Volatile Organic Compounds, Specific Conductance, and Temperature in the Bottom Sediments of Mill Pond, Ashland, Massachusetts, April 2001

By Peter E. Church, Forest P. Lyford, *and* Scott Clifford

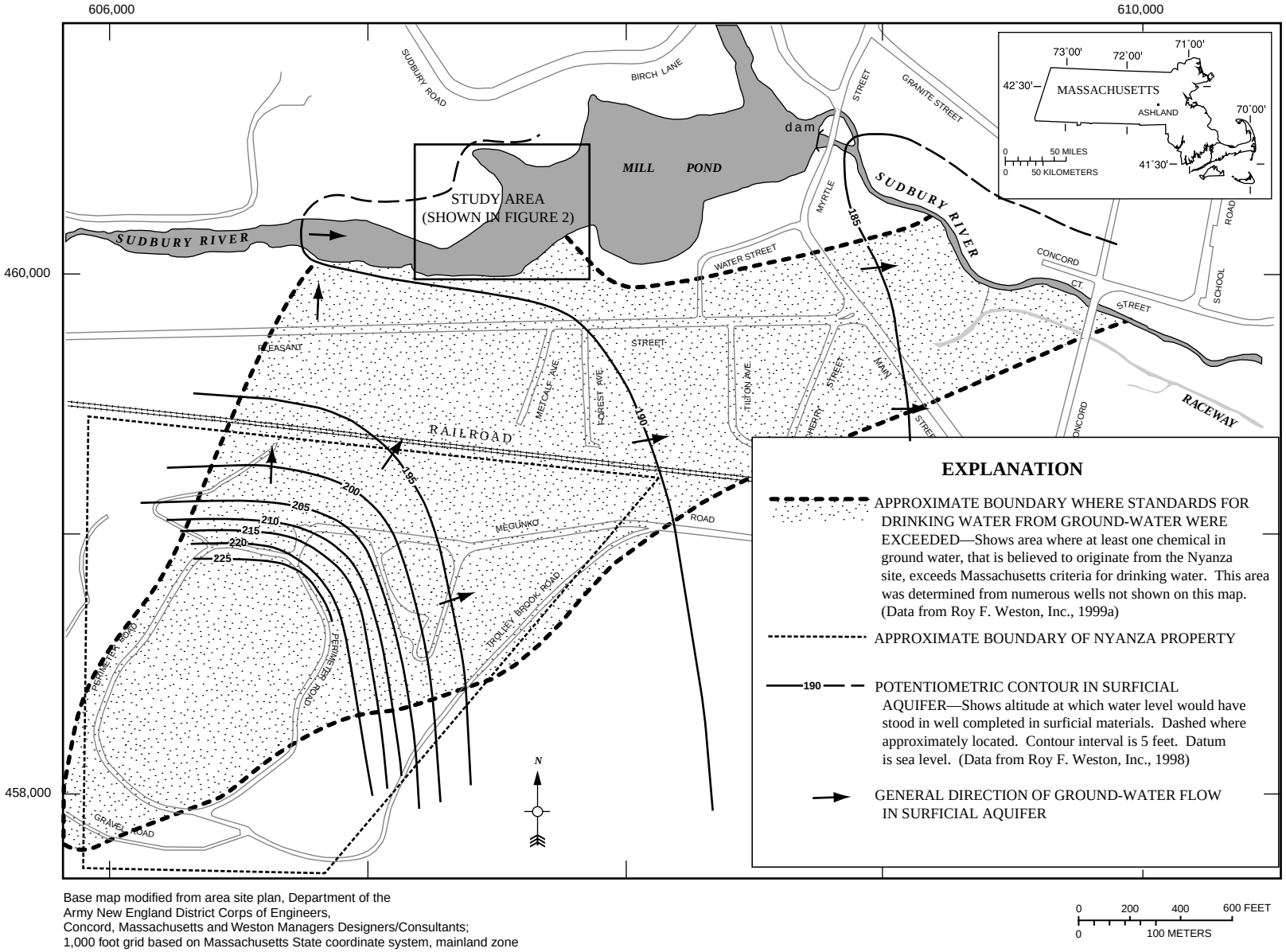
Abstract

A plume of volatile organic compounds in ground water extends northward from the former Nyanza Property in Ashland, Massachusetts, and discharges into the Sudbury River and the upstream end of Mill Pond. A network of polyethylene-membrane passive-vapor-diffusion samplers was installed in February 2001 to help define the lateral extent of the plume under the pond, including an area vegetated by wetland herbs, sedges, and shrubs. Chlorobenzene and trichloroethene were detected with passive-vapor-diffusion samplers at five locations in the bottom sediments of the southern part of the approximate one acre of vegetated area in Mill Pond. Vapor concentrations of chlorobenzene ranged from 178 to 2,210 parts per billion by volume, and vapor concentrations of trichloroethene ranged from 20 to 96 parts per billion by volume. Chlorobenzene also was detected in one sediment-pore-water sample extracted with a push-point sampler in this area; the concentration was 25 micrograms per liter. Toluene was detected with passive-vapor-diffusion samplers at three sites in the open pond area north of the vegetated areas. Vapor concentrations of toluene ranged from 20 to 90 parts per billion by volume.

