U.S. Department of the Interior
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Volatile Organic Compounds Detected in Vapor-Diffusion Samplers Placed in Sediments Along and Near the Shoreline at Allen Harbor Landfill and Calf Pasture Point, Davisville, Rhode Island, March–April 1998

Open-File Report 99–74

Prepared in cooperation with the
U.S. ENVIRONMENTAL PROTECTION AGENCY

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Marlborough, Massachusetts
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U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, *Secretary*

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

CONVERSION FACTORS

Multiply	By	To obtain
feet (ft)	0.3048	meters
inches (in.)	25.40	millimeter
miles (mi)	1.609	kilometers

VERTICAL DATUM

Sea level: 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 the United States and Canada, formerly called Sea Level Datum of 1929.

ABBREVIATIONS

mL milliliters

ppb parts per billion

µg/L micrograms per liter

Volatile Organic Compounds Detected in Vapor-Diffusion Samplers Placed in Sediments Along and Near the Shoreline at Allen Harbor Landfill and Calf Pasture Point, Davisville, Rhode Island, March–April 1998

By Forest P. Lyford, John D. Kliever, *and* Scott Clifford

Abstract

Volatile organic compounds are present in ground water at the Allen Harbor Landfill and the Calf Pasture Point sites on the former Naval Construction Battalion Center in Davisville, R.I. Vapor-diffusion samplers were used at the two sites during March–April 1998 to identify possible discharge points for contaminants along the shore of Allen Harbor and in two wetland areas near the shore. Results from vapor-diffusion samplers will be used in conjunction with other site information to evaluate proposed ground-water monitoring programs.

Volatile organic compounds were detected in 41 of 115 samplers placed along the shoreline at the Allen Harbor Landfill. Trichloroethylene was the principal volatile organic compound detected of eight target compounds. The highest vapor concentration measured exceeded 300,000 parts per billion by volume in an area where TCE was detected in ground water from nearby monitoring wells. Other chemicals detected in vapor-diffusion samplers included tetrachloroethylene, toluene, and benzene. Concentrations of individual volatile organic compounds were less than 100 parts per billion by volume in most samplers.

Volatile organic compounds, principally trichloroethylene, were detected in 7 of 30 samplers placed along the shoreline at Calf Pasture Point; the highest trichloroethylene concentration was 1,900 parts per billion by volume. A trace concentration of tetrachloroethylene was detected in one of the samplers. One of 24 samplers placed in two wetland areas near the shore (suspected discharge areas for ground-water containing volatile organic compounds) detected trichloroethylene at a vapor concentration of 14 parts per billion by volume.

INTRODUCTION

Remedial investigations by the U.S. Navy at the former Naval Construction Battalion Center in Davisville, Rhode Island, have detected volatile organic compounds (VOCs) in ground water at Allen Harbor Landfill and Calf Pasture Point (EA Engineering, Science, and Technology, 1996; 1998a). These two areas are adjacent to Allen Harbor on Narragansett Bay (fig. 1, in back of report). Information about discharge areas for ground water containing VOCs would be useful to the U.S. Environmental Protection Agency (USEPA), in conjunction with other site information, to assess ground-water risks to human health and the environment and design monitoring programs for contaminants in ground water. A survey using vapor-diffusion samplers was requested by USEPA because prior experience had shown the samplers to be a useful and inexpensive reconnaissance tool for identifying discharge points for ground water contaminated by VOCs (Vroblesky and others, 1996; Lyford and others, 1998; J.R Mulanney, U.S. Geological Survey, oral commun., 1997). The method had not been used previously in a coastal setting, so a secondary goal of the study was to determine if vapor-diffusion samplers can yield useful information about discharge points for VOCs in ground water along a coastal shoreline. Although the data presented in this report indicate that vapor-diffusion samplers will detect VOCs in sediments within the zone of tidal fluctuations, the study did not examine possible effects of tidal cycling on concentrations of VOCs in the vapor samples, nor did the study determine actual concentrations of VOCs in ground water where detected in vapor. Also, the study did not attempt to identify discharge points for VOCs in ground water offshore beyond the tidal zone.

