12	80	9.6	0	60	5.76	--	0.23	--	11.78	0.2	16	0	0.2	310

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
MI-63	203	12/15/97	DES	peri	0.1	43	4.3	0	113	5.79	--	0.6	--	8	0.7	19	0	<1	--
MW-16A	233	5/27/97	DES	peri	0.1	55	5.5	0.02	407	5.62	--	0.49	--	11.81	6	35	0	0.53	359
MW-16A	233	12/19/97	DES	peri	0.29	72	20.9	0	636	5.92	--	--	--	--	1.5	16	0	--	166
MW-16A	233	5/13/98	DES	peri	0.16	80	12.8	0	609	5.6	--	5.7	--	11	6	--	0	<1	--
MW-16A	233	11/30/98	DES	peri	0.164	65	10.7	0	559	5.6	--	4.9	--	11	5	23	0	<1	--
MW-16A	233	4/13/99	DES	peri	0.22	95	20.9	0.01	477	5.6	--	5.4	--	10	5	25	0	<1	211
MW-16B	321	5/27/97	DES	peri	0.1	57	5.7	0.01	239	5.8	--	0.51	--	11.4	0.3	19	0	0.5	262
MW-16B	321	6/11/97	USGS	BL	1.69	218	368.4	0.01	340	5.39	--	--	--	--	0.4	14.5	0	--	309
MW-16B	321	12/18/97	DES	peri	0.12	81	9.7	0	386	5.72	--	0.38	--	9.9	0.4	27	0	0.09	289
MW-16B	321	5/11/98	DES	peri	0.14	85	11.9	0	404	5.71	--	0.56	--	10.1	0.4	--	0	0.2	--
MW-16B	321	11/30/98	DES	peri	0.188	50	9.4	0	428	5.7	--	0.4	--	11	0.5	21	0	<1	--
MW-16B	321	4/13/99	DES	peri	0.213	95	20.2	0.01	372	5.5	--	0.3	--	10	0.5	20	0	<1	147
MW-16B	321	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	7/16/99	USGS	peri	0.33	86	28.4	0	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B(d)	321	4/13/99	DES	peri	0.213	95	20.2	0.01	372	5.5	--	0.3	--	10	0.5	20	0	<1	147
MW-16C	344	5/27/97	DES	peri	0.08	65	5.2	0	447	5.41	--	0.3	--	13.23	1	--	0	0.03	299
MW-16C	344	6/12/97	USGS	BL	1.89	222	419.6	0	547	5.67	--	--	--	--	0.9	14	0	--	205
MW-16C	344	12/15/97	DES	peri	0.12	33	4.0	0	370	5.5	--	0.6	--	9	0.3	--	0	<1	--
MW-16C	344	5/11/98	DES	peri	0.14	70	9.8	0	394	5.7	--	0.4	--	10	0.3	--	0	<1	--
MW-16C	344	5/21/98	DES	peri	0.44	55	24.2	0.01	384	--	--	--	--	--	--	--	--	--	311
MW-16C	344	11/30/98	DES	peri	0.17	65	11.1	0	313	5.7	--	0.4	--	12	0.5	30	0	<1	--
MW-16C	344	4/13/99	DES	peri	0.168	90	15.1	0.01	317	5.57	--	0.48	--	9.7	0.4	20	0	0.15	175
MW-16C	344	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16C	344	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16C	344	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16C	344	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16C	344	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	5/27/97	DES	peri	0.03	153	4.6	0	196	8.38	--	0.63	--	14.59	0.8	<10	0	2.3	157
MW-16R	345	12/18/97	DES	peri	0.02	200	4.0	0.24	197	8.92	--	0.31	--	8.9	0.9	<10	0	0.56	10
MW-16R	345	5/13/98	DES	peri	0.02	110	2.2	0.01	212	8.6	--	0.8	--	11	0.9	--	0	<1	--

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
MW-16R	345	11/30/98	DES	peri	0.02	125	2.5	0	185	9	--	1.7	--	10	2	<10	0	<1	--
MW-16R	345	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-A	345	7/30/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-B	345	7/30/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-C	345	7/30/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-D	345	7/30/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	10/28/99	DES	peri	0.028	75	2.1	0.19	224	7.9	--	0.8	--	11	--	--	--	2	-151
MW-16R-A	345	10/28/99	DES	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-B	345	10/28/99	DES	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-C	345	10/28/99	DES	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-D	345	10/28/99	DES	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-27	235	12/2/98	DES	peri	0.136	100	13.6	0	120	6.2	--	0.5	--	11	0.6	23	4.2	1	--
MW-27	235	4/21/99	DES	peri	0.216	55	11.9	0.9	141	6.3	--	0.6	--	7	0.5	19	2.8	1	22
MW-27 (d)	235	12/2/98	DES	peri	0.136	100	13.6	0	120	6.2	--	--	--	--	0.6	23	4.2	1	--
MW-2A	310	9/30/98	DES	peri	0.13	55	7.2	0.01	60	6	--	0.6	--	11	0.6	12	0	<1	--
MW-2B	210	9/30/98	DES	peri	0.14	155	21.7	0	82	6.3	--	0.4	--	12	0.4	15	0.8	6	--
MW-2B(d)	210	9/30/98	DES	peri	0.14	155	21.7	0	82	6.3	--	--	--	--	0.4	15	0.8	6	--
MW-2R	311	9/30/98	DES	peri	0.024	230	5.5	0.03	151	8.75	--	1.41	--	17.2	1	11	--	10.8	--
P-2, river	385	5/28/97	DES	GRAB	--	--	--	--	62	--	6.8	--	17.2	--	9	<10	0	0	353
P-2,river	385	12/18/97	DES	GRAB	--	--	--	--	90	6.42	--	--	--	--	14.7	<10	0	--	122
P-2,river	385	5/13/98	DES	GRAB	--	--	--	--	58	6.21	--	--	--	--	--	--	--	--	--
P-2,river	385	12/9/98	DES	GRAB	--	--	--	--	98	6.67	--	--	--	--	--	--	--	--	--
P-2,River	385	4/19/99	DES	GRAB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
P2-RIVER	385	4/21/99	USGS/EPA	GRAB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-10D	552	5/20/98	DES	peri	0.16	190	30.4	0	539	11.5	--	0.6	--	12	0.6	--	0	4	--
PW-10D	552	12/7/98	DES	peri	0.218	110	24.0	0	256	10.68	--	0.32	--	13.6	0.2	<10	0	0.59	--
PW-10D	552	4/19/99	DES	peri	0.19	185	35.2	0.02	345	11	--	0.3	--	12	0.5	<10	0	<1	60
PW-10M	551	5/20/98	DES	peri	0.16	125	20.0	0	103	5.9	--	6.2	--	13	6	--	0	1	--
PW-10M	551	12/7/98	DES	peri	0.226	61	13.8	0.01	145	5.6	--	0.38	--	12.6	0.4	40	0	0.71	--
PW-10M	551	4/19/99	DES	peri	0.19	75	14.3	0.01	174	5.75	--	7.24	--	11.9	0.6	53	0	0.21	221

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
PW-11D	554	12/3/98	DES	peri	0.208	75	15.6	0	174	5.7	--	0.3	--	11	0.4	21	0	<1	--
PW-11D	554	4/15/99	DES	peri	0.212	90	19.1	0.02	148	5.6	--	0.4	--	10	0.6	17	0	<1	141
PW-11M	553	12/3/98	DES	peri	0.214	35	7.5	0.01	118	5.8	--	0.3	--	11	0.4	21	0	<1	--
PW-11M	553	4/15/99	DES	peri	0.22	55	12.1	0.01	122	5.7	--	0.3	--	10	0.6	19	0	<1	163
PW-12D	557	5/15/98	DES	peri	0.19	82	15.6	0.01	106	5.87	--	0.36	--	10.8	0.3	--	0	0.33	--
PW-12D	557	11/25/98	DES	peri	0.19	85	16.2	0.01	100	5.81	--	0.38	--	10.6	0.4	30	0	1	--
PW-12D	557	4/8/99	DES	peri	0.212	74	15.7	0.02	106	5.77	--	0.35	--	9.7	0.35	55	0	0.1	185
PW-12D	557	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12D	557	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12D	557	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12D	557	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12D	557	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	5/15/98	DES	peri	0.21	60	12.6	0	105	5.87	--	0.37	--	11.5	--	--	--	0.35	--
PW-12M	556	11/25/98	DES	peri	0.206	45	9.3	0	104	5.8	--	0.4	--	11	0.6	25	0	<1	--
PW-12M	556	4/7/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	4/8/99	DES	peri	0.22	80	17.6	0	102	5.8	--	0.3	--	10	0.5	22	0.7	<1	76
PW-12M	556	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	5/15/98	DES	peri	0.14	245	34.3	0	161	7.3	--	0.3	--	12	0.3	--	0	15	--
PW-12R	558	11/25/98	DES	peri	0.13	115	15.0	0	188	7.4	--	0.3	--	11	0.4	<10	1.1	<1	--
PW-12R	558	4/8/99	DES	peri	0.125	95	11.9	0.28	199	7.5	--	0.4	--	10	0.6	<10	1.1	<1	-139
PW-12R	558	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12S	555	5/14/98	DES	peri	0.16	265	42.4	0	118	6.2	--	0.4	--	10	0.4	--	4.7	1	--
PW-12S	555	11/25/98	DES	peri	0.164	55	9.0	0.01	113	5.92	--	0.34	--	11.3	0.1	25	2	0.1	--
PW-12S	555	4/8/99	DES	peri	0.142	115	16.3	0.03	174	5.62	--	2.96	--	10.6	3	24	1.4	0.75	146
PW-12S	555	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12S	555	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
PW-12S	555	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12S	555	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12S	555	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13D	561	7/24/98	USGS	peri	0.15	98	14.7	0.12	173	7.16	--	0.21	--	13.6	0.6	13	0.8	6.57	--
PW-13D	561	11/24/98	DES	peri	0.134	133	17.8	0.12	130	6.69	--	0.31	--	10.5	0.1	17	2.9	0.73	--
PW-13D	561	4/8/99	DES	peri	0.162	55	8.9	0.14	129	6.4	--	0.4	--	11	0.4	18	3.2	<1	-19
PW-13D	561	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13D	561	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13D	561	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13D	561	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13D	561	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	7/23/98	USGS	peri	0.17	105	17.9	0	89	6.76	--	0.44	--	13.5	0.6	27	0.6	0.33	--
PW-13M	560	11/23/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	11/23/98	DES	peri	0.156	95	14.8	0	91	6	--	0.5	--	11	0.6	20	0.5	<1	--
PW-13M	560	2/8/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	2/8/99	USGS	peri	0.45	79	35.6	0.02	95	9.82	--	0.7	--	8.4	0.5	13	0.6	0.55	140
PW-13M	560	4/7/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	4/8/99	DES	peri	0.19	40	7.6	0	97	5.75	--	0.46	--	10.1	0.6	32	0.1	0.24	134
PW-13M	560	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	7/23/98	USGS	peri	0.18	100	18.0	0.01	79	5	--	7.71	--	13.2	7	27	--	0.8	--
PW-13S	559	11/24/98	DES	peri	0.19	70	13.3	0	78	5.8	--	1.9	--	11	2	19	0	<1	--
PW-13S	559	4/8/99	DES	peri	0.212	80	17.0	0.01	84	5.7	--	1	--	11	1.1	18	0	<1	128
PW-13S	559	5/13/99	USGS	peri	0.42	35	14.7	0.03	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	7/24/98	USGS	peri	0.16	94	15.0	0.02	226	5.8	--	0.4	--	13	0.5	35	0.6	<1	--
PW-14D	564	11/23/98	DES	peri	0.1	90	9.0	0	255	5.9	--	0.5	--	10	0.6	21	0	<1	--

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
PW-14D	564	4/7/99	DES	peri	0.182	130	23.7	0.01	212	5.8	--	0.3	--	9	0.5	22	0	<1	158
PW-14D	564	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	7/23/98	USGS	peri	0.16	110	17.6	0	102	5.7	--	0.4	--	13	0.6	35	0.5	<1	--
PW-14M	563	11/23/98	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	11/23/98	DES	peri	0.17	60	10.2	0.02	97	5.83	--	0.43	--	10.9	0.6	35	0	0.18	--
PW-14M	563	2/8/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	4/7/99	DES	peri	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	4/7/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M(d)	563	2/8/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	7/23/98	USGS	peri	0.16	115	18.4	0	178	5.8	--	2.5	--	13	2.5	40	0	<1	--
PW-14S	562	11/23/98	DES`	peri	0.172	98	16.9	0.01	173	6	--	2.4	--	10.6	2	25	0	0.1	--
PW-14S	562	4/7/99	DES	peri	0.166	195	32.4	0.01	138	5.99	--	5.09	--	9	5	26	0	0.59	208
PW-14S	562	5/13/99	USGS	peri	0.43	36	15.5	0.01	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	7/16/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	8/12/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S(d)	562	7/23/98	USGS	peri	0.16	115	18.4	0	178	5.8	--	--	--	--	2.5	40	0	<1	--
PW-1D	531	5/14/98	DES	peri	0.16	72	11.5	0.01	186	5.8	--	0.51	--	12.3	0.3	--	0	0.21	--
PW-1D	531	12/1/98	DES	peri	0.168	65	10.9	0	164	5.88	--	0.41	--	11.2	0.3	30	0	0.75	--
PW-1D	531	4/9/99	DES	peri	0.204	75	15.3	0	143	5.8	--	0.3	--	10	0.5	27	0	<1	162
PW-1S	530	5/14/98	DES	peri	0.16	120	19.2	0	144	5.79	--	1.99	--	12.3	2	--	0	0.25	--
PW-1S	530	12/1/98	DES	peri	0.19	70	13.3	0	131	5.8	--	0.3	--	11	0.4	21	0	<1	--
PW-1S	530	4/9/99	DES	peri	0.194	92	17.8	0	119	5.8	--	0.3	--	10	0.4	25	0	<1	148