Specific conductance and temperature of sediment-pore waters were measured at selected sampling sites in Mill Pond to examine their possible associations with the presence of volatile organic compounds. Temperature in the sediment-pore water also was measured to convert vapor concentrations of volatile organic compounds collected with diffusion samplers to equivalent water concentrations. These equivalent water concentrations were then to be compared with water concentrations collected with a push-point sampler. Because of the limited detections of volatile organic compounds at sites where water samples were collected and where specific conductance and temperature were measured, these potential associations and conversions could not be assessed.

INTRODUCTION

Some of the disposed wastes at the former Nyanza, Inc. property in Ashland, Massachusetts entered the ground-water system and formed a plume that extends to the Sudbury River and a nearby former mill raceway (Roy F. Weston, Inc., 1998) (fig. 1). Volatile organic compounds (VOCs), semi-volatile organic compounds, and metals have been detected in ground-water discharge to the Sudbury River and Mill Pond (Roy F. Weston, Inc., 1999a; 1999b; Lyford and others, 2000). The distribution of VOCs in the river and the southern part of the pond has been mapped on the basis of results of sampling with drive-points and polyethylene-membrane passive-vapor-diffusion (PVD) samplers (Roy F. Weston, 2001; J. P. Campbell, U.S. Geological Survey, written commun., 2001). Other possible areas of VOC discharge, however, including areas vegetated by wetland herbs, sedges, and shrubs that are tolerant to periodic flooding, and the open pond of the northwestern arm of Mill Pond beyond the vegetated areas (fig. 1), were not characterized by these earlier investigations.



Base map modified from area site plan, Department of the Army New England District Corps of Engineers, Concord, Massachusetts and Weston Managers Designers/Consultants; 1,000 foot grid based on Massachusetts State coordinate system, mainland zone

Figure 1. Location of study area, Mill Pond, Ashland, Massachusetts.

In February 2001, the U.S. Geological Survey (USGS), in cooperation with the U.S. Environmental Protection Agency (USEPA), installed PVD samplers in pond-bottom sediments in the approximately 1 acre of vegetated area and the 1 acre of open pond in the northwestern arm of Mill Pond in Ashland, Mass., to identify possible discharge areas of ground water contaminated with VOCs (fig. 1). This report presents VOC, specific conductance, and temperature data collected in the vegetated areas and in the open pond area.

In this study, PVD samplers were used at 64 locations because of their success as a reconnaissance tool in detecting and delineating discharge areas of VOC contaminated ground-water to surface-water bodies at several hazardous-waste sites in New England (Savoie and others, 1999; 2000; Church and others, 2000). In addition, push point samplers were used to collect sediment-pore water adjacent to PVD samplers at several sampling sites to compare vapor concentrations of VOCs with water concentrations of VOCs. Specific conductance of these water samples was measured to assess the possibility of using specific conductance as an indicator of contaminants at these sites, a method similar to that used to estimate concentrations of road-salt in highway runoff (Granato and Smith, 1999).

Water temperatures also were measured at selected sampling sites at the same depths as the deployed PVD samplers to aid in the possible conversion of vapor concentrations of VOCs to water concentrations of VOCs. These converted values were then to be compared to concentrations in samples collected with a push-point sampler. Temperatures also were measured to identify whether temperature anomalies, if present, correlate with areas of VOCs. Water temperatures at the pond bottom at these sites were compared with temperatures at depth for possible identification of ground-water discharge.

The authors thank Sharon M. Hayes, USEPA Site Manager of the Nyanza Chemical Waste Dump Superfund site and Richard E. Willey, USEPA for their assistance and advice during this investigation. Thanks are also extended to Daniel Granz, USEPA, for assistance and advice on the collection of water samples from push-point samplers.

DESCRIPTION OF STUDY AREA

The undulating landscape of the study area is underlain by a surficial aquifer that consists of glacial lake deposits and till, and a fractured crystalline bedrock aquifer. The glacial lake deposits range in grain size from silt to coarse sand and gravel. The thickness of fine-grained sediments increases eastward. The depth to bedrock increases in an east-west trending trough from less than 30 ft in the Mill Pond area to nearly 80 ft beneath the Sudbury River downstream of the pond. Most of the Nyanza Property is on till-covered bedrock, and the Sudbury River is on silt, sand, and gravel (Ebasco Services, Inc., 1991).