The purpose of this report is to present data on vapor concentrations detected in vapor-diffusion samplers installed and retrieved during March–April 1998 at the Allen Harbor Landfill and Calf Pasture Point sites in Davisville, Rhode Island. It is beyond the scope of this report to explain the distribution and concentrations of VOCs detected in the samplers. The vapor samplers were installed and retrieved by USGS personnel assisted by Christine Williams and William Brandon, USEPA, and by John Zimmerman, Dynamac, Inc., a contractor for USEPA. Vapor analyses were done on-site by Scott Clifford, USEPA, using a portable gas chromatograph.

STUDY AREA

The Allen Harbor Landfill and Calf Pasture Point areas are part of the former Naval Construction Battalion Center (NCBC) in Davisville, R.I. NCBC was decommissioned and closed in 1994 (EA Engineering, Science, and Technology, 1998a). Investigations of the two areas have identified contaminants in ground water, principally VOCs. Both areas are on the shore of Allen Harbor, which is connected to Narragansett Bay by an entrance channel (fig. 1). Tidal fluctuations in the harbor are generally about 5 ft (EA Engineering, Science, and Technology, 1996).

Allen Harbor Landfill

Allen Harbor Landfill occupies most of an area between Sanford Road and Allen Harbor (fig. 1). Landfill materials are about 20 ft thick or less. Geologic materials beneath the landfill and shoreline include a discontinuous layer of fine to very fine sand, generally less than 15 ft thick, over a layer of silt that is 20 to 50 ft thick. Peat layers are present in some locations at the top of the sand layer. The silt layer overlies till, where present, or bedrock. The depth to the bottom of the silt layer below sea level ranges from 30 to 50 ft (EA Engineering, Science, and Technology, 1996, figs. 3-3 to 3-5). Ground water in landfill materials and the sand layer flows from a water-table mound centered near well MW09-18I (EA Engineering, Science, and Technology, 1996, fig. 3–10) eastward to the shore and southward to a mud-flat area (fig. 2, in back of report). Ground water also flows westward toward a wetland on the west side of Sanford Road (fig. 1) during wet seasons (EA Engineering, Science, and Technology, 1996, chap. 3, p. 10). The mound is not apparent in water levels measured in wells screened near the bottom of the silt layer and in deeper geologic units. Ground-water flow at depth is predominantly eastward and southeastward toward Allen Harbor; flow directions change somewhat with tidal fluctuations (EA Engineering, Science, and Technology, 1996, figs. 3-10 to 3-18). Vertical hydraulic gradients are downward in the area of the water-table mound and upward near the shore (EA Engineering, Science, and Technology, 1996, figs. 3-3

to 3-5 and table 3-3). Gradients reverse in some wells near the shore during high tide, but the reversal is not consistently observed for all tidal cycles.

The landfill received a variety of wastes generated at the NCBC from 1946 until 1974, when disposal activities ceased. A variety of VOCs, including petroleum-based compounds (benzene, toluene, ethylbenzene, and the xylenes) and chlorinated compounds, have been detected in several monitoring wells placed within the landfill area. The highest concentrations of VOCs were observed at monitoring well MW09-20I (380,500 μg/L total chlorinated VOCs), completed in the sand layer near the shore (fig. 2) (EA Engineering, Science, and Technology, 1996, figs. 4-18 and 4-20). Compounds detected at MW09-20I include 1,2-dichloroethylene, trichloroethylene (TCE), 1,1,2-trichloroethane, and tetrachlorethane. Other wells where concentrations of total VOCs exceed 2,000 μg/L include MW09-07D, MW09-09D, and MW09-14D (EA Engineering, Science, and Technology, 1996, fig. 4-22), which are screened near the bottom of the silt layer. VOCs also have been detected in water from borings installed in sediments offshore in the harbor (EA Engineering, Science, and Technology, 1998b).