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
PW-2D	534	5/18/98	DES	peri	0.17	87	14.8	0	595	5.6	--	1.1	--	12	1	--	0	<1	--
PW-2D	534	12/4/98	DES	peri	0.21	83	17.4	0.01	282	5.98	--	0.53	--	12.9	0.4	25	0	0.19	--
PW-2D	534	4/14/99	DES	peri	0.204	70	14.3	0.01	294	5.7	--	0.5	--	11	0.7	18	0	<1	195
PW-2M	533	5/20/98	DES	peri	0.19	75	14.3	0.02	146	6.2	--	6.4	--	11.6	6	--	0	0.9	--
PW-2M	533	12/4/98	DES	peri	0.212	61	12.9	0	298	5.7	--	0.6	--	12	0.6	27	0	<1	--
PW-2M	533	4/14/99	DES	peri	0.23	95	21.9	0.01	260	5.6	--	0.8	--	11	1	20	0	<1	175
PW-2R	535	5/20/98	DES	peri	0.03	192	5.8	0	208	9.91	--	1.43	--	--	--	--	--	44.4	--
PW-2R	535	12/4/98	DES	peri	0.02	65	1.3	0	232	10.1	--	2	--	17	2	<10	0	20	--
PW-2R	535	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-2R	535	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-2R	535	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-2S	532	5/18/98	DES	peri	0.19	123	23.4	0.01	119	5.87	--	8.34	--	11.2	8	--	0	0.62	--
PW-2S	532	12/4/98	DES	peri	0.196	68	13.3	0.01	194	6.06	--	3.91	--	12.7	4	30	0	0.54	--
PW-2S	532	4/14/99	DES	peri	0.197	202	39.8	0.02	665	5.92	--	3.07	--	9.7	3	40	0	0.52	286
PW-3D	537	12/3/98	DES	peri	0.218	45	9.8	0	105	6	--	0.3	--	11	0.4	20	0	<1	--
PW-3D	537	4/14/99	DES	peri	0.202	60	12.1	0.01	84	6.01	--	0.27	--	8.4	0.4	18	0	0.12	175
PW-3S	536	12/3/98	DES	peri	0.22	30	6.6	0	111	5.8	--	3.9	--	11	4	12	0	<1	--
PW-3S	536	4/14/99	DES	peri	0.215	45	9.7	0.01	125	6.7	--	3.4	--	6	4	11	0	<1	212
PW-4D	539	12/7/98	DES	peri	0.206	55	11.3	0	462	6	--	2.6	--	14	3	21	0	<1	--
PW-4D	539	4/22/99	DES	peri	0.216	65	14.0	0.06	512	5.93	--	2.89	--	11.5	3	22	0	0.25	199
PW-4M	538	12/7/98	DES	peri	0.226	85	19.2	0	442	5.9	--	3.9	--	15	5	30	0	<1	--
PW-4M	538	4/22/99	DES	peri	0.224	60	13.4	0.03	415	5.98	--	5.03	--	11.7	5	25	0	0.35	297
PW-4M (d)	538	12/7/98	DES	peri	0.226	85	19.2	0	442	5.9	--	--	--	--	5	30	0	<1	--
PW-5D	541	12/7/98	DES	peri	0.208	65	13.5	0	305	5.73	--	0.56	--	11.1	0.5	20	0	0.2	--
PW-5D	541	4/19/99	DES	peri	0.2	90	18.0	0.03	201	5.8	--	0.4	--	12	0.5	23	0	<1	144
PW-5M	540	12/8/98	DES	peri	0.2	50	10.0	0	122	5.72	--	3.32	--	10.6	3.5	23	0	0.47	--
PW-5M	540	4/19/99	DES	peri	0.176	60	10.6	0.03	121	5.72	--	2.14	--	11.5	1.5	26	0	0.13	263
PW-5R	542	12/8/98	DES	peri	0.02	170	3.4	0.07	2751	12.5	--	2.3	--	6	5	<10	0	<1	--
PW-5R	542	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-5R	542	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-5R	542	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-6D	545	5/21/98	DES	peri	0.17	230	39.1	0	338	8.5	--	1.7	--	13	1.5	--	0	17	--
PW-6D	545	12/10/98	DES	peri	0.416	232	96.5	1.66	393	8.58	--	1.21	--	10.5	1	25	0	218	--
PW-6D	545	4/21/99	DES	peri	0.192	240	46.1	0.1	372	8.7	--	0.3	--	12	0.6	<10	0	1	-158

Appendix 2a. Sampling information and field parameters, May 1997 to October 1999, Milford, New Hampshire.

Well Name	Well #	Date	Source	Pump TYPE	Pump Rate (L/min)	Duration (min)	Volume Pumped (L)	Drawdown (ft)	SC (µmhos/cm)	pH	DO hole (mg/l)	DO flowthru (mg/l)	Temp hole (°C)	Temp flowthru (°C)	DO© (mg/l)	CO_2© (mg/l)	Fe2+© (mg/l)	Turbidity (NTU)	Obs. Eh (mv)
PW-6D(d)	545	5/21/98	DES	peri	0.17	230	39.1	0	--	--	--	--	--	--	--	--	--	--	--
PW-6M	544	5/21/98	DES	peri	0.17	90	15.3	0	142	5.8	--	2.66	--	12.9	2	--	0.6	0.81	--
PW-6M	544	12/10/98	DES	peri	0.185	65	12.0	0	185	5.8	--	0.4	--	11	0.5	25	0	1	--
PW-6M	544	4/21/99	DES	peri	0.183	47	8.6	0.02	131	5.96	--	1.48	--	12.1	1	25	0	0.48	185
PW-6R	546	12/10/98	DES	peri	0.02	180	3.6	0.39	2189	12.3	--	2.3	--	8	3	<10	0	5	--
PW-6R	546	5/13/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-6R	546	6/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-6R	546	9/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-6S	543	5/21/98	DES	peri	0.2	174	34.8	0	143	5.78	--	6.47	--	12.7	7	--	0.2	1.1	--
PW-6S	543	12/10/98	DES	peri	0.211	165	34.8	0.02	226	5.6	--	0.6	--	11	0.6	30	0	<1	--
PW-6S	543	4/21/99	DES	peri	0.19	70	13.3	0.01	250	5.76	--	1.83	--	11.8	1	45	0	0.26	230
PW-7M	548	12/9/98	DES	peri	0.194	55	10.7	0	138	6.4	--	0.5	--	11	0.6	17	0.5	1	--
PW-7M	548	4/15/99	DES	peri	0.198	103	20.4	0.19	130	6.48	--	0.15	--	11.5	0.3	20	0.04	0.61	82
PW-7S	547	12/9/98	DES	peri	0.202	50	10.1	0	150	6.2	--	0.5	--	12	0.6	16	1.4	<1	--
PW-7S	547	4/15/99	DES	peri	0.202	60	12.1	0.02	116	6.32	--	0.22	--	11.9	0.4	20	1.1	0.6	67
PW-8M	549	4/20/99	DES	peri	0.202	90	18.2	0.01	259	6.76	--	2.22	--	11.7	3	19	0	1.96	155
PW-9M	550	4/20/99	DES	peri	0.218	95	20.7	0	213	5.5	--	1.4	--	9	1.3	30	0	<1	175
PW-9M(d)	550	4/20/99	DES	peri	0.218	95	20.7	0	213	5.5	--	1.4	--	9	1.3	30	0	<1	175
Trip blank		2/19/98	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trip blank	0	3/1/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/7/99	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/8/99	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/12/99	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/14/99	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/19/99	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/21/99	DES	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	5/12/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	6/10/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank		7/14/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	7/27/99	USGS	NA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	8/10/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	9/9/99	USGS	DB	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

	Well		NH_4^+	S_2^-	Cl^-	SO_4^{2-}	NO_3-&NO_2-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Fe(total)	Mg^{2+}	Mn^{2+}	K^+	Na^+	CH_4	TOC	Br-	SC-lab	$CaCO_3$
Name	#	Date	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(µmhos/cm)	(mg/l)
(DB blank)	--	2/8/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(eq. blank)	--	9/30/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	5/11/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	5/13/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	5/18/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	5/19/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	5/21/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	7/21/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	7/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	9/18/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	9/30/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	10/20/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	11/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	11/30/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	12/1/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	12/3/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	12/7/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	12/8/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	12/8/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(trip blank)	--	2/8/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-12	407	5/28/97	<0.5	--	185	14	2.27	--	--	--	12.2	<0.05	2.01	0.03	3.71	100	0.151	<2	--	--	10.6
B95-12	407	10/28/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<0.01	--	1.65	747	8.8
B95-12	407	12/15/97	--	--	230	14	--	2.36	<0.05	0.005	13.5	<0.05	2.2	0.033	4.24	123	<0.01	<1	1.67	805	9
B95-12	407	2/19/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.009	--	1.38	845	8.4
B95-12	407	5/18/98	--	--	205	14	--	--	--	--	12.7	<0.05	2.03	0.032	3.86	117	1.75	0.47	1.72	743	9
B95-12	407	7/22/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.86	0.75	1.91	712	10.8
B95-12	407	12/2/98	--	--	200	13	2.39	1.03	--	0.005	13.3	<0.05	2.27	0.032	3.74	114	1.887	0.34	2.01	745	9.4
B95-12	407	4/13/99	--	--	205	14	2.07	0.75	--	0.003	11.5	<0.05	1.96	0.028	3.85	111	--	--	1.57	--	10.2
B95-12(d)	407	5/28/97	<0.25	--	190	14	2.27	--	--	--	12.2	<0.05	2	0.03	3.7	98.9	0.209	<2	--	--	--
B95-13	408	5/28/97	<0.25	--	40	9	0.9	--	--	--	11.5	<0.05	2.26	0.406	1.79	17.3	1.335	<2	--	--	13.6
B95-13	408	10/28/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	10/28/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.39	--	<0.4	184	12.6
B95-13	408	2/20/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	2/20/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.16	--	<0.2	155	13.6
B95-13	408	5/21/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.12	--	--	--	--

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

	Well		NH_4^+	S_2^-	Cl^-	SO_4^{2-}	NO_3-&NO_2-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Fe(total)	Mg^{2+}	Mn^{2+}	K^+	Na^+	CH_4	TOC	Br-	SC-lab	$CaCO_3$
Name	#	Date	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(µmhos/cm)	(mg/l)
B95-13	408	5/21/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	5/21/98	--	--	25	10	--	--	--	--	9.69	<0.05	1.92	0.326	1.43	13.2	4.36	0.57	0.368	151	12.8
B95-13	408	7/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.34	1.03	0.156	184	13.8
B95-13	408	7/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	7/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.29	0.86	0.059	180	17.8
B95-13	408	7/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.45	0.83	0.077	180	15.2
B95-13	408	7/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.089	178	14.6
B95-13	408	9/30/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	11/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	11/24/98	--	--	20	10	0.48	0.28	--	0.004	8.86	<0.05	1.8	0.311	1.19	10.9	66.63	0.85	0.3	146	15.2
B95-13	408	2/8/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	2/8/99	--	--	--	--	--	0.29	--	--	--	--	--	--	--	--	10.519	0.79	0.389	132	16
B95-13	408	4/7/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/14/99	--	--	19	9	0.48	0.17	--	0.003	8.34	<0.05	1.7	0.323	1.29	9.43	14.36	0.84	--	--	42.6
B95-13	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14.84	1.33	0.242	124	17.6
B95-13	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13.18	--	--	--	17.2
B95-13	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15.49	--	--	--	--
B95-13	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14.28	--	--	--	16.4
B95-13	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16.6
B95-13	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16.4
B95-13	408	4/20/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/20/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/20/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	4/20/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13	408	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13 (d)	408	2/8/99	--	--	--	--	--	0.26	--	--	--	--	--	--	--	--	11.19	0.64	0.351	130	16
B95-13(d)	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13(d)	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	NH_4^+ (mg/l)	S_2^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	NO_3-&NO_2- (mg/l)	NO_3^- (mg/l)	NO_2^- (mg/l)	PO_4^{3-} (mg/l)	Ca^{2+} (mg/l)	Fe(total) (mg/l)	Mg^{2+} (mg/l)	Mn^{2+} (mg/l)	K^+ (mg/l)	Na^+ (mg/l)	CH_4 (mg/l)	TOC (mg/l)	Br- (mg/l)	SC-lab (µmhos/cm)	$CaCO_3$ (mg/l)
B95-13(d)	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13(d)	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13(d)	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13(d)	408	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16.4
B95-13-A	408	7/30/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13-B	408	7/30/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-13-C	408	7/30/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	5/28/97	<0.25	--	12	13	0.82	--	--	--	8.49	<0.05	1.78	0.134	1.44	6.79	1.155	<2	--	--	14
B95-15	409	10/30/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	10/30/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.35	--	0.19	111	12.2
B95-15	409	2/20/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.91	--	<0.2	114	11.6
B95-15	409	5/18/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	5/18/98	--	--	12	12	--	--	--	--	8.14	<0.05	1.71	0.119	1.37	7.27	3.47	0.45	0.259	107	12.6
B95-15	409	7/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	7/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.98	0.93	0	107	14
B95-15	409	9/30/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	11/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	11/24/98	--	--	15	38	0.1	0.07	--	0.008	10.3	<0.05	2.06	0.198	2.02	19	15.64	1.1	0.27	195	16.6
B95-15	409	2/8/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	2/8/99	--	--	--	--	--	0.01	--	--	--	--	--	--	--	--	0.739	0.99	0.428	188	13.6
B95-15	409	4/7/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.11	0.149	--	13.8
B95-15	409	4/8/99	--	--	18	24	0.09	0.09	--	0.005	7.97	<0.05	1.53	0.248	1.87	14.8	--	--	0.149	--	13.8
B95-15	409	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15	409	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-15(d)	409	9/30/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B95-3	398	5/29/97	<0.25	--	11	9	<0.05	--	--	--	6.15	1.3	1.42	0.323	0.95	6.7	0.202	<2	--	--	16.6
B95-3	398	6/17/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.012	--	--	--	9.4
B95-3	398	12/16/97	--	<0.1	13	8	--	<0.05	<0.05	0.007	5.36	1.86	1.23	0.241	1.13	7.12	1.74	1.1	<0.4	89	10.2
B95-3	398	5/12/98	--	--	--	--	--	--	--	--	7.52	<0.05	1.48	<0.01	4.41	4.06	1.8	1.54	--	--	--
B95-3	398	12/3/98	--	--	12	9	<0.05	0	--	0.01	5.84	1.28	1.34	0.323	1	6.64	2.105	0.92	0.14	91	12.2
B95-3	398	4/20/99	--	--	17	8	--	<0.05	<0.05	0.002	4.48	0.511	1.09	0.177	1.3	10.11	--	--	0.119	--	10.2