Ground water flows northward from the Superfund site to Mill Pond and eastward to the Sudbury River and former mill raceway downstream from a dam that forms the pond (Roy F. Weston, Inc., 1998) (fig.1). A plume of contaminants in the surficial and bedrock aquifers extends from the area of the Nyanza property northward to the Sudbury River and Mill Pond and to the river and raceway downstream from the dam (fig. 1). Contaminants detected in ground water near the river and pond include the VOCs 1,1,1- trichloroethane (1,1,1-TCA), benzene, chlorobenzene (CB), cis-dichloroethene (cis-DCE), tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride. Chlorobenzene, TCE, and cis-DCE are the VOCs most commonly detected in ground water at this site. Also detected in ground water are mercury and the semi-volatile organic compounds (SVOCs) 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene (Roy F. Weston, Inc., 1999a; 1999b). Contaminants appear to be absent near the downstream part of Mill Pond, where water-level data show the pond is a source of recharge to ground water (Roy F. Weston, Inc., 1999b).

SAMPLING METHODS

The PVD samplers were constructed in accordance with methods described by Vroblesky and others (1996). A sampler consists of a 40-milliliter, uncapped glass bottle secured with plastic cable ties inside two heat-sealed lengths of polyethylene-membrane tubing. Plastic cable ties attach the sampler to the wire of a survey flag, which allows for marking and retrieval of

the sampler. Duplicate samples for quality control are obtained by attaching two samplers to the same survey flag.

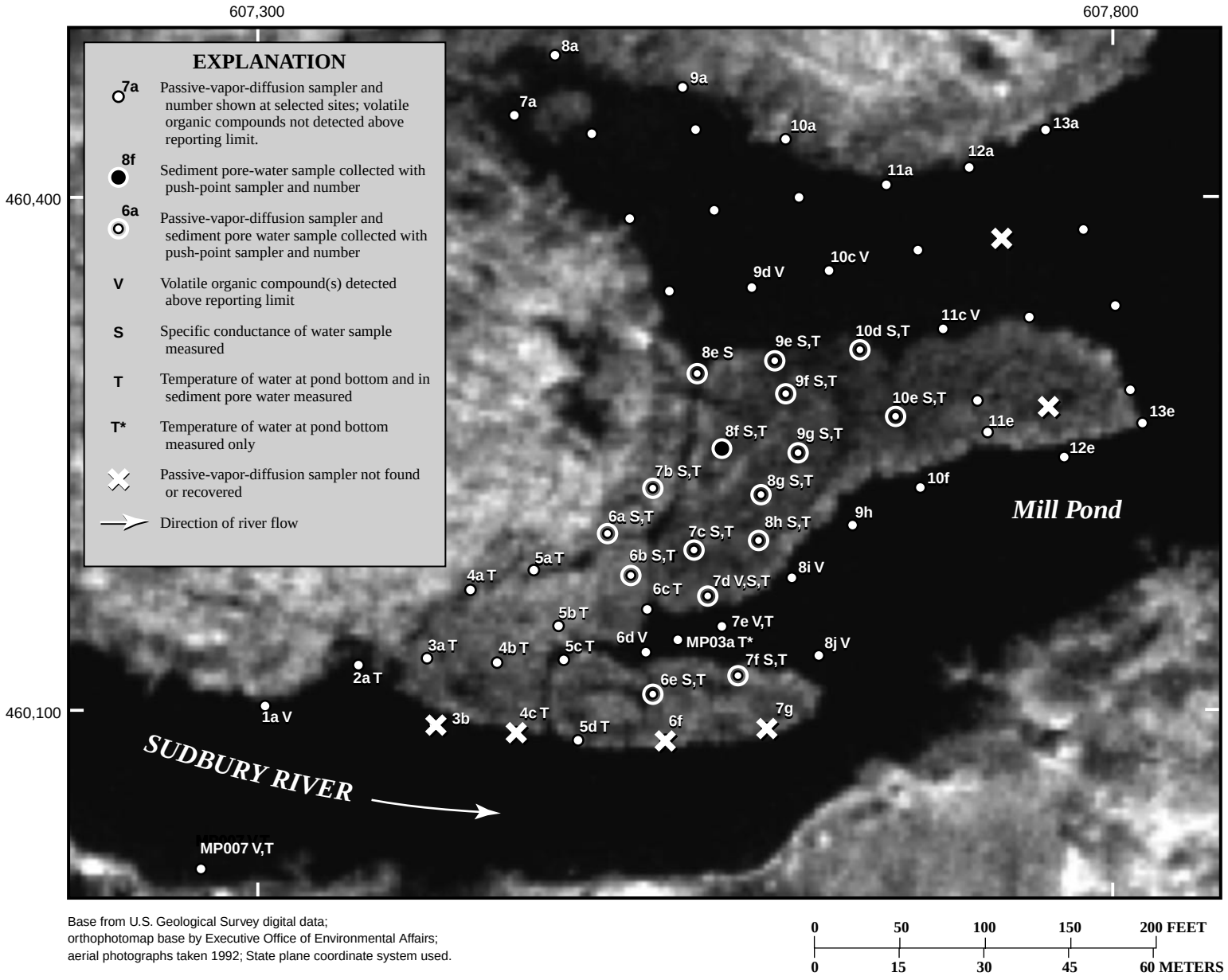
Samplers generally are placed manually 8 to 10 in. deep in the bottom sediments of surface-water bodies with the bottle opening facing downward. Organic vapors from VOCs in the saturated sediments diffuse through the two layers of polyethylene and equilibrate with air in the bottle. Equilibration time has been shown to be 24 hours or less in a controlled laboratory setting (Vroblesky and others, 1996). In a field setting, however, two weeks is recommended for equilibration (Don Vroblesky, U.S. Geological Survey, oral commun., 1997). The additional time is necessary because it allows concentrations of VOCs in ground water to re-equilibrate after the sediment is disturbed by installation of the sampler. Once the sampler has been retrieved, the outer tubing is removed to shed attached sediment, and a cap is immediately screwed onto the bottle over the inner tubing.