The substrate in the tidal zone at the south end of the landfill consists of fine-grained estuarine deposits on a tidal mud flat that is exposed during low tide (fig. 2). Channels carry water through the area during low tide. A channel along the shore on the south side of the landfill drains the wetland area west of the landfill (fig. 1). The substrate in the tidal zone along the east side of the landfill from the mud-flat area north to a small jetty (fig. 2) consist mainly of landfill debris and sand. North of the jetty, the tidal zone substrate consists mainly of sand. Seeps are apparent in several locations in the tidal zone during low tide. Along the east side of the landfill north to the jetty, the surface slopes steeply into the harbor and the tidal zone is generally 5 to 10 ft wide. North of the jetty, the slope of the surface is gentler than to the south and the width of the tidal zone is generally greater than 10 ft. A small escarpment stabilized by vegetation marks the high tide position north of the jetty.

Calf Pasture Point

The stratigraphy at Calf Pasture Point is similar to that at Allen Harbor Landfill. Fine to very fine sand overlies a layer of silt, which, in turn, overlies till or bedrock (EA Engineering, Science, and Technology, 1998a, figs. 3-3 to 3-9). The silt layer is absent along a north-south-trending till ridge between wells MW07-26S and MW07-21S (fig. 3, in back of report). Potentiometric maps indicate that ground water flows in an arcuate pattern from the area near well MW07-14D southeastward toward Allen Harbor, southward toward the entrance channel to Allen Harbor, and southeastward toward Narragansett Bay (EA Engineering, Science, and Technology, 1998a, figs. 3-12 to 3-20). Flow patterns appear to be similar for the sand, till, and bedrock units. Vertical hydraulic gradients generally are downward, but near well MW07-21S the gradient is upward, except during periods of high tide when the gradient is zero or downward (EA Engineering, Science, and Technology, 1998a, table 3-3).

The source of VOCs in ground water at Calf Pasture Point is not well documented but is believed to be containers of chemicals disposed of in pits in the general area of well MW07-14D (fig. 3) (EA Engineering, Science, and Technology, 1998a, fig. 1-2). VOCs, principally chlorinated compounds, in ground water are found in fractured crystalline bedrock and surficial material across an area that extends southwestward to Allen Harbor, southward toward the entrance to Allen Harbor, and eastward about one-half to two-thirds of the distance between Allen Harbor and Narragansett Bay (EA Engineering, Science, and Technology, 1998a, figs. 4-17 to 4-19). In general, highest concentrations of VOCs in ground water are in wells completed below the silt layer at depths of 30 ft or more, except in the area of the till ridge where the silt layer is absent and VOCs are present at shallow depths of 25 ft or less. Several compounds have been detected in the VOC plume including vinyl chloride, 1,2-dichloroethene, tetrachloroethylene (PCE), TCE, and 1,1,2,2-tetrachloroethane.

The substrate in the tidal zone at Calf Pasture Point consists mainly of fine to medium sand. The slope of the land surface in the tidal zone is gentle at the south end in the entrance channel to Allen Harbor and on the northwest side of the study area. In these

areas, the tidal zone ranges from 20 to 70 ft. Along the western shore, slopes are steeper and the width of the tidal zone is generally less than 10 ft.

STUDY METHODS

Vapor-diffusion samplers were constructed as described in Vroblesky and others (1996). The samplers consist of a 40-mL, air-filled glass bottle wrapped in two polyethylene bags held in place with cable ties. Duplicate samples for quality control are constructed by placing two polyethylene-wrapped bottles in the outer bag. The sampler is attached to a survey flag for marking and retrieval. When the sampler is placed in water or saturated sediments containing VOCs, organic vapors diffuse through the two layers of polyethylene and equilibrate with air in the bottle. The time required for equilibration is 24 hours or less in a controlled setting (Vroblesky and others, 1996). Additional time may be required after placement of the samplers to allow concentrations of VOCs in ground water to re-equilibrate in disturbed materials; a period of 2 weeks is recommended (D.A. Vroblesky, U.S. Geological Survey, oral commun. 1997). After retrieving the sampler, the outer bag is removed to shed attached sediment, and a cap is immediately screwed onto the bottle over the inner bag. In this study, the samplers were placed at depths of 6 to 10 in. by manual insertion behind a shovel blade driven into the sediments or by placement in a hole formed by the pointed end of a pickax.