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	NH_4^+ (mg/l)	S_2^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	NO_3-&NO_2- (mg/l)	NO_3^- (mg/l)	NO_2^- (mg/l)	PO_4^{3-} (mg/l)	Ca^{2+} (mg/l)	Fe(total) (mg/l)	Mg^{2+} (mg/l)	Mn^{2+} (mg/l)	K^+ (mg/l)	Na^+ (mg/l)	CH_4 (mg/l)	TOC (mg/l)	Br- (mg/l)	SC-lab (µmhos/cm)	$CaCO_3$ (mg/l)
B95-5	400	6/2/97	<0.25	--	3	14	1.3	--	--	--	6.56	<0.05	1.32	<0.01	4.08	2.88	<0.01	<2	--	--	8.4
B95-5	400	12/17/97	--	--	3	13	--	0.78	<0.05	0.004	5.66	<0.05	1.13	<0.01	3.77	2.6	0.02	<1	<0.4	71	8.2
B95-5	400	5/12/98	--	--	9	13	--	--	--	--	--	--	--		--	--	1.79	0.55	0.199	98	9
B95-5	400	12/2/98	--	--	2	13	0.69	0.34	--	0.005	4.98	<0.05	0.954	<0.01	3.39	2.81	1.819	0.43	0	69	8.8
B95-5	400	4/21/99	--	--	4	11	--	0.76	<0.05	0.002	5.7	<0.05	1.18	<0.01	3.56	2.54	--	--	0.094	--	9.8
B95-6	401	6/16/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.035	--	--	--	14
B95-6	401	12/17/97	--	--	17	7	--	<0.05	<0.05	0.004	3.86	1.49	0.82	1.1	1.38	11.6	50.22	1.6	<0.4	111	13.2
B95-6	401	5/12/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31.06	0.86	--	--	--
B95-6	401	12/2/98	--	--	13	10	0.08	0	--	0.006	4.87	0.684	1.06	1.73	1.2	10.4	3.014	1.13	0.14	112	8.4
B95-6	401	4/21/99	--	--	13	10	--	<0.05	<0.05	<0.001	4.26	1.71	0.96	1.51	1.29	10.1	--	--	0.195	--	15.4
B95-7	402	12/17/97	--	--	104	11	--	0.86	<0.05	0.004	11.6	<0.05	2.36	0.051	3.23	53	0.02	<1	0.86	385	11.8
B95-7	402	1/12/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.99	447	--
B95-8	403	6/16/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<0.01	--	--	--	12.8
B95-8	403	12/16/97	--	--	125	7	--	0.97	<0.05	0.006	20.8	<0.05	4.3	<0.01	3.06	48.8	0.13	<1	0.94	108	11.6
B95-8	403	5/12/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.82	0.46	--	--	--
B95-8	403	12/7/98	--	--	130	11	1.26	0.67	--	0.003	16.7	<0.05	3.47	<0.01	3.46	63.6	2.038	0.49	1.54	502	13.6
B95-8	403	4/22/99	--	--	127	12	0.99	--	--	0.004	21.8	<0.05	4.36	0.016	2.51	54	--	--	1.29	--	15.6
B95-9	404	5/29/97	<0.25	--	180	11	1.2	--	--	--	13	<0.05	1.8	0.056	2.83	97.8	0.013	<2	--	--	13.4
B95-9	404	12/16/97	--	--	164	12	--	0.86	<0.05	0.006	12.4	<0.05	1.66	0.079	2.68	88.4	0.06	<1	1.16	595	14.4
B95-9	404	5/12/98	--	--	138	11	--	--	--	--	12.2	<0.05	1.72	0.067	2.39	79.2	3.16	0.76	1.23	516	12.6
B95-9	404	12/3/98	--	--	71	32	2.3	1.63	--	0.006	15.8	<0.05	2.76	0.455	2.98	43.5	2.25	1.99	0.75	376	14
B95-9	404	4/22/99	--	--	62	27	1.9	--	--	0.002	13.6	0.081	2.34	0.127	2.47	33.5	--	--	3.44	--	11.4
B95-9(d)	404	12/16/97	--	--	162	12	--	0.86	<0.05	0.008	12.3	<0.05	1.63	0.079	2.62	87.9	--	<1	--	--	--
B95-9(d)	404	5/12/98	--	--	138	11	--	--	--	--	12.2	<0.05	1.72	0.065	2.35	78.7	2.65	0.63	1.33	519	11.8
equip blank	--	2/19/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	4/15/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	7/30/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	8/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
equip blank	0	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-1	565	3/1/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.76	0.502	128	14.8
EW-1	565	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-1	565	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	NH_4^+ (mg/l)	S_2^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	NO_3^-&NO_2^- (mg/l)	NO_3^- (mg/l)	NO_2^- (mg/l)	PO_4^{3-} (mg/l)	Ca^{2+} (mg/l)	Fe(total) (mg/l)	Mg^{2+} (mg/l)	Mn^{2+} (mg/l)	K^+ (mg/l)	Na^+ (mg/l)	CH_4 (mg/l)	TOC (mg/l)	Br- (mg/l)	SC-lab (µmhos/cm)	$CaCO_3$ (mg/l)
EW-2	566	3/1/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.57	0	39	9.8
EW-2	566	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-2	566	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EW-2dup	566	3/1/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HM-1	299	5/29/97	<0.25	--	13	10	0.32	--	--	--	7.29	0.112	1.58	0.524	1.32	7.78	4.436	<2	--	--	14
HM-1	299	12/15/97	--	<0.1	14	10	--	0.12	<0.05	0.015	7.07	0.711	1.55	0.501	1.26	7.56	15.26	1	<0.4	108	10
lab blank	0	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	7/15/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	7/30/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
lab blank	0	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MI-19	30	5/30/97	<0.25	--	<2	15	<0.05	--	--	--	19.6	4.75	5.13	0.143	2.45	23.9	2.282	<2	--	--	98
MI-20	31	5/30/97	<0.5	--	51	7	0.2	--	--	--	1.54	<0.05	0.277	0.016	0.658	35.7	<0.01	2.2	--	--	11.8
MI-20	31	12/17/97	--	--	142	10	--	0.06	<0.05	0.019	8.59	0.808	1.47	0.06	1.79	74.1	--	2.2	1.5	519	6.6
MI-21	33	5/30/97	<0.25	--	14	5	0.08	--	--	--	3.01	0.054	0.626	0.018	0.832	9.36	0.06	<2	--	--	7.4
MI-21	33	5/14/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.8	3.06	--	--	--
MI-22	35	12/16/97	--	--	8	13	--	1.16	0.08	0.013	22.9	0.144	2.86	0.026	0.99	8.66	0.49	<1	<0.4	194	58.4
MI-22	35	5/13/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MI-23	37	12/16/97	--	--	13	6	--	1.15	<0.05	0.006	6.2	<0.05	1.05	<0.01	1.61	8.6	<0.01	2.1	<0.4	--	12.2
MI-23	37	5/13/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MI-25	40	6/2/97	<0.25	--	18	10	0.11	--	--	--	10.4	5.18	2.79	0.361	2.31	22	31.78	<2	--	--	41.2
MI-25	40	12/15/97	--	--	130	13	--	0.24	<0.05	0.013	21	0.968	3.92	0.532	2.83	65.7	1.48	<1	0.92	500	33.4
MI-27	42	5/29/97	<0.25	--	205	12	1.67	--	--	--	15.8	<0.05	2.89	0.017	4.64	107	<0.01	<2	--	--	12.2
MI-27	42	12/15/97	--	--	220	12	--	1.52	<0.05	0.004	14.3	<0.05	2.59	0.015	4.51	106.4	--	<1	1.67	741	9
MI-32	46	6/2/97	<0.25	--	29	7	1.22	--	--	--	8.26	0.1	1.07	<0.01	1.78	15.6	0.396	<2	--	--	11
MI-32	46	5/12/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.83	0.71	--	--	--
MI-32	46	12/4/98	--	--	80	11	1.02	0.67	--	0.009	11.7	0.109	1.71	0.077	2.96	42.2	1.983	0.61	0.83	332	10.8
MI-32	46	4/20/99	--	--	55	18	--	1.35	<0.05	<0.001	11.7	<0.05	1.62	0.028	2.24	28.5	--	--	0.641	--	12.2
MI-63	203	5/29/97	<0.5	--	16	9	0.5	--	--	--	7.09	0.062	1.38	0.745	1.07	9.1	2.91	<2	--	--	14.4
MI-63	203	12/15/97	--	--	16	10	--	0.3	<0.05	0.004	6.43	0.322	1.3	0.73	1.09	9.09	3.28	1.1	<0.4	104	12.6
MW-16A	233	5/27/97	<0.25	--	140	12	1.57	--	--	--	12.9	<0.05	1.79	0.021	2.68	72.9	0.261	<2	--	--	12
MW-16A	233	12/19/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.172	--	1.47	645	9
MW-16A	233	5/13/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.7	--	--	--
MW-16A	233	11/30/98	--	--	150	12	1.48	0.76	--	0.004	11.1	<0.05	1.55	0.021	2.58	85.6	2	0.52	1.41	567	9.6