The PVD samplers were installed at 62 locations in the soft, organic-rich bottom sediments in the vegetated areas and in the open area of the shallow northwestern arm of Mill Pond on February 28, 2001, while much of the pond surface was frozen (fig. 2). Samplers were installed with a pipe-insertion method (Lyford and others, 1999) through holes drilled in the ice in an approximate 50 by 50-ft grid, and set uniformly about 8-in. deep in the sediment (fig. 2). Duplicate samplers were installed at six of the 62 sampling sites. Most sampling sites were surveyed with a global positioning system on March 2, 2001.

The PVD samplers were retrieved on April 10 and 11, 2001. Five of the 62 PVD samplers installed were not found, and one sampler was not recovered because the wire of the survey marker broke free of the sampler. Two additional samplers, installed on February 16, 2001 near existing well points, one near the right bank of the Sudbury River as it opens into Mill Pond (PVD sampler MP007), and the other in open water between two vegetated areas (PVD sampler MP03a), were also retrieved (fig. 2). Vapor in the 58 PVD samplers recovered, and in the six duplicate samplers, two trip blank samples, and one equipment blank sample, were analyzed on site for the target compounds CB and TCE with the USEPA Region I standard air-screening method (U.S. Environmental Protection Agency, 1998a). Concentrations of VOCs in vapor-phase are reported in units of parts per billion by volume (ppb v). Reporting limits were 20 ppb v for CB and 5 ppb v for TCE.

Before retrieval of the PVD sampler, a push-point sampler was used to collect water samples at 16 sites in the vegetated areas of the pond. The sampler, also known as the MHE PP27 sampler, or the Henry sampler, is a 1/8-in-diameter screened tube that is pushed by hand into the sediment to collect water from pores in the sediment. Of the 16 sites sampled, 15 were adjacent (within 1 ft) to the location of the PVD sampler (fig. 2). Samples were taken at the same depths as the PVD samplers. Water was extracted from the push-point sampler by suction with a 50 ml volume syringe, and at least 3 syringe volumes were removed. Sample water was poured into a 40-ml glass vial for head-space analysis of VOCs when temperature and specific conductance differed by 10 percent or less in two successive syringe volumes. The last specific conductance measurement recorded in the push-point sampler collection of water was selected for comparison with concentrations of VOCs detected in PVD and push-point samplers. An additional water sample was collected from the Sudbury River approximately 800 ft upstream of Mill Pond from near the center of the channel by lowering a 40 mL vial to the center of the water column. Water samples were analyzed on site for VOCs, in accordance with the USEPA Region I standard head-space screening method (U.S. Environmental Protection Agency, 1998b). Concentrations of VOCs in water-phase are reported in units of micrograms per liter. Reporting limits for the target compounds CB and TCE were 1.0 µg/L and 0.5 µg/L, respectively.

Water temperatures at the pond bottom were measured at 28 sampling sites and temperatures were measured at depths of the PVD samplers at 27 of these sites. At 15 of the sites where temperature was measured at the pond bottom and at depth, push-point water samples and specific conductance measurements also were obtained (fig. 2). Temperatures were measured by inserting a thin thermocouple probe into the sediment and by holding the probe at the pond bottom.



Base from U.S. Geological Survey digital data;
orthophotomap base by Executive Office of Environmental Affairs;
aerial photographs taken 1992; State plane coordinate system used.

Figure 2. Data-collection points, Mill Pond, Ashland, Massachusetts.