Samplers at the Allen Harbor Landfill were installed during March 16–20, 1998, at locations shown in figure 2 and retrieved during low tide on April 1–2, 1998. Most samplers (1 to 79) were installed during low tide at intervals of about 25 ft along a 1,700-ft length of the shoreline. Samplers also were placed at 20 selected high-tide locations (H1 to H20) (for comparison to results from the low-tide locations), at 12 locations where ground-water was discharging in seeps (S1 to S12), and at four locations on mud flats south of the landfill area (M1 to M4). Duplicate samplers were placed at six low-tide locations (locations 20, 30, 40, 50, 60, and 70).

Samplers at Calf Pasture Point were installed during April 7-9, 1998, at locations shown in figure 3 and retrieved during April 28-29, 1998. Most samplers were placed during low tide (samplers 1 to 30) at intervals of 50 ft along about 1,300 ft of shoreline. The spacing was greater on the southeast side of the study area. Samplers were placed at the high tide level at seven locations (H1-H7) for comparison to results from low-tide locations. Additionally, 24 samplers (W1 to W24) were placed in 2 wetland areas inland from the entrance channel to Allen Harbor and in 4 seepage areas (S1 to S4) near the shore (fig. 3). Duplicate samplers were placed at three low-tide locations (locations 10, 20, and 30), two wetland locations (W5 and W16), and one high-tide location (H1).

Vapor samplers were analyzed onsite for VOCs using the USEPA Region I standard air screening method (U.S. Environmental Protection Agency, 1998). Vapor samples were analyzed using Photovac gas chromatograph equipped with a 4-foot by 1/8-inch SE-30 column and photoionization detector. Samples were analyzed within 24 hours of sample collection. Target compounds for analysis were benzene, TCE, toluene, PCE, chlorobenzene, ethylbenzene, meta/para-xylene, and ortho-xylene. The reporting limits for target compounds from the two areas are given in table 1 (in back of report).

Locations of samples at both sites were determined using a global positioning system (GPS). Operation of the GPS was checked by comparing surveyed locations with the locations of several monitoring wells determined by GPS.

VOLATILE ORGANIC COMPOUNDS DETECTED IN VAPOR-DIFFUSION SAMPLERS

Volatile organic compounds were detected in numerous vapor samplers placed at the Allen Harbor Landfill and in a few samplers placed at the Calf Pasture Point site. The concentrations in air, reported in parts per billion by volume, are typically several times higher than concentrations in water reported in micrograms per liter (D.A. Vroblesky, oral commun., 1998). The exchange of water between surface water and ground water during tidal cycling could affect the apparent concentrations of VOCs detected in vapor samplers, but the effects of tides were not investigated in this study. Results of vapor analyses for samplers that contained detectable concentrations of VOCs are reported in tables 2 and 3 (in back of report).

Allen Harbor Landfill

VOCs were detected in 41 of 115 vapor-diffusion samplers placed near the Allan Harbor Landfill (table 2, fig. 2). TCE was the most common VOC detected in the samplers. Other VOCs detected included benzene, toluene, and PCE. Vapor concentrations were less than 200 ppb at all locations except 6, 33, 34 and 35. A benzene concentration of 940 ppb was observed in sampler 6. Elevated concentrations of TCE were observed in sampler 33 (340,000 ppb), sampler 34 (250 ppb), and sampler 35 (19,000 ppb). An elevated PCE concentration of 1,700 ppb was also detected in sampler 33. VOCs were detected at several high tide locations and at several seeps. The concentrations detected at seeps were generally near reporting limits (table 1) except at seep sampler S10, where 200 ppb of TCE was detected.

Calf Pasture Point

VOCs were detected in 7 of 30 vapor samplers placed along the shore at Calf Pasture point (table 3, fig. 3). Concentrations ranged from a trace amount in sampler 13 to 1,900 ppb in sampler 22. The detections appear to be clustered near an inlet of Allen Harbor on the west side of the study area and near a former dock on the south side of the study area. TCE was detected in only one (W14) of 24 samplers placed in the wetland areas.