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	NH_4^+ (mg/l)	S_2^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	NO_3-&NO_2- (mg/l)	NO_3^- (mg/l)	NO_2^- (mg/l)	PO_4^{3-} (mg/l)	Ca^{2+} (mg/l)	Fe(total) (mg/l)	Mg^{2+} (mg/l)	Mn^{2+} (mg/l)	K^+ (mg/l)	Na^+ (mg/l)	CH_4 (mg/l)	TOC (mg/l)	Br- (mg/l)	SC-lab (µmhos/cm)	$CaCO_3$ (mg/l)
MW-16A	233	4/13/99	--	--	131	13	1.74	0.67	--	0.004	8.41	<0.05	1.2	0.016	2.31	72.6	--	--	1.07	--	10.8
MW-16B	321	5/27/97	0.5	--	72	10	1.75	--	--	--	9	<0.05	1.21	0.163	2.77	41.2	0.159	<2	--	--	13.2
MW-16B	321	6/11/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<0.01	--	--	--	11
MW-16B	321	12/18/97	--	<0.1	94	9	--	1.58	<0.05	0.004	12	<0.05	1.65	0.203	2.9	49.3	0.68	<1	1	386	11.2
MW-16B	321	5/11/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.96	0.67	--	--	--
MW-16B	321	11/30/98	--	--	108	8	1.25	0.47	--	0.006	14.6	<0.05	2.02	0.195	2.89	58.5	2.21	0.54	1.75	441	10.6
MW-16B	321	4/13/99	--	--	102	9	1.32	0.36	--	0.006	11.1	<0.05	1.6	0.142	2.62	48.1	--	--	0.821	--	11.2
MW-16B	321	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B	321	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16B(d)	321	4/13/99	--	--	101	9	1.34	0.48	--	0.005	11.4	<0.05	1.61	0.144	2.67	49	--	--	0.896	--	13
MW-16C	344	5/27/97	<0.25	--	138	12	1.11	--	--	--	17.3	<0.05	3.04	0.277	2.82	64.8	0.495	<2	--	--	11.6
MW-16C	344	6/12/97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<0.01	--	--	--	12.4
MW-16C	344	12/15/97	--	--	86	10	--	1.09	<0.05	0.005	12.7	--	2.27	0.223	2.04	42	0.24	<1	0.54	345	11.6
MW-16C	344	5/11/98	--	--	101	9	--	--	--	--	15.2	<0.05	2.69	0.255	2.36	50.4	2	0.58	1.05	397	9.8
MW-16C	344	5/21/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.14	--	1.02	380	10.6
MW-16C	344	11/30/98	--	--	74	9	1.09	0.65	--	0.005	13.3	<0.05	2.38	0.272	1.92	38.8	2.62	0.43	0.78	323	11.2
MW-16C	344	4/13/99	--	--	80	11	1.03	0.24	--	0.005	13.4	<0.05	2.48	0.3	2.03	37.5	--	--	0.658	--	12.8
MW-16C	344	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16C	344	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16C	344	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16C	344	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16C	344	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	5/27/97	0.5	--	27	5	<0.05	--	--	--	20.7	0.235	2.62	0.062	1.69	17.5	967.12	<2	--	--	58.6
MW-16R	345	12/18/97	--	<0.1	24	3	--	<0.05	<0.05	0.027	15.6	0.114	1.98	0.013	1.65	18.2	1147.61	1.1	<0.4	197	54.4
MW-16R	345	5/13/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	29.86	1.04	--	--	--
MW-16R	345	11/30/98	--	--	21	1	0.57	0	--	0.049	13.7	<0.05	1.69	0.012	1.4	20.7	1763.35	1.5	0.64	212	54.8
MW-16R	345	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	NH_4^+ (mg/l)	S_2^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	NO_3-&NO_2- (mg/l)	NO_3^- (mg/l)	NO_2^- (mg/l)	PO_4^{3-} (mg/l)	Ca^{2+} (mg/l)	Fe(total) (mg/l)	Mg^{2+} (mg/l)	Mn^{2+} (mg/l)	K^+ (mg/l)	Na^+ (mg/l)	CH_4 (mg/l)	TOC (mg/l)	Br- (mg/l)	SC-lab (µmhos/cm)	$CaCO_3$ (mg/l)
MW-16R-A	345	7/30/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-B	345	7/30/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-C	345	7/30/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-D	345	7/30/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R	345	10/28/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-A	345	10/28/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-B	345	10/28/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-C	345	10/28/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-16R-D	345	10/28/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW-27	235	12/2/98	--	--	18	5	0.05	0.03	--	0.007	3.78	6.36	0.926	0.544	1.15	12.2	301.778	1.58	0.22	104	15.2
MW-27	235	4/21/99	--	--	26	4	--	0.06	<0.05	0.002	4.04	7.04	1.17	0.497	1.38	13.9	--	--	0.42	--	11.8
MW-27 (d)	235	12/2/98	--	--	18	5	0.05	0.05	--	0.008	3.77	6.35	0.904	0.543	1.12	12	233.254	1.27	0.21	105	16
MW-2A	310	9/30/98	--	--	7	7.33	--	<0.05	<0.05	<0.001	3.45	<0.05	0.824	0.025	0.876	5.95	1.91	1.75	--	--	8.6
MW-2B	210	9/30/98	--	--	9	7.42	--	<0.05	<0.05	0.026	6.35	0.669	1.41	0.466	1.02	5.87	4.67	0.75	--	--	16
MW-2B(d)	210	9/30/98	--	--	9	7.89	--	<0.05	<0.05	0.011	6.27	0.642	1.38	0.459	0.996	5.86	4.71	0.76	--	--	15.6
MW-2R	311	9/30/98	--	--	3	7.24	--	<0.05	<0.05	0.003	14.8	1.7	2.12	0.065	0.705	14.2	250.55	0.76	--	--	62
P-2, river	385	5/28/97	<0.25	--	13	5	0.06	--	--	--	--	--	--	--	--	--	--	3	--	--	7.8
P-2,river	385	12/18/97	--	<0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<0.4	--	6
P-2,river	385	5/13/98	--	--	10	4	--	--	--	--	2.06	0.279	0.476	0.039	0.497	7.12	2.09	3.8	0.21	58	3.6
P-2,river	385	12/9/98	--	--	16	6	0.12	0.06	--	0.021	3.47	0.36	0.79	0.021	1.1	11.2	2.063	3.43	0.28	98	7.4
P-2,River	385	4/19/99	--	--	17	5	0.09	0.02	--	0.01	2.9	0.181	0.67	0.023	0.684	10.6	--	--	--	--	--
P2-RIVER	385	4/21/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-10D	552	5/20/98	--	--	37	11	--	--	--	--	59	0.574	0.993	0.044	17.1	17.6	2.99	1.85	0.457	475	82.2
PW-10D	552	12/7/98	--	--	15	13	0.85	0.34	--	0.103	39.4	<0.05	1.34	<0.01	3.51	7.82	5.023	0.91	0.61	252	86.6
PW-10D	552	4/19/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.079	--	5.6
PW-10M	551	5/20/98	--	--	16	6	--	--	--	--	5.17	0.072	0.952	0.016	2.65	10.7	4.46	1.57	0.309	110	14
PW-10M	551	12/7/98	--	--	17	20	0.33	0.07	--	0.007	9.91	<0.05	1.79	0.027	2.95	11.9	52.262	1.97	0.33	161	18.4
PW-10M	551	4/19/99	--	--	17	31	--	--	--	--	11.8	<0.05	2.2	0.05	2.97	13.4	--	--	0.086	--	20
PW-11D	554	12/3/98	--	--	14	38	0.29	0.26	--	0.004	10.4	0.106	2.13	0.195	2.07	17.6	4.985	0.98	0.16	181	15.6
PW-11D	554	4/15/99	--	--	19	30	0.06	0	--	0.005	6.91	0.118	1.44	0.34	1.67	16.8	--	--	0.381	--	12.2
PW-11M	553	12/3/98	--	--	16	14	<0.05	0.02	--	0.003	5.78	<0.05	1.07	0.093	2.81	12.7	17.606	1.24	0.19	125	13.4
PW-11M	553	4/15/99	--	--	19	14	0.18	0.04	--	0.001	6.04	<0.05	1.25	0.099	2.69	12.5	--	--	0.228	--	12.8
PW-12D	557	5/15/98	--	--	14	9	--	--	--	--	7.09	0.1	1.56	0.363	1.31	8.59	8.87	0.98	0.288	107	13
PW-12D	557	11/25/98	--	--	13	10	<0.05	0.01	--	0.006	7.02	<0.05	1.54	0.466	1.16	8.6	5.44	0.94	0.3	112	14
PW-12D	557	4/8/99	--	--	14	10	0.07	0.09	--	0.007	6.71	<0.05	1.53	0.449	1.25	8.11	--	0.73	0.117	--	13

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

	Well		NH_4^+	S_2^-	Cl^-	SO_4^{2-}	NO_3-&NO_2-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Fe(total)	Mg^{2+}	Mn^{2+}	K^+	Na^+	CH_4	TOC	Br-	SC-lab	$CaCO_3$
Name	#	Date	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(µmhos/cm)	(mg/l)
PW-12D	557	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12D	557	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12D	557	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12D	557	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12D	557	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	5/15/98	--	--	14	9	--	--	--	--	6.64	0.203	1.46	0.296	1.3	9.78	9.02	0.82	0.315	106	12.6
PW-12M	556	11/25/98	--	--	13	9	<0.05	0.01	--	0.009	6.69	0.134	1.43	0.386	1.34	8.4	7.69	0.9	0.25	111	13.8
PW-12M	556	4/7/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.89	0.058	--	14
PW-12M	556	4/8/99	--	--	13	9	0.1	0.07	--	0.001	6.23	0.454	1.39	0.433	1.53	8.26	--	--	0.058	--	14
PW-12M	556	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12M	556	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	5/15/98	--	--	12	9	--	--	--	--	21.5	1.03	2.24	0.316	1.11	8.07	4.2	0.91	0.285	169	48.2
PW-12R	558	11/25/98	--	--	12	8	<0.05	0.01	--	0.024	23.5	1.2	2.31	0.425	1.18	8.21	6.62	0.96	0.33	207	60.8
PW-12R	558	4/8/99	--	--	12	7	<0.05	0.07	--	0.027	22.4	1.13	2.31	0.383	1.37	8.12	--	0.94	0.104	--	61
PW-12R	558	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12R	558	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12S	555	5/14/98	--	--	17	6	--	--	--	--	4.62	5.04	0.924	0.661	1.06	10.7	2.29	1.1	0.35	108	15.2
PW-12S	555	11/25/98	--	--	16	10	<0.05	0.03	--	0.009	5.32	3.23	1.05	0.671	0.915	10.7	2.26	1.2	0.3	119	11.6
PW-12S	555	4/8/99	--	--	35	10	0.47	0.24	--	0.004	7.84	1.12	1.32	0.432	1.53	16.5	--	0.9	0.283	--	7.4
PW-12S	555	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12S	555	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12S	555	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12S	555	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-12S	555	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13D	561	7/24/98	--	--	12	11	<0.05	--	--	0.098	15.9	0.963	1.33	0.205	4.26	12.6	6.09	1.8	0	170	47.2
PW-13D	561	11/24/98	--	--	13	8	<0.05	0.01	--	0.023	8.52	4.65	1.44	0.569	2.37	9.44	3.9	0.64	0.21	118	23.8
PW-13D	561	4/8/99	--	--	13	8	0.06	0.02	--	0.022	6.91	6.06	1.41	0.59	1.69	9.39	--	0.91	0.181	--	21.2
PW-13D	561	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13D	561	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

	Well		NH_4^+	S_2^-	Cr	SO_4^{2-}	NO_3-&NO_2-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Fe(total)	Mg^{2+}	Mn^{2+}	K^+	Na^+	CH_4	TOC	Br-	SC-lab	$CaCO_3$
Name	#	Date	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(µmhos/cm)	(mg/l)
PW-13D	561	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13D	561	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13D	561	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	7/23/98	--	--	13	7	<0.05	--	--	0.005	5.14	0.272	1.12	1.13	0.732	7.86	2.9	1.31	0	89	10.2
PW-13M	560	11/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	11/23/98	--	--	13	7	<0.05	0.02	--	0.003	5.54	0.408	1.12	1.11	0.687	8	3.8	0.78	0.2	95	11.6
PW-13M	560	2/8/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	2/8/99	--	--	--	--	--	0.01	--	--	--	--	--	--	--	--	2.434	1.03	0.241	98	14.4
PW-13M	560	4/7/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.86	0.062	--	11.2
PW-13M	560	4/8/99	--	--	13	7	<0.05	0.03	--	0.007	5.27	0.401	1.08	1.03	0.767	7.9	--	--	0.062	--	11.2
PW-13M	560	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13M	560	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	7/23/98	--	--	10	6	0.23	--	--	0.005	5.3	<0.05	0.767	<0.01	2.06	6.62	2.24	0.91	0	80	11.6
PW-13S	559	11/24/98	--	--	10	6	0.35	0.17	--	0.003	5.32	<0.05	0.845	0.014	2.15	6.67	2.15	0.94	0.1	89	11
PW-13S	559	4/8/99	--	--	10	6	0.49	0.21	--	0.005	5.47	<0.05	0.834	0.02	2.23	6.72	--	0.8	0.012	--	12
PW-13S	559	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-13S	559	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	7/24/98	--	--	50	11	0.89	--	--	0.005	15.1	0.374	2.9	0.695	1.62	20.1	--	0.96	0.159	235	18
PW-14D	564	11/23/98	--	--	56	11	0.82	0.74	--	0.009	15.9	0.08	3.11	0.718	1.69	23.3	3.18	0.42	0.66	259	16.2
PW-14D	564	4/7/99	--	--	40	11	0.58	0.29	--	0.006	11.6	<0.05	2.31	0.531	1.55	19.6	--	0.92	0.43	--	17
PW-14D	564	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14D	564	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	7/23/98	--	--	15	7	0.06	--	--	0.005	6.59	0.246	1.43	1.12	0.724	7.82	3.39	0.92	0	101	13.2
PW-14M	563	11/23/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	11/23/98	--	--	14	7	<0.05	0.02	--	0.009	6.47	0.211	1.44	1.15	0.759	8.24	2.72	0.74	0.19	106	12.6