DISTRIBUTION OF VOLATILE ORGANIC COMPOUNDS

At nine sampling sites, VOCs were detected with PVD samplers, and at one sampling site a VOC was detected with the push-point sampler (fig. 2, **table 1**). The VOCs—CB and TCE—were detected on the right bank of Sudbury River where it opens into Mill Pond and were also detected in the southern part of vegetated areas. Toluene was detected in the open pond area north of the vegetated areas (fig. 2). At six sites (sites MP007, 1a, 6d, 7e, 8i, and 8j) CB was detected with PVD samplers above reporting limits. Concentrations ranged from 178 to 2,210 ppb v. At four of these six sites (MP007, 6d, 7e, and 8i) TCE was detected above reporting limits at concentrations ranging from 20 to 138 ppb v. Toluene was detected with PVD samplers at or above reporting limits of 20 ppb v at three sites (9d, 10c, and 11c) at concentrations ranging from 20 to 90 ppb v. No VOCs were detected in the river sample upstream of Mill Pond.

At 14 of the 15 sites where samples were collected with both PVD and push-point sampling methods, no VOCs were detected. At site 7d, CB was detected above the reporting limit in the sediment-pore-water sample collected with the push-point sampler at a concentration of 25 µg/L. In the adjacent PVD sampler, CB and other VOCs, however, were not detected. Although the push-point sampler was inserted to the same depth in the pond bottom sediments as the PVD sampler, the samplers were laterally about 10 in. apart.

No VOCs were detected in the six PVD duplicate samples, nor were they detected in the first day's trip-blank sample and the equipment-blank sample. Toluene was detected at a concentration of 496 ppb v in the second day's trip-blank sample, but the source of toluene is unknown. The PVD samples from the three sampling sites where toluene was detected were analyzed on the first day of sampling, when VOCs were not detected in the trip-blank sample.

Because areas of ground-water discharge to surface-water bodies can become areas of surface-water recharge to ground water at times of high surface-water levels, and therefore, alter pathways of contaminants at the ground-water/surface-water interface, water levels in the Sudbury River at Mill Pond were examined for a period from about two months before the PVD samplers were installed to about three months after the samplers were retrieved. Although the nearest stream gage (Sudbury River at Saxonville, Mass., 01098530) is about 10 mi. downstream, stage and discharge data from the temporary USGS stream gage about 1/2 mile downstream of Mill Pond from March 1994 through September 1995 (station no. 01097480), were shown to correlate well with the Saxonville stream-gage data (R.S. Socolow, U.S. Geological Survey, oral commun., 2001). Stage measurements of the Sudbury River at the Saxonville stream gage from January through June 2001 (**fig. 3**) show an increase of nearly 7 ft in the later part of March and early April, and a recession of about 8 ft by mid-May 2001. These data indicate that a rise and fall of about 1–2 ft at Mill Pond may have occurred when the PVD samplers were buried in the pond-bottom sediment.

Table 1. Volatile organic compound, specific conductance, and temperature data, Mill Pond, Ashland, Massachusetts, April 10–11, 2001

[**Volatile organic compounds:** Samples taken 8 inches below pond bottom; (5), reporting limit. **Specific conductance:** Compensated to 25 degrees Celsius. CB, chlorobenzene; dup, duplicate sample; NA, not applicable; PVD, passive-vapor-diffusion sampler; TCE, trichloroethene; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter; ppb v, parts per billion by volume; *, sample not collected and (or) parameter not measured; °C, degrees Celsius; --, not detected above reporting limit]