REFERENCES

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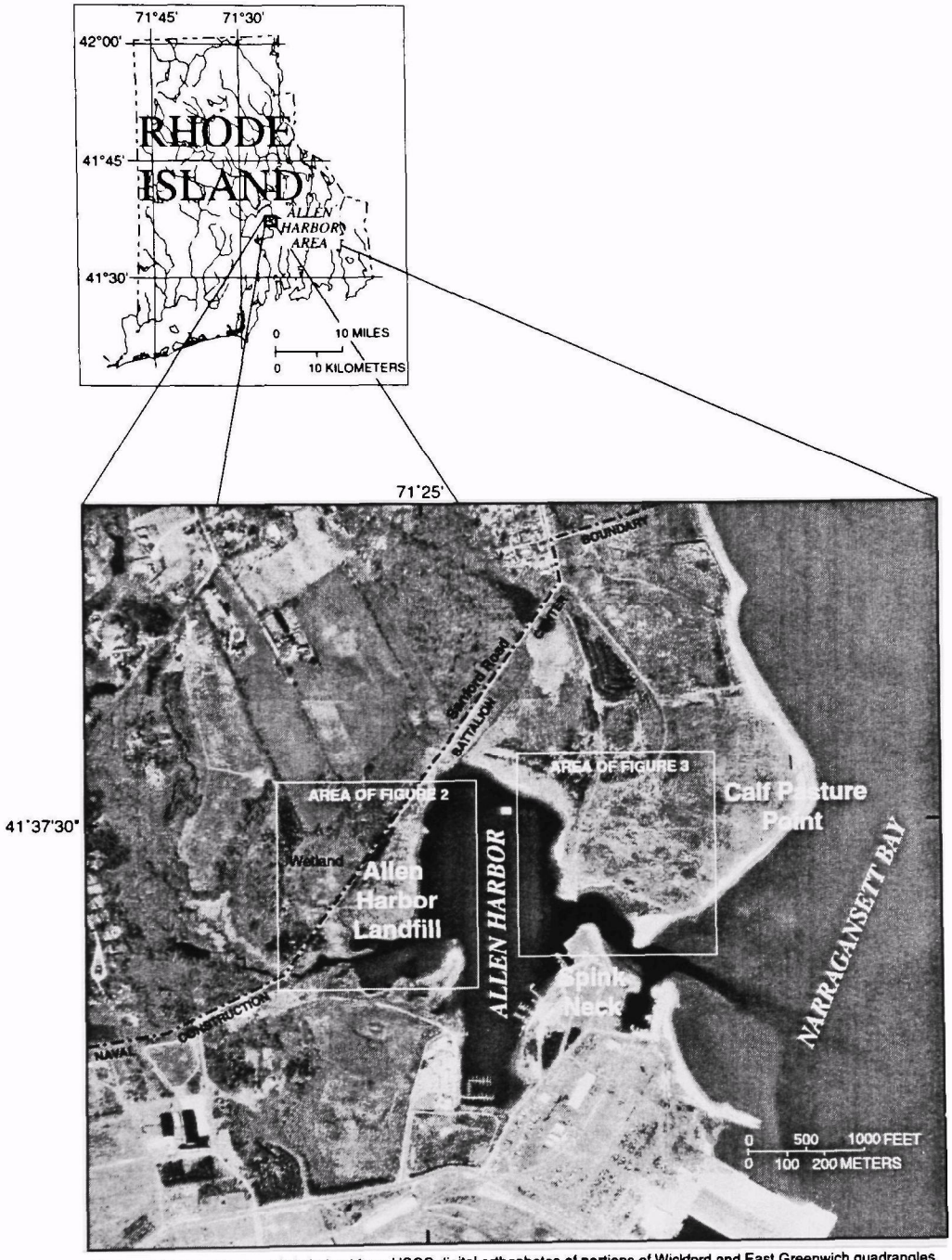
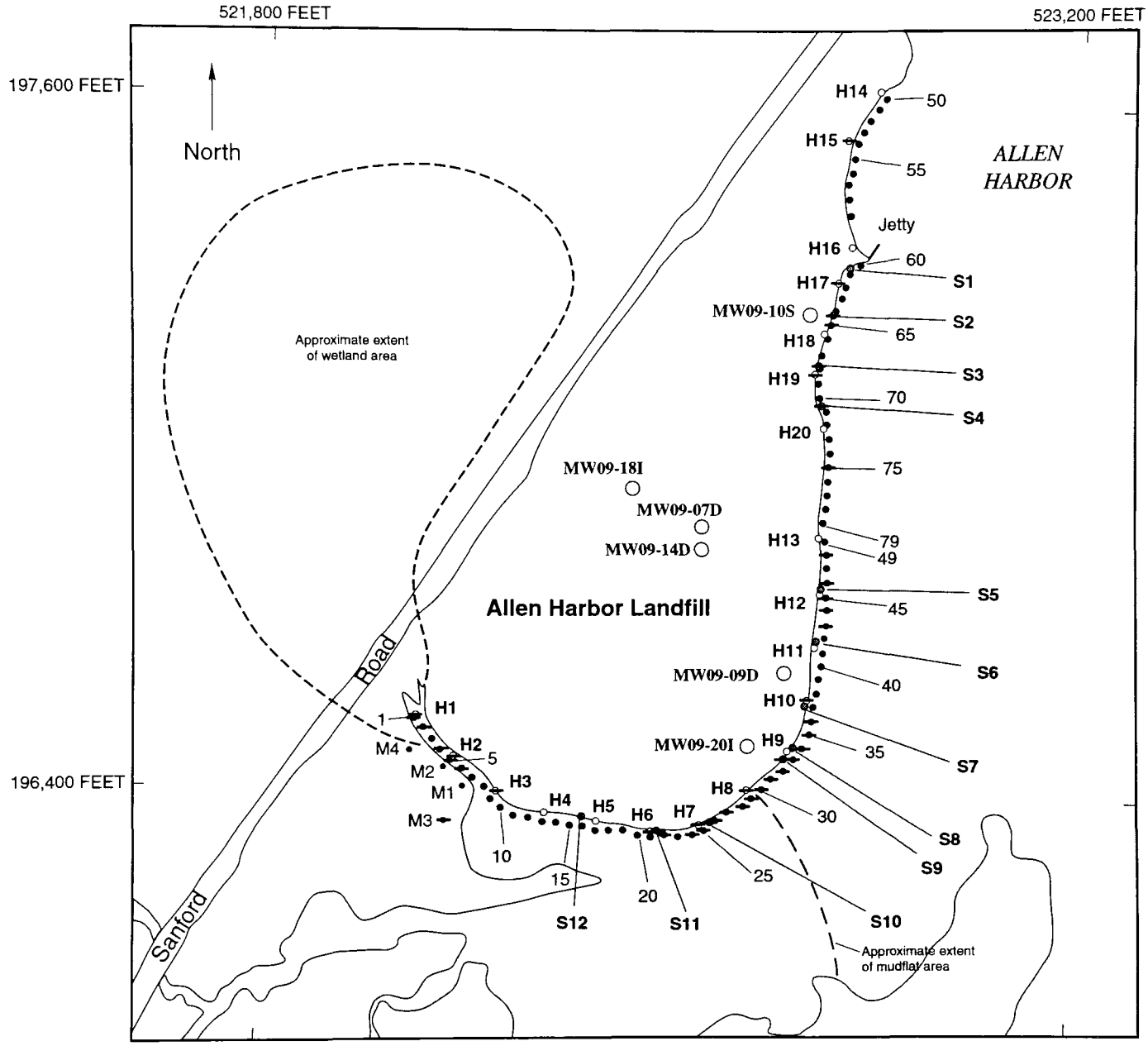