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	NH_4^+ (mg/l)	S_2^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	NO_3-&NO_2- (mg/l)	NO_3^- (mg/l)	NO_2^- (mg/l)	PO_4^{3-} (mg/l)	Ca^{2+} (mg/l)	Fe(total) (mg/l)	Mg^{2+} (mg/l)	Mn^{2+} (mg/l)	K^+ (mg/l)	Na^+ (mg/l)	CH_4 (mg/l)	TOC (mg/l)	Br- (mg/l)	SC-lab (µmhos/cm)	$CaCO_3$ (mg/l)
PW-14M	563	2/8/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	4/7/99	--	--	16	8	0.09	0.12	--	0.018	6.86	0.144	1.44	1.01	1.29	8.36	--	0.84	0.134	--	15
PW-14M	563	4/7/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M	563	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14M(d)	563	2/8/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	7/23/98	--	--	24	15	1.5	--	--	0.005	11.6	0.079	3.41	0.051	3.37	13.5	1.97	0.82	0	178	23
PW-14S	562	11/23/98	--	--	23	13	1.51	0.94	--	0.005	11.4	<0.05	2.59	0.013	3.2	13.3	2.15	0.59	0.32	177	21
PW-14S	562	4/7/99	--	--	18	12	1.08	0.46	--	0.004	9.98	<0.05	2.12	<0.01	2.55	10.3	--	0.7	0.223	--	20
PW-14S	562	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	7/16/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	8/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S	562	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-14S(d)	562	7/23/98	--	--	24	15	1.47	--	--	0.007	11.4	0.063	3.34	0.044	3.37	13.4	2.19	1.02	0	178	21.6
PW-1D	531	5/14/98	--	--	36	10	--	--	--	--	11.6	0.272	2.3	0.371	1.62	17.4	3.06	0.84	0.513	186	13
PW-1D	531	12/1/98	--	--	29	12	0.52	0.24	--	0.004	10.6	0.054	2.11	0.33	1.36	16.2	6.05	0.58	0.34	169	14.4
PW-1D	531	4/9/99	--	--	20	16	0.19	0.06	--	0.007	8.68	<0.05	1.81	0.27	1.33	13	--	--	0.248	--	15
PW-1S	530	5/14/98	--	--	24	10	--	--	--	--	9.43	0.058	1.81	0.055	1.18	12.5	4488.47	0.9	0.418	144	13
PW-1S	530	12/1/98	--	--	20	9	0.55	0.25	--	0.004	9.63	0.103	1.82	0.257	1.23	11	6.05	0.8	0.34	140	16
PW-1S	530	4/9/99	--	--	17	8	0.553	0.19	--	0.002	8.02	<0.05	1.59	0.287	1.37	9.12	--	--	0.221	--	16.4
PW-2D	534	5/18/98	--	--	160	14	--	--	--	--	20.1	0.222	3.65	0.075	3.59	83.3	1.83	0.55	1.41	588	9.6
PW-2D	534	12/4/98	--	--	65	10	0.91	0.44	--	0.004	12.4	<0.05	2.01	0.036	2.18	34.5	1.965	0.69	--	--	--
PW-2D	534	4/14/99	--	--	74	10	1.22	0.32	--	0.005	13.7	<0.05	2.25	0.063	2.56	35	--	--	0.601	--	18
PW-2M	533	5/20/98	--	--	21	7	--	--	--	--	12.7	<0.05	1	<0.01	4.45	13	1.97	1.02	0.382	161	20
PW-2M	533	12/4/98	--	--	69	11	0.97	0.64	--	0.005	16.7	<0.05	1.92	0.014	5.79	30.1	2.3	0.99	0.78	310	15.2
PW-2M	533	4/14/99	--	--	54	16	1.24	0.49	--	0.005	12	<0.05	1.46	0.013	4.5	29.6	--	--	0.576	--	18.4
PW-2R	535	5/20/98	--	--	25	7	--	--	--	--	13	1.74	2.3	0.104	12.2	21.3	2.21	0.88	0.291	203	65
PW-2R	535	12/4/98	--	--	8	16	0.07	0.04	--	0.109	8.44	0.764	1.66	0.047	18.1	24.9	4.786	0.98	0.31	239	73.4
PW-2R	535	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-2R	535	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	NH_4^+ (mg/l)	S_2^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	NO_3-&NO_2- (mg/l)	NO_3^- (mg/l)	NO_2^- (mg/l)	PO_4^{3-} (mg/l)	Ca^{2+} (mg/l)	Fe(total) (mg/l)	Mg^{2+} (mg/l)	Mn^{2+} (mg/l)	K^+ (mg/l)	Na^+ (mg/l)	CH_4 (mg/l)	TOC (mg/l)	Br- (mg/l)	SC-lab (µmhos/cm)	$CaCO_3$ (mg/l)
PW-2R	535	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-2S	532	5/18/98	--	--	15	11	--	--	--	--	7.4	<0.05	0.912	<0.01	2.09	13.2	2.07	1.13	0.281	126	11
PW-2S	532	12/4/98	--	--	30	12	1.72	1.04	--	0.004	14.6	<0.05	1.15	<0.01	3.52	16.9	1.983	1.04	0.73	207	20.4
PW-2S	532	4/14/99	--	--	27	200	5.57	1.36	--	0.004	88.2	<0.05	8.19	0.015	5.36	26.3	--	--	0.171	--	31.4
PW-3D	537	12/3/98	--	--	10	13	0.18	0.13	--	0.005	9.63	<0.05	1.89	0.602	1.61	6.41	1.933	0.89	0.27	117	19
PW-3D	537	4/14/99	--	--	9	9	<0.05	0	--	0.004	5.9	<0.05	1.17	0.414	1.28	6.22	--	--	0.115	--	13
PW-3S	536	12/3/98	--	--	17	14	0.24	0.12	--	0.004	5.58	<0.05	1.07	<0.01	1.22	12.1	1.909	2.68	0.25	96	5.8
PW-3S	536	4/14/99	--	--	16	22	0.29	0.06	--	0.004	8.56	<0.05	1.37	<0.01	1.2	10.2	--	--	0.175	--	7.6
PW-4D	539	12/7/98	--	--	110	12	1.16	0.63	--	0.005	17.2	<0.05	3.06	0.037	3.53	60	2.476	0.46	1.25	478	22.2
PW-4D	539	4/22/99	--	--	141	12	0.74	--	--	0.001	13.5	0.075	2.56	0.03	3.67	72	--	--	1.37	--	15.2
PW-4M	538	12/7/98	--	--	116	17	1.17	0.53	--	0.003	5.9	<0.05	0.92	0.014	2.6	74.6	5.191	0.9	1.2	454	21.2
PW-4M	538	4/22/99	--	--	109	12	1.1	--	--	0.001	6.98	<0.05	1.09	0.014	2.44	65.9	--	--	1.32	--	16.2
PW-4M (d)	538	12/7/98	--	--	115	17	1.15	0.52	--	0.004	5.88	<0.05	0.915	0.014	2.55	73.8	1.85	0.75	1.19	459	20.6
PW-5D	541	12/7/98	--	--	80	9	0.93	0.56	--	0.003	14.7	<0.05	2.99	0.044	2.32	34	1.941	0.61	0.65	317	12.4
PW-5D	541	4/19/99	--	--	34	20	--	--	--	--	8.98	<0.05	1.66	0.094	1.91	22.5	--	--	0.25	--	18
PW-5M	540	12/8/98	--	--	17	8	1.14	0.35	--	0.006	7.13	<0.05	1.06	<0.01	2.6	11.8	1.973	0.76	0.5	248	66.4
PW-5M	540	4/19/99	--	--	16	8	--	--	--	--	6.62	<0.05	1.01	0.01	2.49	10.7	--	--	0.103	--	55.6
PW-5R	542	12/8/98	--	--	10	11	0.64	0.48	--	0.009	146	<0.05	<0.1	<0.01	35.9	41.2	7.493	5.51	1.03	2490	517
PW-5R	542	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-5R	542	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-5R	542	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-6D	545	5/21/98	--	--	28	39	--	--	--	--	12.8	0.802	2.61	0.188	38.4	23	2.32	3.22	0.399	322	61.2
PW-6D	545	12/10/98	--	--	8	76	0.26	0.22	0.05	0.351	25.9	9.91	3.95	0.167	5.29	57.7	2.418	7.74	0.28	415	91.2
PW-6D	545	4/21/99	--	--	27	44	--	--	--	--	24.3	0.127	1.82	0.064	7.43	45	--	--	0.445	--	96.4
PW-6D(d)	545	5/21/98	--	--	28	38	--	--	--	--	12.5	0.76	2.54	0.183	37.9	22.3	2.3	3.13	0.386	318	61.8
PW-6M	544	5/21/98	--	--	21	10	--	--	--	--	8.39	0.382	1.25	0.418	3.48	13.8	2.5	1.9	0.328	149	16.8
PW-6M	544	12/10/98	--	--	21	21	1.26	0.55	--	0.002	11.9	0.088	1.64	0.586	3.2	14.3	3.383	1.86	0.27	186	19
PW-6M	544	4/21/99	--	--	24	6	--	--	--	--	7.33	0.05	1.13	0.395	2.18	12.4	--	--	0.381	--	15.8
PW-6R	546	12/10/98	--	--	25	20	0.31	0.31	--	0.021	113	0.213	<0.1	<0.01	87.5	38.6	6.427	5.67	1.47	2030	-400
PW-6R	546	5/13/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-6R	546	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-6R	546	9/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PW-6S	543	5/21/98	--	--	19	10	--	--	--	--	10.3	0.28	1.47	0.395	3.17	13	2.45	1.7	0.321	144	16.8
PW-6S	543	12/10/98	--	--	21	39	3.03	1.81	--	0.006	19.8	<0.05	1.95	0.271	3.57	15.5	3.752	1.96	0.44	235	15
PW-6S	543	4/21/99	--	--	34	47	--	--	--	--	22.3	<0.05	2.49	0.366	3.36	16.3	--	--	0.154	--	15.4

Appendix 2b. Detected ions and compounds, May 1997 to October 1999, Milford, New Hampshire.

	Well		NH_4^+	S_2^-	Cl^-	SO_4^{2-}	NO_3-&NO_2-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Fe(total)	Mg^{2+}	Mn^{2+}	K^+	Na^+	CH_4	TOC	Br-	SC-lab	$CaCO_3$
Name	#	Date	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(µmhos/cm)	(mg/l)
PW-7M	548	12/9/98	--	--	9	18	0.09	0.04	--	0.011	10.2	0.243	2.83	0.223	2.21	11	4.396	0.64	0.1	144	31
PW-7M	548	4/15/99	--	--	10	14	--	--	--	--	8.87	0.208	2.53	0.171	1.83	9.84	--	--	0.239	--	29.6
PW-7S	547	12/9/98	--	--	14	20	<0.05	0.02	--	0.007	11.3	1.05	2.68	0.239	2.71	10.2	7.139	5.47	0.23	156	22
PW-7S	547	4/15/99	--	--	9	18	--	--	--	--	7.94	1.33	1.97	0.236	2.14	8.9	--	--	0.017	--	25
PW-8M	549	4/20/99	--	--	9	36	--	--	--	--	28.4	0.107	3.14	0.031	11	13.1	--	--	0.147	--	76.4
PW-9M	550	4/20/99	--	--	13	53	--	0.62	<0.05	0.001	19.5	0.078	2.78	0.043	1.54	12.1	--	--	0.184	--	16.4
PW-9M(d)	550	4/20/99	--	--	23	53	--	0.63	<0.05	0.002	19.9	0.069	2.84	0.045	1.56	12.3	--	--	0.147	--	16.2
Trip blank	--	2/19/98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trip blank	0	3/1/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/7/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/8/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/19/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	4/21/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	5/12/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	6/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	--	7/14/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	7/27/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	8/10/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trip blank	0	9/9/99	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 2c. Major detected volatile organic compounds (VOCs), May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	Pump TYPE	PCE	TCE	CIS-DCE	111-Tri	MTBE	Acetone	Vinyl Chloride	Comments
(DB blank)		2/8/99	DB	U 2	U 2	U 2	U 2	U 2	52	U 2	
(eq. blank)		9/30/98	DB	U 2	U 2	U 2	U 2	U 2	60	U 2	
(trip blank)		5/11/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		5/13/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		5/18/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		5/19/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		5/21/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		7/21/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		7/23/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		9/29/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		10/20/98	NA	U 0.5	U 0.5	U 0.5	U 0.5	U 0.5	U 10	U 0.5	
(trip blank)		11/23/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		11/30/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		12/1/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		12/3/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		12/7/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		12/8/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		12/8/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
(trip blank)		2/8/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-12	407	5/28/97	peri	U 2	U 2	--	U 2	U 2	U 10	U 2	
B95-12	407	10/28/97	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-12	407	12/15/97	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-12	407	2/19/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-12	407	5/18/98	peri	U 2	U 2	U 2	U 2	3.3	U 10	U 2	
B95-12	407	7/22/98	peri	--	--	--	--	--	--	--	
B95-12	407	12/2/98	peri	U 2	U 2	U 2	U 2	3.2	U 10	U 2	
B95-12	407	4/13/99	peri	U 2	U 2	U 2	U 2	3.7	U 10	U 2	
B95-12(d)	407	5/28/97	peri	U 2	U 2	--	U 2	U 2	12	U 2	
B95-13	408	5/28/97	peri	2000	180	--	11	U 2	U 10	U 2	
B95-13	408	10/28/97	BL	--	--	--	--	--	--	--	
B95-13	408	10/28/97	peri	3100	270	150	U 40	U 40	U 200	U 40	
B95-13	408	2/20/98	BL	4100	290	150	U 100	U 100	U 500	U 100	
B95-13	408	2/20/98	peri	3700	280	150	U 100	U 100	U 500	U 100	
B95-13	408	5/21/98	BL	4100	270	160	U 100	U 100	U 500	U 100	
B95-13	408	5/21/98	DB	3200	250	150	U 100	U 100	U 500	U 100	
B95-13	408	5/21/98	peri	3300	230	160	U 40	U 40	U 200	U 40	
B95-13	408	7/23/98	BL	3900	230	150	U 50	U 50	U 250	U 50	
B95-13	408	7/23/98	DB	3100	220	150	U 50	U 50	U 250	U 50	
B95-13	408	7/23/98	peri	2800	190	140	U 50	U 50	U 250	U 50	
B95-13	408	7/23/98	peri	3400	210	150	U 50	U 50	U 250	U 50	
B95-13	408	7/23/98	voss	3100	200	140	U 50	U 50	U 250	U 50	
B95-13	408	9/30/98	DB	1900	170	140	U 50	U 50	U 250	U 50	
B95-13	408	11/23/98	DB	1900	170	140	U 40	U 40	U 200	U 40	
B95-13	408	11/24/98	peri	2100	130	140	U 40	U 40	U 200	U 40	
B95-13	408	2/8/99	DB	1400	130	170	U 25	U 25	U 125	U 25	
B95-13	408	2/8/99	peri	1500	97	180	U 40	U 40	U 200	U 40	
B95-13	408	4/7/99	DB	950	200	160	U 20	U 20	U 100	U 20	
B95-13	408	4/14/99	peri	1400	110	180	U 20	U 20	U 100	U 20	(split with p.48f)