Site ID	Sampling method(s)	Volatile organic compounds						Specific Conductance 8 inches below pond bottom (µS/cm)	Temperature (° C)	
		PVD sample (ppb v)			Push-point sample (µg/L)				Immediately above pond bottom	8 inches below pond bottom
		TCE (5)	CB (20)	Toluene (20)	TCE (0.5)	CB (20)	Toluene (1.0)			
MP007	PVD	138	520	--	*	*	*	*	9.4	8.9
1a	PVD	--	178	--	*	*	*	*	*	*
2a	PVD	--	--	--	*	*	*	*	7.5	6.1
3a	PVD	--	--	--	*	*	*	*	6.3	6.1
3b	PVD	Sampler not found			*	*	*	*	*	*
4a	PVD	--	--	--	*	*	*	*	8.4	6.7
4b	PVD	--	--	--	*	*	*	*	8.2	6.3
4c	PVD	Unable to recover sample			*	*	*	*	8.4	6.4
5a	PVD	--	--	--	*	*	*	*	8.1	6.3
5b	PVD	--	--	--	*	*	*	*	7.2	6.1
5c	PVD	--	--	--	*	*	*	*	6.9	6.2
5c-dup	PVD	--	--	--	NA	NA	NA	NA	NA	NA
5d	PVD	--	--	--	*	*	*	*	8.4	6.2
6a	PVD, Push-Point	--	--	--	--	--	--	825	8.8	7.0
6b	PVD, Push-Point	--	--	--	--	--	--	546	9.0	7.2
6c	PVD	--	--	--	*	*	*	*	8.7	5.6
6d	PVD	33	402	--	*	*	*	*	*	*
6e	PVD, Push-Point	--	--	--	--	--	--	530	8.4	6.3
6f	PVD	Sampler not found			*	*	*	*	*	*
MP03A	PVD	--	--	--	*	*	*	*	7.2	*
7a	PVD	--	--	--	*	*	*	*	*	*
7b	PVD, Push-Point	--	--	--	--	--	--	468	8.8	6.4
7c	PVD, Push-Point	--	--	--	--	--	--	768	8.8	6.2
7d	PVD, Push-Point	--	--	--	--	25	--	1,554	9.1	6.9
7e	PVD	20	2,210	--	*	*	*	*	7.3	7.3
7f	PVD, Push-Point	--	--	--	--	--	--	508	7.2	6.6
7f-dup	PVD	--	--	--	NA	NA	NA	NA	NA	NA
7g	PVD	Sampler not found			*	*	*	*	*	*
8a	PVD	--	--	--	*	*	*	*	*	*
8b	PVD	--	--	--	*	*	*	*	*	*
8c	PVD	--	--	--	*	*	*	*	*	*
8d	PVD	--	--	--	*	*	*	*	*	*
8e	PVD, Push-Point	--	--	--	--	--	--	490	*	*
8e-dup	PVD	--	--	--	NA	NA	NA	NA	NA	NA
8f	Push-Point	*	*	*	--	--	--	471	9.7	7.8

Table 1. Volatile organic compound, specific conductance, and temperature data, Mill Pond, Ashland, Massachusetts, April 10–11, 2001 —*Continued*

Site ID	Sampling method(s)	Volatile organic compounds						Specific Conductance 8 inches below pond bottom (μS/cm)	Temperature (°C)	
		PVD sample (ppb v)			Push-point sample (μg/L)					
		TCE (5)	CB (20)	Toluene (20)	TCE (0.5)	CB (20)	Toluene (1.0)		Immediately above pond bottom	8 inches below pond bottom
8g	PVD, Push-Point	--	--	--	--	--	--	621	12.2	9.3
8h	PVD, Push-Point	--	--	--	--	--	--	646	8.8	6.1
8i	PVD	96	1,530	--	*	*	*	*	*	*
8j	PVD	--	560	--	*	*	*	*	*	*
9a	PVD	--	--	--	*	*	*	*	*	*
9b	PVD	--	--	--	*	*	*	*	*	*
9c	PVD	--	--	--	*	*	*	*	*	*
9d	PVD	--	--	20	*	*	*	*	*	*
9e[1]	PVD, Push-Point	--	--	--	--	--	--	515	10.4	7.9
9e dup	PVD	--	--	--	NA	NA	NA	NA	NA	NA
9f	PVD, Push-Point	--	--	--	--	--	--	435	8.8	6.3
9g	PVD, Push-Point	--	--	--	--	--	--	625	13.0	8.5
9g-dup	PVD	--	--	--	NA	NA	NA	NA	NA	NA
9h	PVD	--	--	--	*	*	*	*	*	*
10a	PVD	--	--	--	*	*	*	*	*	*
10b	PVD	--	--	--	*	*	*	*	*	*
10c	PVD	--	--	24	*	*	*	*	*	*
10d	PVD, Push-Point	--	--	--	--	--	--	554	12.9	8.4
10e	PVD, Push-Point	--	--	--	--	--	--	552	11.6	7.7
10f	PVD	--	--	--	*	*	*	*	*	*
11a	PVD	--	--	--	*	*	*	*	*	*
11b	PVD	--	--	--	*	*	*	*	*	*
11c	PVD	--	--	90	*	*	*	*	*	*
11d	PVD	--	--	--	*	*	*	*	*	*
11e	PVD	--	--	--	*	*	*	*	*	*
12a	PVD	--	--	--	*	*	*	*	*	*
12b	PVD	Sampler not found			*	*	*	*	*	*
12c	PVD	--	--	--	*	*	*	*	*	*
12c-dup	PVD	--	--	--	NA	NA	NA	NA	NA	NA
12d	PVD	Sampler not found			*	*	*	*	*	*
12e	PVD	--	--	--	*	*	*	*	*	*
13a	PVD	--	--	--	*	*	*	*	*	*
13b	PVD	--	--	--	*	*	*	*	*	*
13c	PVD	--	--	--	*	*	*	*	*	*
13d	PVD	--	--	--	*	*	*	*	*	*
13e	PVD	--	--	--	*	*	*	*	*	*