Photographic base (composite) derived from USGS digital orthophotos of portions of Wickford and East Greenwich quadrangles, 1:5,000, UTM, North American Datum 1983. The photos have been digitally retouched to reduce sunlight reflections off the water.

Figure 1. Location of Allen Harbor Landfill and Calf Pasture Point study areas, Davisville, Rhode Island.



Base traced from U.S. Geological Survey digital orthophoto 1:12000, GPS from Trimble Asset Surveyor, 1927 North American Datum, Rhode Island coordinate system used

SCALE 1:600

0 100 200 300 400 500 FEET

0 20 40 60 80 100 120 METERS

EXPLANATION

55 • LOW-TIDE SAMPLER AND NUMBER

H6 ○ HIGH-TIDE SAMPLER AND NUMBER

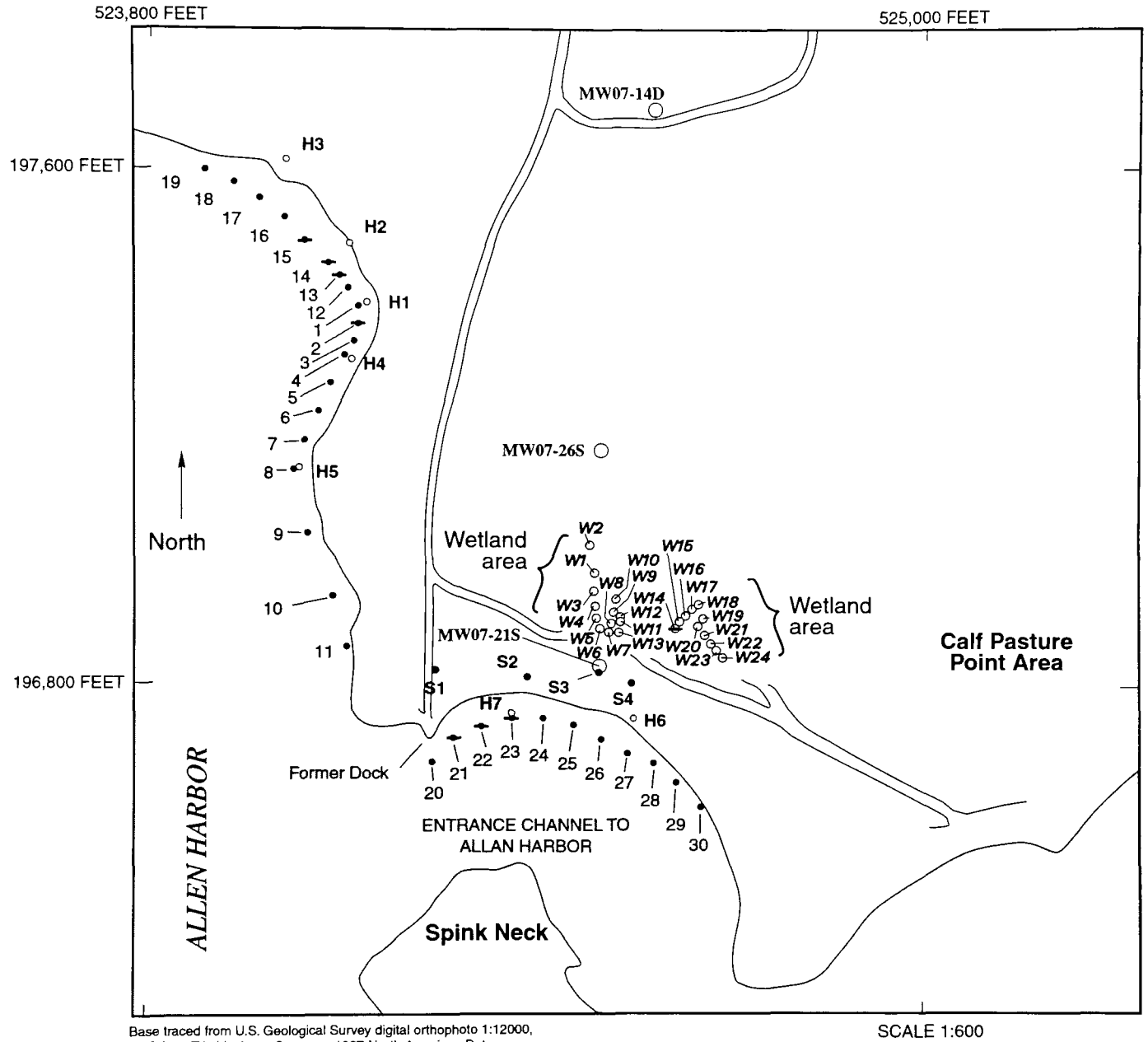
M4 • MUDFLAT SAMPLER AND NUMBER

S3 ◉ SEEP SAMPLER AND NUMBER

MW09-20I ○ SELECTED MONTORING WELL AND NUMBER

— INDICATES VOLATILE ORGANIC COMPOUNDS WERE DETECTED IN VAPOR SAMPLER

Figure 2. Locations of vapor-diffusion samplers, samplers that detected organic vapors, and selected monitoring wells, Allen Harbor Landfill, Davisville, Rhode Island.



EXPLANATION

55 • LOW-TIDE SAMPLER AND NUMBER

H6 ○ HIGH-TIDE SAMPLER AND NUMBER

S3 • SEEP SAMPLER AND NUMBER

W2 ○ WETLAND SAMPLER AND NUMBER

MW07-21S ○ SELECTED MONITORING WELL AND NUMBER

— INDICATES VOLATILE ORGANIC COMPOUNDS WERE DETECTED IN VAPOR SAMPLER

Figure 3. Locations of vapor-diffusion samplers, samplers that detected organic vapors and selected monitoring wells, Calf Pasture Point study areas, Davisville, Rhode Island.

Table 1. Reporting limits for target volatile organic compounds at Allen Harbor Landfill and Calf Pasture Point, Davisville, Rhode Island, March–April 1998

Compound	Reporting limit (parts per billion by volume)	
	Allen Harbor Landfill	Calf Pasture Point