Appendix 2c. Major detected volatile organic compounds (VOCs), May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	Pump TYPE	PCE	TCE	CIS-DCE	111-Tri	MTBE	Acetone	Vinyl Chloride	Comments
B95-13	408	4/14/99	BL	1700	120	190	U 50	U 50	U 250	U 50	(split with b.45f)
B95-13	408	4/14/99	peri	1685	100	--	--	--	--	--	name= p.25f
B95-13	408	4/14/99	peri	1717	96	--	--	--	--	--	name= p.48f
B95-13	408	4/14/99	BL	2010	101	--	--	--	--	--	name= b.45f
B95-13	408	4/14/99	BL	2006	99	--	--	--	--	--	name= b.97f
B95-13	408	4/14/99	peri	1877	113	--	--	--	--	--	name= p.1+
B95-13	408	4/14/99	BL	2032	118	--	--	--	--	--	name= b.1+
B95-13	408	4/14/99	BL	1738	105	--	--	--	--	--	name= b.5r2
B95-13	408	4/14/99	peri	1841	98	--	--	--	--	--	name= p.49r2
B95-13	408	4/14/99	peri	1783	104	--	--	--	--	--	name= p.33r
B95-13	408	4/20/99	BL	1608	86	--	--	--	--	--	
B95-13	408	4/20/99	BL	1702	91	--	--	--	--	--	
B95-13	408	4/20/99	BL	1750	92	--	--	--	--	--	
B95-13	408	4/20/99	BL	1674	89	--	--	--	--	--	
B95-13	408	5/13/99	DB	1700	97	190	U 20	U 20	U 100	U 20	
B95-13	408	6/10/99	DB	1400	92	180	U 20	U 20	U 100	U 20	21,methylene chloride
B95-13	408	6/10/99	peri	1200	85	170	U 20	U 20	U 100	U 20	
B95-13	408	7/16/99	DB	850	51	110	U 20	U 20	U 100	U 20	
B95-13	408	8/12/99	DB	520	35	95	U 10	U 10	U 50	U 10	
B95-13	408	9/10/99	DB	690	30	71	U 10	U 10	U 50	U 10	
B95-13 (d)	408	2/8/99	peri	1600	100	190	U 40	U 40	U 200	U 40	
B95-13(d)	408	4/14/99	peri	1945	101	--	--	--	--	--	(duplicate with p.25f)
B95-13(d)	408	4/14/99	peri	1963	103	--	--	--	--	--	(duplicate with p.48f)
B95-13(d)	408	4/14/99	BL	2052	116	--	--	--	--	--	(duplicate with b.45f)
B95-13(d)	408	4/14/99	peri	2010	99	--	--	--	--	--	(duplicate with p.49r2)
B95-13-A	408	7/30/99	DB	290	40	100	U 5	U 5	U 25	U 5	
B95-13-B	408	7/30/99	DB	590	40	100	U 20	U 20	U 100	U 20	
B95-13-C	408	7/30/99	DB	590	40	100	U 20	U 20	U 100	U 20	
B95-15	409	5/28/97	peri	920	22	--	U 2	U 2	U 10	U 2	
B95-15	409	10/30/97	BL	--	--	--	--	--	--	--	
B95-15	409	10/30/97	peri	1200	24	33	U 20	U 20	U 100	U 20	
B95-15	409	2/20/98	peri	830	32	47	U 20	U 20	U 100	U 20	
B95-15	409	5/18/98	DB	1000	28	43	U 20	U 20	U 100	U 20	
B95-15	409	5/18/98	peri	890	27	45	U 10	U 10	U 50	U 10	
B95-15	409	7/23/98	DB	1400	42	63	U 20	U 20	U 100	U 20	
B95-15	409	7/23/98	peri	1200	39	68	U 20	U 20	U 100	U 20	
B95-15	409	9/30/98	DB	2000	38	48	U 50	U 50	U 250	U 50	
B95-15	409	11/23/98	DB	480	29	37	U 20	U 20	U 100	U 20	
B95-15	409	11/24/98	peri	350	26	36	U 20	U 20	U 100	U 20	
B95-15	409	2/8/99	DB	350	26	22	U 4	U 4	U 20	U 4	
B95-15	409	2/8/99	peri	310	27	22	U 4	U 4	U 20	U 4	
B95-15	409	4/7/99	DB	210	28	22	U 4	U 4	U 20	U 4	
B95-15	409	4/8/99	peri	91	14	22	U 2	U 2	U 10	U 2	
B95-15	409	5/13/99	DB	160	19	26	U 3.34	U 3.34	U 16.7	U 3.34	
B95-15	409	6/10/99	peri	93	13	14	U 2	U 2	U 10	U 2	
B95-15	409	6/10/99	DB	110	17	21	U 5	U 5	U 25	U 5	
B95-15	409	7/16/99	DB	89	14	14	U 2	U 2	U 10	U 2	
B95-15	409	9/10/99	DB	86	12	9.6	U 2	U 2	U 10	U 2	

Appendix 2c. Major detected volatile organic compounds (VOCs), May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	Pump TYPE	PCE	TCE	CIS-DCE	111-Tri	MTBE	Acetone	Vinyl Chloride	Comments
B95-15	409	9/10/99	peri	82	9.3	7.9	U 2	U 2	U 10	U 2	
B95-15(d)	409	9/30/98	DB	1900	U 50	46	U 50	U 50	U 250	U 50	
B95-3	398	5/29/97	peri	U 2	U 2	--	U 2	U 2	U 10	U 2	
B95-3	398	6/17/97	BL	U 2	U 2	--	U 2	U 2	U 10	U 2	
B95-3	398	12/16/97	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-3	398	5/12/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-3	398	12/3/98	peri	2.1	U 2	U 2	U 2	U 2	U 10	U 2	
B95-3	398	4/20/99	peri	20	7.2	6	U 2	U 2	U 10	U 2	
B95-5	400	6/2/97	peri	U 2	U 2	--	U 2	U 2	U 10	U 2	
B95-5	400	12/17/97	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-5	400	5/12/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-5	400	12/2/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-5	400	4/21/99	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-6	401	6/16/97	BL	U 2	U 2	--	U 2	U 2	U 10	U 2	
B95-6	401	12/17/97	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-6	401	5/12/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-6	401	12/2/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-6	401	4/21/99	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
B95-7	402	12/17/97	peri	15	2.1	U 2	U 2	3.8	U 10	U 2	
B95-7	402	1/12/98	peri	--	--	--	--	--	--	--	
B95-8	403	6/16/97	BL	9.3	U 2	--	U 2	2.5	U 10	U 2	
B95-8	403	12/16/97	peri	240	2.6	6.4	U 2	2.4	U 10	U 2	
B95-8	403	5/12/98	peri	34	2.5	3	U 2	8.2	U 10	U 2	
B95-8	403	12/7/98	peri	65	U 2	U 2	U 2	5.2	U 10	U 2	
B95-8	403	4/22/99	peri	79	3.6	U 2	U 2	7	U 10	U 2	
B95-9	404	5/29/97	peri	52	2.1	--	U 2	17	U 10	U 2	
B95-9	404	12/16/97	peri	140	3.8	U 2	U 2	6.5	U 10	U 2	
B95-9	404	5/12/98	peri	120	2.6	U 2	U 2	4.4	U 10	U 2	
B95-9	404	12/3/98	peri	610	U 6.6	U 6.6	U 6.6	U 6.6	U 33.3	U 6.6	
B95-9	404	4/22/99	peri	440	U 10	U 10	U 10	U 10	U 50	U 10	
B95-9(d)	404	12/16/97	peri	140	3.5	U 2	U 2	6.5	U 10	U 2	
B95-9(d)	404	5/12/98	peri	120	2.9	U 2	U 2	5.2	U 10	U 2	
equip blank	0	2/19/98	DB	3.5	U 2	U 2	U 2	U 2	U 10	U 2	
equip blank	0	4/15/99	NA	U 2	U 2	U 2	U 2	U 2	25	U 2	
equip blank	0	5/13/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
equip blank	0	6/10/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
equip blank	0	7/16/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
equip blank	0	7/30/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
equip blank	0	8/13/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
equip blank	0	9/10/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
EW-1	565	3/1/99	NA	2500	160	U 100	U 100	U 100	U 500	U 100	
EW-1	565	7/16/99	NA	880	59	75	U 20	U 20	U 100	U 20	
EW-1	565	9/10/99	NA	820	41	54	U 20	U 20	U 100	U 20	
EW-2	566	3/1/99	NA	10	U 2	U 2	U 2	U 2	34	U 2	
EW-2	566	7/16/99	NA	520	89	54	8.7	U 6.67	U 33.33	U 6.67	
EW-2	566	9/10/99	NA	520	44	77	U 10	U 10	U 50	U 10	
EW-2dup	566	3/1/99	NA	11	U 2	U 2	U 2	U 2	44	U 2	
HM-1	299	5/29/97	peri	670	66	--	U 2	U 2	U 10	U 2	

Appendix 2c. Major detected volatile organic compounds (VOCs), May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	Pump TYPE	PCE	TCE	CIS-DCE	111-Tri	MTBE	Acetone	Vinyl Chloride	Comments
HM-1	299	12/15/97	peri	500	120	70	U 10	U 10	U 50	U 10	
lab blank	0	5/13/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
lab blank	0	6/10/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
lab blank	0	7/15/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
lab blank	0	7/30/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
lab blank	0	8/12/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
lab blank	0	9/10/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
MI-19	30	5/30/97	peri	U 2	U 2	--	U 2	U 2	U 10	U 2	
MI-20	31	5/30/97	peri	U 2	U 2	--	U 2	U 2	U 10	U 2	
MI-20	31	12/17/97	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
MI-21	33	5/30/97	peri	U 2	U 2	--	U 2	U 2	U 10	U 2	
MI-21	33	5/14/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
MI-22	35	12/16/97	peri	3400	160	57	U 50	U 50	U 250	U 50	
MI-22	35	5/13/98	peri	2400	130	U 40	U 40	U 40	U 200	U 40	
MI-23	37	12/16/97	peri	340	61	320	U 6.66	U 6.66	U 33.3	U 6.66	
MI-23	37	5/13/98	peri	180	68	140	U 2	U 2	U 10	U 2	
MI-25	40	6/2/97	peri	85	18	--	U 2	U 2	U 10	25	
MI-25	40	12/15/97	peri	13	4.7	6.2	U 2	U 2	U 10	4.5	
MI-27	42	5/29/97	peri	U 2	U 2	--	U 2	U 2	U 10	U 2	
MI-27	42	12/15/97	peri	U 2	U 2	U 2	U 2	3.2	U 10	U 2	
MI-32	46	6/2/97	peri	1000	79	--	59	U 2	U 10	U 2	
MI-32	46	5/12/98	peri	1100	65	44	39	U 20	U 100	U 20	
MI-32	46	12/4/98	peri	700	38	19	17	U 10	U 50	U 10	
MI-32	46	4/20/99	peri	550	41	29	21	U 10	U 50	U 10	
MI-63	203	5/29/97	peri	2100	130	--	2.7	U 2	U 10	4.1	
MI-63	203	12/15/97	peri	1700	120	170	U 28.6	U 28.6	U 143	U 28.6	
MW-16A	233	5/27/97	peri	71	U 2	--	U 2	2.7	U 10	U 2	
MW-16A	233	12/19/97	peri	--	--	--	--	--	--	--	
MW-16A	233	5/13/98	peri	39	U 2	U 2	U 2	13	U 10	U 2	
MW-16A	233	11/30/98	peri	59	U 2	U 2	U 2	4	U 10	U 2	
MW-16A	233	4/13/99	peri	64	U 2	U 2	U 2	2.8	U 10	U 2	
MW-16B	321	5/27/97	peri	320	11	--	3.3	U 2	U 10	U 2	
MW-16B	321	6/11/97	BL	510	12	--	U 2	U 2	U 10	U 2	
MW-16B	321	12/18/97	peri	360	11	U 10	U 10	U 10	U 50	U 10	
MW-16B	321	5/11/98	peri	310	11	U 5	U 5	U 5	U 25	U 5	
MW-16B	321	11/30/98	peri	310	12	U 10	U 10	U 10	U 50	U 10	
MW-16B	321	4/13/99	peri	280	15	8.7	7.2	U 4	U 20	U 4	
MW-16B	321	5/13/99	DB	400	19	11	U 5	U 5	U 25	U 5	
MW-16B	321	6/10/99	DB	330	16	8.8	U 4	U 4	U 20	U 4	
MW-16B	321	7/16/99	DB	260	10	5.2	U 5	U 5	U 25	U 5	
MW-16B	321	7/16/99	peri	210	8.5	4.2	U 4	U 4	U 20	U 4	
MW-16B	321	8/12/99	DB	100	8.4	U 5	U 5	U 5	U 25	U 5	
MW-16B	321	9/10/99	DB	320	9.7	4.1	U 4	U 4	U 20	U 4	
MW-16B(d)	321	4/13/99	peri	260	15	8.6	U 4	U 4	U 20	U 4	
MW-16C	344	5/27/97	peri	560	42	--	5.5	2.2	U 10	U 2	
MW-16C	344	6/12/97	BL	930	51	--	U 2	U 2	U 10	U 2	
MW-16C	344	12/15/97	peri	1200	110	79	22	U 10	U 50	U 10	
MW-16C	344	5/11/98	peri	1200	110	75	U 20	U 20	U 100	U 20	

Appendix 2c. Major detected volatile organic compounds (VOCs), May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	Pump TYPE	PCE	TCE	CIS-DCE	111-Tri	MTBE	Acetone	Vinyl Chloride	Comments
MW-16C	344	5/21/98	peri	--	--	--	--	--	--	--	
MW-16C	344	11/30/98	peri	1600	130	85	23	U 20	U 100	U 20	
MW-16C	344	4/13/99	peri	1100	110	81	U 20	U 20	U 100	U 20	
MW-16C	344	5/13/99	DB	1300	110	97	22	U 20	U 100	U 20	
MW-16C	344	6/10/99	DB	1000	78	63	U 20	U 20	U 100	U 20	
MW-16C	344	7/16/99	DB	880	60	43	U 20	U 20	U 100	U 20	
MW-16C	344	8/12/99	DB	880	56	41	U 20	U 20	U 100	U 20	
MW-16C	344	9/10/99	DB	860	45	38	U 20	U 20	U 100	U 20	
MW-16R	345	5/27/97	peri	510	53	--	U 2	3.9	11	U 2	
MW-16R	345	12/18/97	peri	330	41	43	U 10	U 10	U 50	U 10	
MW-16R	345	5/13/98	peri	390	48	48	U 10	U 10	U 50	U 10	
MW-16R	345	11/30/98	peri	300	34	44	U 10	U 10	U 50	U 10	
MW-16R	345	5/13/99	DB	470	61	56	U 5	U 5	U 25	U 5	
MW-16R	345	6/10/99	DB	330	55	51	U 3.34	U 3.34	U 16.67	U 3.34	
MW-16R	345	7/16/99	DB	320	44	38	U 4	U 4	U 20	U 4	
MW-16R	345	8/12/99	DB	160	33	38	U 5	U 5	U 25	U 5	
MW-16R	345	9/10/99	DB	210	36	41	U 2	U 2	U 10	U 2	
MW-16R-A	345	7/30/99	DB	78	25	32	U 2	U 2	U 10	U 2	
MW-16R-B	345	7/30/99	DB	110	29	38	U 5	U 5	U 25	U 5	
MW-16R-C	345	7/30/99	DB	180	32	35	U 4	U 4	U 20	U 4	
MW-16R-D	345	7/30/99	DB	110	49	110	U 5	U 5	U 25	U 5	
MW-16R	345	10/28/99	peri	260	56	140	U 4	U 4	U 20	U 4	
MW-16R-A	345	10/28/99	DB	270	37	43	U 2	U 2	U 10	U 2	
MW-16R-B	345	10/28/99	DB	310	66	98	U 5	U 5	U 25	U 5	
MW-16R-C	345	10/28/99	DB	340	83	110	U 5	U 5	U 25	U 5	
MW-16R-D	345	10/28/99	DB	630	98	190	U 10	U 10	U 50	U 10	
MW-27	235	12/2/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
MW-27	235	4/21/99	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
MW-27 (d)	235	12/2/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
MW-2A	310	9/30/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
MW-2B	210	9/30/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
MW-2B(d)	210	9/30/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
MW-2R	311	9/30/98	peri	26	5.9	U 2	U 2	U 2	U 10	U 2	
P-2, river	385	5/28/97	GRAB	--	--	--	--	--	--	--	
P-2,river	385	12/18/97	GRAB	--	--	--	--	--	--	--	
P-2,river	385	5/13/98	GRAB	--	--	--	--	--	--	--	
P-2,river	385	12/9/98	GRAB	--	--	--	--	--	--	--	
P-2,River	385	4/19/99	GRAB	--	--	--	--	--	--	--	
P2-RIVER	385	4/21/99	GRAB	U 0.2	U 0.2	U 0.2	U 0.2	U 0.2	U 1	U 0.2	
PW-10D	552	5/20/98	peri	2200	80	U 40	U 40	U 40	U 200	U 40	
PW-10D	552	12/7/98	peri	6300	U 100	U 100	U 100	U 100	U 500	U 100	
PW-10D	552	4/19/99	peri	1800	62	45	U 40	U 40	U 200	U 40	
PW-10M	551	5/20/98	peri	130	30	130	U 2	U 2	U 10	U 2	
PW-10M	551	12/7/98	peri	140	32	110	U 2	U 2	U 10	3.3	
PW-10M	551	4/19/99	peri	66	22	82	U 2	U 2	U 10	2.3	
PW-11D	554	12/3/98	peri	1200	44	U 20	U 20	U 20	U 100	U 20	
PW-11D	554	4/15/99	peri	330	41	20	U 20	U 20	U 100	U 20	
PW-11M	553	12/3/98	peri	45	13	26	U 2	U 2	U 10	U 2	