[1]Specific conductance at pond bottom at site 9e, 322 μS/cm

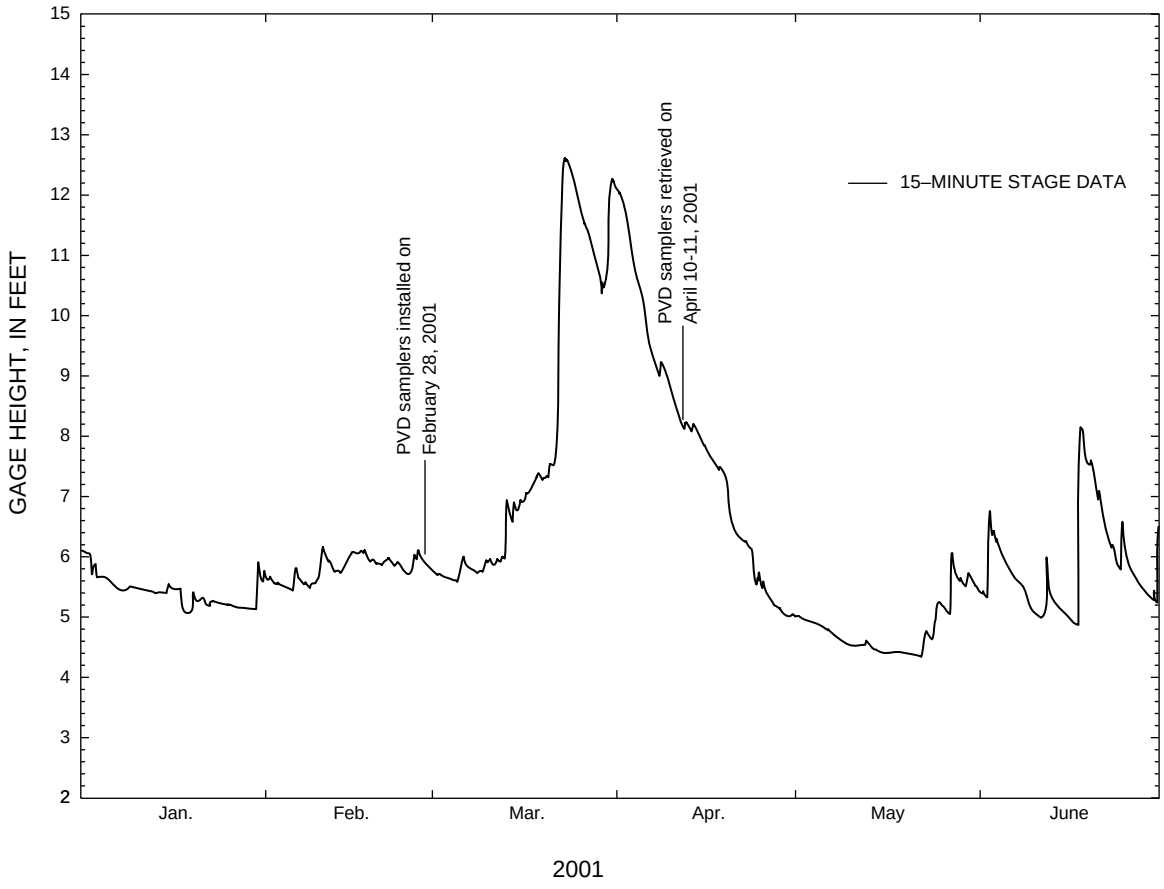


Figure 3. Sudbury River stage at U.S. Geological Survey stream gage Sudbury River at Saxonville, Massachusetts (station 01098530), January 1 to June 30, 2001.

SPECIFIC CONDUCTANCE AND TEMPERATURE

Relations between VOCs and specific conductance and temperatures could not be assessed because of limited data. Specific conductances of the 16 water samples obtained with the push-point sampler ranged from 435 to 1,554 µS/cm. The highest specific conductance (1,554 µS/cm) among these sampling sites was measured at site 7d, where a CB concentration of 25 µg/L was detected. Specific conductances from the remaining 15 water samples, which ranged from 435 to 825 µS/cm, are all associated with water samples and vapor samples from which VOCs were not detected (fig. 2, table 1). At site 9e, specific conductance was measured in water at the pond bottom, as well as at the depth of the PVD sampler. Specific conductance at the pond bottom was 322 µS/cm, and at depth was 515 µS/cm.

Temperatures at the pond bottom and in the pond-bottom sediment at depths of the PVD samplers were measured at 27 sites—one on the right bank of the Sudbury River as it opens into Mill Pond (site MW007), one between vegetated areas (site 7e), and 25 sites within the vegetated areas of the pond (fig. 2, table 1). At site MP03a, the water was too deep to insert the temperature probe into the bottom sediments from a boat; therefore, only the pond-bottom temperature was measured. The pond-bottom temperatures were higher than the temperatures at depths in the pond-bottom sediment at the all sites, except at site 7e, where the temperatures were the same. Pond-bottom temperatures range from 6.3°C to 13.0°C, and temperatures in the pond-bottom sediments range from 5.6°C to 9.3°C. Differences in pond bottom and pond-bottom-sediments temperatures range from 0.0°C to 4.5°C, with a mean of 2.1 °C and median of 2.0°C.