Benzene	10	5
Trichloroethylene (TCE)	10	6
Toluene	35	30
Tetrachloroethylene (PCE)	20	15
Chlorobenzene	70	60
Ethylbenzene	90	80
meta/para-Xylene	90	70
ortho-Xylene	100	95

Table 3. Concentrations of volatile organic compounds in vapor-diffusion samplers at Calf Pasture Point, Davisville, Rhode Island, April 1998

[Concentrations in parts per billion by volume in vapor; No., number; TCE, trichloroethylene; PCE, tetrachloroethylene; trace, compound identified on chromatograph but at a concentration below the reporting limit --, not detected]

Sample No.	TCE	PCE
2	13	--
13	trace	--
14	17	--
15	60	trace
21	220	--
22	1,900	--
23	30	--
W14	14	--

Table 2. Concentrations of volatile organic compounds in vapor-diffusion samplers at Allen Harbor Landfill, Davisville, Rhode Island, April 1998

[Concentrations in parts per billion by volume in vapor; D, duplicate; No., number; TCE, trichloroethylene; PCE, tetrachloroethylene; trace, compound identified on chromatograph but at a concentration below the reporting limit ;--, not detected]

Sample No.	Benzene	Toluene	TCE	PCE	Sample No.	Benzene	Toluene	TCE	PCE
1	13	--	--	--	45	23	--	--	--
2	--	--	16	--	46	19	40	--	--
4	12	--	25	--	48	--	--	13	--
5	23	--	--	--	65	--	--	trace	--
6	940	--	--	--	75	--	--	13	--
22	--	--	12	--	H1	--	--	23	86
24	13	--	--	--	H2	--	--	12	--
25	--	--	14	--	H3	--	--	28	--
26	--	--	39	--	H6	--	--	13	--
27	--	--	19	--	H7	--	--	52	--
28	--	--	42	--	H8	--	44	20	--
30	--	--	48	--	H10	--		11	trace
30 D	--	--	52	--	H15	210	140	40	
31	--	--	11	--	H17	--	--	15	82
32	--	--	79	--	H19	--	--	trace	
33	--	--	340,000	1,700	S2	--	--	--	trace
34	--	--	250	--	S3	--	--	trace	--
35	--	--	19,000	--	S4	--	--	15	trace
36	--	--	58	--	S9	--	--	trace	--
43	171	141	46	--	S10	--	--	200	--
44	--	trace	36	--	M3	--	--	trace	--