Appendix 2c. Major detected volatile organic compounds (VOCs), May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	Pump TYPE	PCE	TCE	CIS-DCE	111-Tri	MTBE	Acetone	Vinyl Chloride	Comments
PW-11M	553	4/15/99	peri	8.6	3.2	3.8	U 2	U 2	U 10	U 2	
PW-12D	557	5/15/98	peri	550	52	87	U 10	U 10	U 50	U 10	
PW-12D	557	11/25/98	peri	700	43	56	U 2	U 2	U 10	U 2	
PW-12D	557	4/8/99	peri	550	33	28	U 10	U 10	U 50	U 10	
PW-12D	557	5/13/99	DB	660	35	30	U 10	U 10	U 50	U 10	
PW-12D	557	6/10/99	DB	510	36	35	U 10	U 10	U 50	U 10	
PW-12D	557	7/16/99	DB	480	32	28	U 10	U 10	U 50	U 10	
PW-12D	557	8/12/99	DB	430	65	71	U 5	U 5	U 25	U 5	
PW-12D	557	9/10/99	DB	380	41	53	U 5	U 5	U 25	U 5	
PW-12M	556	5/15/98	peri	610	53	85	U 10	U 10	U 50	U 10	
PW-12M	556	11/25/98	peri	700	41	57	U 2	U 2	U 10	U 2	
PW-12M	556	4/7/99	DB	440	62	30	U 10	U 10	U 10	U 10	
PW-12M	556	4/8/99	peri	530	42	46	27	U 10	U 50	U 10	
PW-12M	556	5/13/99	DB	630	170	69	U 10	U 10	U 50	U 10	
PW-12M	556	6/10/99	DB	490	78	41	U 10	U 10	U 50	U 10	
PW-12M	556	7/16/99	DB	190	71	93	U 10	U 10	U 50	U 10	
PW-12M	556	8/12/99	DB	63	41	58	U 2	U 2	U 10	U 2	
PW-12M	556	9/10/99	DB	U 4	5.3	380	U 4	U 4	U 20	U 4	
PW-12R	558	5/15/98	peri	1200	89	110	U 20	U 20	U 100	U 20	
PW-12R	558	11/25/98	peri	870	340	120	U 2	U 2	U 10	U 2	
PW-12R	558	4/8/99	peri	530	380	130	U 10	U 10	U 50	U 10	
PW-12R	558	5/13/99	DB	260	480	350	U 20	U 20	U 100	U 20	
PW-12R	558	6/10/99	DB	330	680	210	U 10	U 10	U 50	U 10	
PW-12R	558	7/16/99	DB	280	560	280	U 10	U 10	U 50	U 10	
PW-12R	558	8/12/99	DB	46	490	570	U 10	U 10	U 50	U 10	
PW-12R	558	9/10/99	DB	53	760	490	U 10	U 10	U 50	U 10	
PW-12S	555	5/14/98	peri	8.7	U 2	U 2	U 2	U 2	U 10	U 2	
PW-12S	555	11/25/98	peri	9.7	2.4	4.1	U 2	U 2	U 10	U 2	
PW-12S	555	4/8/99	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
PW-12S	555	5/13/99	DB	36	3.9	8.7	U 2	U 2	U 10	U 2	
PW-12S	555	6/10/99	DB	3.3	U 2	U 2	U 2	U 2	U 10	U 2	
PW-12S	555	7/16/99	DB	170	U 2	U 2	U 2	U 2	U 10	U 2	
PW-12S	555	8/12/99	DB	62	U 2	U 2	U 2	U 2	U 10	U 2	
PW-12S	555	9/10/99	DB	21	U 2	U 2	U 2	U 2	U 10	U 2	
PW-13D	561	7/24/98	peri	1000	54	85	U 2	U 2	U 10	2	
PW-13D	561	11/24/98	peri	1100	63	100	U 20	U 20	U 100	U 20	
PW-13D	561	4/8/99	peri	760	55	92	U 20	U 20	U 100	U 20	
PW-13D	561	5/13/99	DB	720	54	96	U 20	U 20	U 100	U 20	
PW-13D	561	6/10/99	DB	810	92	110	U 20	U 20	U 100	U 20	
PW-13D	561	7/16/99	DB	650	140	130	U 10	U 10	U 50	U 10	
PW-13D	561	8/12/99	DB	35	110	780	U 10	U 10	U 50	U 10	
PW-13D	561	9/10/99	DB	69	160	1800	U 40	U 40	U 200	U 40	2.7,carbon disulfide
PW-13M	560	7/23/98	peri	400	25	40	U 2	U 2	U 10	U 2	
PW-13M	560	11/23/98	DB	630	30	43	U 10	U 10	U 50	U 10	
PW-13M	560	11/23/98	peri	490	26	39	U 10	U 10	U 50	U 10	
PW-13M	560	2/8/99	DB	140	10	12	U 2	U 2	U 10	U 2	
PW-13M	560	2/8/99	peri	120	9.4	13	U 2	U 2	U 10	U 2	
PW-13M	560	4/7/99	DB	270	23	25	U 4	U 4	U 20	U 4	

Appendix 2c. Major detected volatile organic compounds (VOCs), May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	Pump TYPE	PCE	TCE	CIS-DCE	111-Tri	MTBE	Acetone	Vinyl Chloride	Comments
PW-13M	560	4/8/99	peri	240	18	25	U 4	U 4	U 20	U 4	
PW-13M	560	5/13/99	DB	320	22	40	U 10	U 10	U 50	U 10	
PW-13M	560	6/10/99	DB	170	13	20	U 4	U 4	U 20	U 4	
PW-13M	560	7/16/99	DB	110	10	15	U 2	U 2	U 10	U 2	
PW-13M	560	8/12/99	DB	90	8.5	12	U 2	U 2	U 10	U 2	
PW-13M	560	9/10/99	DB	120	8.6	9.1	U 2	U 2	U 10	U 2	
PW-13S	559	7/23/98	peri	93	8.4	29	U 2	U 2	U 10	U 2	
PW-13S	559	11/24/98	peri	94	9.6	25	U 2	U 2	U 10	U 2	
PW-13S	559	4/8/99	peri	70	9.8	24	U 2	U 2	U 10	U 2	
PW-13S	559	5/13/99	peri	78	8.4	27	U 2	U 2	U 10	U 2	
PW-13S	559	5/13/99	DB	120	U 20	31	U 20	U 20	U 100	U 20	
PW-13S	559	6/10/99	DB	88	9.9	28	U 2	U 2	U 10	U 2	
PW-13S	559	7/16/99	DB	86	10	26	U 2	U 2	U 10	U 2	
PW-13S	559	8/12/99	DB	68	6.6	15	U 2	U 2	U 10	U 2	
PW-13S	559	9/10/99	DB	41	3.3	6.1	U 2	U 2	U 10	U 2	
PW-14D	564	7/24/98	peri	2500	180	110	8.4	U 2	U 10	U 2	
PW-14D	564	11/23/98	peri	1900	150	130	U 40	U 40	U 200	U 40	
PW-14D	564	4/7/99	peri	2300	220	120	U 40	U 40	U 200	U 40	
PW-14D	564	5/13/99	DB	2800	200	150	U 40	U 40	U 200	U 40	
PW-14D	564	6/10/99	DB	2900	240	170	U 40	U 40	U 200	U 40	
PW-14D	564	7/16/99	DB	2700	210	140	U 40	U 40	U 200	U 40	
PW-14D	564	8/12/99	DB	2500	190	130	U 40	U 40	U 200	U 40	
PW-14D	564	9/10/99	DB	2700	150	110	U 40	U 40	U 200	U 40	
PW-14M	563	7/23/98	peri	1300	110	210	5.5	U 2	U 10	2.8	
PW-14M	563	11/23/98	DB	1400	92	190	U 40	U 40	U 200	U 40	
PW-14M	563	11/23/98	peri	1200	93	200	U 40	U 40	U 200	U 40	21,methylene chloride
PW-14M	563	2/8/99	DB	1200	96	190	U 20	U 20	U 100	U 20	
PW-14M	563	4/7/99	peri	760	92	160	12	U 10	U 50	U 10	25,Meth.Chl;76,Benzene;200,THF
PW-14M	563	4/7/99	DB	1100	110	190	U 20	U 20	U 100	U 20	
PW-14M	563	5/13/99	DB	1400	110	250	U 20	U 20	U 100	U 20	
PW-14M	563	6/10/99	DB	1400	130	300	U 20	U 20	U 100	U 20	
PW-14M	563	7/16/99	DB	940	87	200	U 20	U 20	U 100	U 20	
PW-14M	563	8/12/99	DB	940	85	200	U 20	U 20	U 100	U 20	
PW-14M	563	9/10/99	DB	1100	87	200	U 20	U 20	U 100	U 20	
PW-14M(d)	563	2/8/99	DB	1200	91	180	U 20	U 20	U 100	U 20	
PW-14S	562	7/23/98	peri	840	76	95	12	U 2	U 10	U 2	
PW-14S	562	11/23/98	peri	990	82	120	U 20	U 20	U 100	U 20	
PW-14S	562	4/7/99	peri	620	61	82	U 20	U 20	U 100	U 20	
PW-14S	562	5/13/99	peri	890	73	130	U 20	U 20	U 100	U 20	
PW-14S	562	5/13/99	DB	790	69	120	U 20	U 20	U 100	U 20	
PW-14S	562	6/10/99	DB	610	58	99	8.1	U 6.66	U 33.33	U 6.66	
PW-14S	562	7/16/99	DB	520	41	61	U 10	U 10	U 50	U 10	
PW-14S	562	8/12/99	DB	560	33	47	U 10	U 10	U 50	U 10	
PW-14S	562	9/10/99	DB	640	31	41	U 10	U 10	U 50	U 10	
PW-14S(d)	562	7/23/98	peri	870	75	91	12	U 2	U 10	U 2	
PW-1D	531	5/14/98	peri	2600	220	130	U 40	U 40	U 200	U 40	
PW-1D	531	12/1/98	peri	2400	160	110	U 40	U 40	U 200	U 40	
PW-1D	531	4/9/99	peri	940	80	65	U 40	U 40	U 200	U 40	