At the 27 sites where temperatures were measured, VOCs were detected at only three of the sites (MP007, 7d, and 7e). Temperatures at the pond bottom at these three sites were 9.4°C, 9.1°C, and 7.3°C, respectively. At site MP007, pond-bottom temperature was 0.5°C higher than that in the pond-bottom sediments at the depth the PVD sampler. Pond-bottom temperature was 2.2°C higher at site 7d, and was the same at site 7e. Because of this limited data, however, associations of pond-bottom temperatures, temperature in the pond-bottom sediments, and vertical differences in temperatures with discharge of VOC contaminated ground water could not be evaluated.

REFERENCES CITED

Church, P.E., Lyford, F.P., and Clifford, Scott, 2000, Distribution of selected volatile organic compounds determined with water-to-vapor diffusion samplers at the interface between ground water and surface water, Centredale Manor Site, North Providence, Rhode Island, September 1999: U.S. Geological Survey Open-File Report 00-276, 9 p., 1 pl.

Ebasco Services, Inc., 1991, Draft Final Remedial Investigation Report, Nyanza II—Groundwater Study, Ashland, Massachusetts, v. I: Boston, Mass., variable paging.

Granato, G.E., and Smith, K.P., 1999, Estimating concentrations of road-salt constituents in highway runoff from measurements of specific conductance: U.S. Geological Survey Water-Resources Investigations Report 99-4077, 22 p.

Lyford, F.P, Flight, L.E., Stone, J.R., and Clifford, Scott, 1999, Distribution of trichloroethylene and geologic controls on contaminant pathways near the Royal River, McKin Superfund Site Area, Gray, Maine: U.S. Geological Survey Water-Resources Investigations Report 99-4125, 20 p.

Lyford, F.P., Willey, R.E., and Clifford, Scott, 2000, Field tests of polyethylene-membrane diffusion samplers for characterizing volatile organic compounds in stream-bottom sediments, Nyanza Chemical Waste Dump Superfund Site, Ashland, Massachusetts: U. S. Geological Survey Water-Resources Investigations Report 00-4108, 19 p.

Roy F. Weston, Inc., 1998, Groundwater sampling, Nyanza Chemical Waste Dump Superfund Site, Ashland, Massachusetts: Manchester, N.H., variable paging.

Roy F. Weston, Inc., 1999a, Evaluation of Contamination, Nyanza Chemical Waste Dump Superfund Site, Ashland, Massachusetts: Manchester, N.H., variable paging.

Roy F. Weston, Inc., 1999b, Semi-annual groundwater monitoring report, Spring 1999, Nyanza Chemical Waste Dump Superfund Site, Ashland, Massachusetts, draft report: Manchester, N.H., variable paging.

Roy F. Weston, Inc., 2001, Draft groundwater toxicity evaluation report, Nyanza Chemical Waste Dump Superfund Site, Operable Unit II (OU II), Ashland, Massachusetts: Manchester, N.H., variable paging.

Savoie, J.G., Lyford, F.P., and Scott Clifford, 1999, Potential for advection of volatile organic compounds in ground water to the Cochato River, Baird & McGuire Superfund Site, Holbrook, Massachusetts, March and April 1998: U.S. Geological Survey Water-Resources Investigations Report 98-4257, 19 p.

Savoie, J.G., LeBlanc, D.R., Blackwood, D.S., McCobb, T.D., Rendigs, R.R.,and Scott Clifford, 2000, Delineation of discharge areas of two contaminant plumes by use of diffusion samplers, Johns Pond, Cape Cod, Massachusetts, 1998: U.S. Geological Survey Water-Resources Investigations Report 00-4017, 30 p.

U.S. Environmental Protection Agency, 1998a, Ambient air grab sample analysis for volatile organic compounds, Region 1: Internal Standard Operation Procedure no. EIA-FLDGRAB1.SOP, U.S. Environmental Protection Agency, March 1998, 6 p.

U.S. Environmental Protection Agency, 1998b, Head space screening for volatile organic compounds in aqueous, soil, and drum samples: Region I, Internal Standard Operating Procedure no. EIA-FLDVOA1.SOP, U.S. Environmental Protection Agency, March 1998, 11 p.

Vroblesky, D.A., Rhodes, L.C., Robertson, J.F., and Harrigan, J.A., 1996, Locating VOC contamination in a fractured-rock aquifer at the ground-water/surface-water interface using passive vapor collectors: Ground Water, v. 34, no. 2, p. 223-230.