Appendix 2c. Major detected volatile organic compounds (VOCs), May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	Pump TYPE	PCE	TCE	CIS-DCE	111-Tri	MTBE	Acetone	Vinyl Chloride	Comments
PW-1S	530	5/14/98	peri	3400	250	160	U 50	U 50	U 250	U 50	
PW-1S	530	12/1/98	peri	3000	170	190	U 40	U 40	U 200	U 40	
PW-1S	530	4/9/99	peri	1200	87	200	U 40	U 40	U 200	U 40	
PW-2D	534	5/18/98	peri	170	9.4	4.7	U 2	3.8	U 10	U 2	
PW-2D	534	12/4/98	peri	1700	170	91	20	U 20	U 100	U 20	
PW-2D	534	4/14/99	peri	1000	140	88	U 20	U 20	U 100	U 20	27 THF, 5.1 Carbon disulfide
PW-2M	533	5/20/98	peri	1100	190	180	120	U 20	U 100	U 20	15,THF
PW-2M	533	12/4/98	peri	1600	130	68	23	U 20	U 100	U 20	11,THF
PW-2M	533	4/14/99	peri	950	110	89	26	U 20	U 100	U 20	
PW-2R	535	5/20/98	peri	36	6.2	2.1	U 2	U 2	U 10	U 2	
PW-2R	535	12/4/98	peri	20	3.6	U 2	U 2	U 2	U 10	U 2	
PW-2R	535	5/13/99	DB	29	4.4	U 2	U 2	U 2	U 10	U 2	
PW-2R	535	6/10/99	DB	28	5.1	U 2	U 2	U 2	U 10	U 2	
PW-2R	535	9/10/99	DB	38	4	U 2	U 2	U 2	U 10	U 2	
PW-2S	532	5/18/98	peri	830	120	110	43	U 20	U 100	U 20	
PW-2S	532	12/4/98	peri	1400	140	110	65	U 20	U 100	U 20	
PW-2S	532	4/14/99	peri	530	73	63	27	U 20	U 100	U 20	
PW-3D	537	12/3/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
PW-3D	537	4/14/99	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
PW-3S	536	12/3/98	peri	2.1	U 2	U 2	U 2	U 2	U 10	U 2	
PW-3S	536	4/14/99	peri	2	U 2	U 2	U 2	U 2	U 10	U 2	
PW-4D	539	12/7/98	peri	38	5.9	U 2	U 2	4.2	U 10	U 2	
PW-4D	539	4/22/99	peri	U 2	U 2	U 2	U 2	6.1	U 10	U 2	
PW-4M	538	12/7/98	peri	2.1	U 2	U 2	U 2	U 2	U 10	U 2	
PW-4M	538	4/22/99	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
PW-4M (d)	538	12/7/98	peri	U 2	U 2	U 2	U 2	U 2	U 10	U 2	2.9 Toluene
PW-5D	541	12/7/98	peri	1500	190	100	U 20	U 20	U 100	U 20	3.9,Toluene
PW-5D	541	4/19/99	peri	770	100	97	U 20	U 20	U 100	U 20	2.1,Xylene; 4.3,Toluene
PW-5M	540	12/8/98	peri	1400	160	120	57	U 20	U 100	U 20	3.9 Toluene
PW-5M	540	4/19/99	peri	520	98	150	21	U 10	U 50	U 10	
PW-5R	542	12/8/98	peri	95	14	9.6	4.5	U 2	28	U 2	
PW-5R	542	5/13/99	DB	170	21	15	6.5	U 2	U 10	U 2	
PW-5R	542	6/10/99	DB	170	24	16	7	U 2	U 10	U 2	
PW-5R	542	9/10/99	DB	190	22	13	5.8	U 2	U 10	U 2	
PW-6D	545	5/21/98	peri	4900	U 100	U 100	U 100	U 100	U 500	U 100	
PW-6D	545	12/10/98	peri	610	U 10	U 10	U 10	U 10	U 50	U 10	
PW-6D	545	4/21/99	peri	3600	U 100	U 100	U 100	U 100	U 500	U 100	
PW-6D(d)	545	5/21/98	peri	4800	U 100	U 100	U 100	U 100	U 500	U 100	
PW-6M	544	5/21/98	peri	3300	1300	800	U 66	U 66	U 330	U 66	
PW-6M	544	12/10/98	peri	3600	1300	650	U 40	U 40	U 200	U 40	
PW-6M	544	4/21/99	peri	2300	390	240	U 50	U 50	U 250	U 50	
PW-6R	546	12/10/98	peri	940	43	U 20	U 20	U 20	U 100	U 20	
PW-6R	546	5/13/99	DB	1200	62	30	U 20	U 20	U 100	U 20	
PW-6R	546	6/10/99	DB	1600	64	U 20	U 20	U 20	U 100	U 20	
PW-6R	546	9/10/99	DB	2000	47	U 40	U 40	U 40	U 200	U 40	
PW-6S	543	5/21/98	peri	1700	1400	1100	U 50	U 50	U 250	U 50	
PW-6S	543	12/10/98	peri	3100	1600	850	U 40	U 40	U 200	U 40	
PW-6S	543	4/21/99	peri	4000	2000	1400	U 50	U 50	U 250	U 50	

Appendix 2c. Major detected volatile organic compounds (VOCs), May 1997 to October 1999, Milford, New Hampshire.

Name	Well #	Date	Pump TYPE	PCE	TCE	CIS-DCE	111-Tri	MTBE	Acetone	Vinyl Chloride	Comments
PW-7M	548	12/9/98	peri	12	2.3	U 2	U 2	U 2	U 10	U 2	
PW-7M	548	4/15/99	peri	5.8	U 2	U 2	U 2	U 2	U 10	U 2	
PW-7S	547	12/9/98	peri	40	2.5	U 2	U 2	U 2	U 10	U 2	
PW-7S	547	4/15/99	peri	8.5	U 2	U 2	U 2	U 2	U 10	U 2	
PW-8M	549	4/20/99	peri	540	12	U 10	U 10	U 10	U 50	U 10	
PW-9M	550	4/20/99	peri	2.9	U 2	U 2	U 2	U 2	U 10	U 2	
PW-9M(d)	550	4/20/99	peri	2.6	U 2	U 2	U 2	U 2	U 10	U 2	
Trip blank	0	2/19/98	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
Trip blank	0	3/1/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	4/7/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	4/8/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	4/12/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	4/14/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	4/19/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	4/21/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	5/12/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	6/10/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	7/14/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	7/27/99	NA	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	8/10/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	
trip blank	0	9/9/99	DB	U 2	U 2	U 2	U 2	U 2	U 10	U 2	

Appendix 3.Comparison of concentrations of volatile-organic compounds (tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2,-dichloroethene (*cis*-1,2DCE) from diffusion and peristaltic-pump samples at coincident sampled depth intervals

[All units in part per billion (ppb)]

Well name	Well number	Retrieval date	Peristaltic samples					Diffusion samples			
			Pump rate (liter/ minute)	Pumped volume (liters)	PCE	TCE	*cis*-1,2DCE	Deployment time (days)	PCE	TCE	*cis*-1,2DCE
B95-13	408	05/21/98	0.5	52.0	3300	230	160	90	3200	250	150
B95-13	408	07/23/98	0.5	14.0	3400	210	150	63	3100	220	150
B95-13	408	07/23/98	0.24	31.9	2800	190	140	63	3100	220	150
B95-13	408	11/23/98	0.16	12.3	2100	130	140	54	1900	170	140
B95-13	408	02/08/99	0.49	31.9	1500	97	180	77	1400	130	170
B95-13	408	04/14/99	0.48	54.0	1400	110	180	7	950	200	160
B95-13	408	06/10/99	0.45	21.6	1200	85	170	28	1400	92	180
B95-15	409	05/18/98	0.49	30.4	890	27	45	87	1000	28	43
B95-15	409	07/23/98	0.49	53.9	1200	39	68	66	1400	42	63
B95-15	409	11/23/98	0.21	12.4	350	26	36	63	480	29	37
B95-15	409	02/08/99	0.47	62.0	310	27	22	77	350	26	22
B95-15	409	04/07/99	0.41	45.5	91	14	22	58	210	28	22
B95-15	409	06/10/99	0.47	19.3	93	13	14	28	110	17	21
MW-16B	321	07/16/99	0.33	28.4	210	8.5	4.2	36	260	10	5.2
PW-13S	559	05/13/99	0.42	15.5	78	8.4	27	35	120	[1]10	31

Appendix 3.Comparison of concentrations of volatile-organic compounds (tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2,-dichloroethene (*cis*-1,2DCE) from diffusion and peristaltic-pump samples at coincident sampled depth intervals

[All units in part per billion (ppb)]

Well name	Well number	Retrieval date	Peristaltic samples					Diffusion samples			
			Pump rate (liter/ minute)	Pumped volume (liters)	PCE	TCE	*cis*-1,2DCE	Deployment time (days)	PCE	TCE	*cis*-1,2DCE
PW-13M	560	11/23/98	0.16	14.8	490	26	39	123	630	30	43
PW-13M	560	02/08/99	0.45	35.6	120	9.4	13	77	140	10	12
PW-14S	562	05/13/99	0.43	15.5	890	73	130	14	790	69	120
PW-14M	563	11/23/98	0.17	10.2	1200	93	200	123	1400	92	190
PW-14M	563	04/07/99	--	--	760	92	160	77	1100	110	190

[1]Concentration estimated at one half of detection level.

Appendix 4.Comparison of concentrations of volatile-organic compounds (tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2,-dichloroethene (*cis*-1,2DCE) from diffusion and bladder-pump samples at coincident sampled depth intervals

[All units in parts per billion (ppb)]

Well name	Well number	Retrieval date	Bladder samples					Diffusion samples			
			Pump rate (liter/ minute)	Pumped volume (liters)	PCE	TCE	*cis*-1,2DCE	Deployment time (days)	PCE	TCE	*cis*-1,2DCE
B95-13	408	05/21/98	0.62	62.0	4100	270	160	90	3200	250	150
B95-13	408	07/23/98	0.88	84.5	3900	230	150	63	3100	220	150
B95-13	408	04/14/99	0.45	87.0	1700	120	190	7	950	200	160

Appendix 5. Relative percent difference (RPD) for individual well comparison of peristaltic samples and diffusion samples. (PCE, Tetrachloroethylene; TCE, Trichloroethylene; CIS-1,2DCE, cis,1,2-dichloroethylene; negative values indicate that sample concentrations from diffusion sampler were greater than those from the perstaltic pump; % means percent; ppb, parts per billion)

Reference Number Fig. 15a&b	Well Name	USGS Number	Peristaltic Sample Date	PCE (ppb)	TCE (ppb)	CIS-1,2DCE (ppb)	Diffusion Sample Date	PCE (ppb)	TCE (ppb)	CIS-1,2DCE (ppb)	RPD PCE	RPD TCE	RPD CIS
1	B95-13	408	5/21/98	3300	230	160	5/21/98	3200	250	150	3.08%	-8.33%	6.45%
2	B95-13	408	7/23/98	2800	190	140	7/23/98	3100	220	150	-10.17%	-14.63%	-6.90%
3	B95-13	408	7/23/98	3400	210	150	7/23/98	3100	220	150	9.23%	-4.65%	0.00%
4	B95-13	408	11/23/98	2100	130	140	11/23/98	1900	170	140	10.00%	-26.67%	0.00%
5	B95-13	408	2/8/99	1500	97	180	2/8/99	1400	130	170	6.90%	-29.07%	5.71%
6	B95-13	408	4/14/99	1400	110	180	4/7/99	950	200	160	38.30%	-58.06%	11.76%
7	B95-13	408	6/10/99	1200	85	170	6/10/99	1400	92	180	-15.38%	-7.91%	-5.71%
8	B95-15	409	5/18/98	890	27	45	5/18/98	1000	28	43	-11.64%	-3.64%	4.55%
9	B95-15	409	7/23/98	1200	39	68	7/23/98	1400	42	63	-15.38%	-7.41%	7.63%
10	B95-15	409	11/23/98	350	26	36	11/23/98	480	29	37	-31.33%	-10.91%	-2.74%
11	B95-15	409	2/8/99	310	27	22	2/8/99	350	26	22	-12.12%	3.77%	0.00%
12	B95-15	409	4/7/99	91	14	22	4/7/99	210	28	22	-79.07%	-66.67%	0.00%
13	B95-15	409	6/10/99	93	13	14	6/10/99	110	17	21	-16.75%	-26.67%	-40.00%
14	MW-16B	321	7/16/99	210	8.5	4.2	7/16/99	260	10	5.2	-21.28%	-16.22%	-21.28%
15	PW-13M	560	11/23/98	490	26	39	11/23/98	630	30	43	-25.00%	-14.29%	-9.76%
16	PW-13M	560	2/8/99	120	9.4	13	2/8/99	140	10	12	-15.38%	-6.19%	8.00%
17	PW-13S	559	5/13/99	78	8.4	27	5/13/99	120	10	31	-42.42%	-17.39%	-13.79%
18	PW-14M	563	11/23/98	1200	93	200	11/23/98	1400	92	190	-15.38%	1.08%	5.13%
19	PW-14M	563	4/7/99	760	92	160	4/7/99	1100	110	190	-36.56%	-17.82%	-17.14%
20	PW-14S	562	5/13/99	890	73	130	5/13/99	790	69	120	11.90%	5.63%	8.00%

Appendix 6. Absolute relative percent difference (ARPD) information for positive detections in duplicate sample comparison.
("U", undetected at given level; --, not analyzed; PCE, Tetrachloroethylene; TCE, Trichloroethylene;CIS-1,2DCE, cis-1,2-dichloroethane; ppb, parts per billion; % means percent; peri, peristaltic; DB, diffusion bag; NA, sample outflow of extraction well port)

Well Name	USGS Number	Sample Date	Pump Type	PCE (ppb)	TCE (ppb)	CIS-1,2DCE (ppb)	DUPLICATE PCE (ppb)	DUPLICATE TCE (ppb)	DUPLICATE CIS-1,2DCE (ppb)	ARPD PCE	ARPD TCE	ARPD CIS-1,2DCE
B95-9	404	12/16/97	peri	140	3.8	U 2	140	3.5	U 2	0.00%	8.22%	--
B95-9	404	5/12/98	peri	120	2.6	U 2	120	2.9	U 2	0.00%	10.91%	--
B95-12	407	5/28/97	peri	U 2	U 2	--	U 2	U 2	--	--	--	--
B95-13	408	2/8/99	peri	1500	97	180	1600	100	190	6.45%	3.05%	5.41%
B95-15	409	9/30/98	DB	2000	38	48	1900	U 50	46	5.13%	--	4.26%
EW-2	566	3/1/99	NA	10	U 2	U 2	11	U 2	U 2	9.52%	--	--
MW-16B	321	4/13/99	peri	280	15	8.7	260	15	8.6	7.41%	0.00%	1.16%
PW-4M	538	12/7/98	peri	2.1	U 2	U 2	U 2	U 2	U 2	--	--	--
PW-6D	545	5/21/98	peri	4900	U 100	U 100	4800	U 100	U 100	2.06%	--	--
PW-9M	550	4/20/99	peri	2.9	U 2	U 2	2.6	U 2	U 2	10.91%	--	--
PW-14S	562	7/23/98	peri	840	76	95	870	75	91	3.51%	1.32%	4.30%
PW-14M	563	2/8/99	DB	1200	96	190	1200	91	180	0.00%	5.35%	5.41%