ETHYLENE DIBROMIDE (EDB) TRENDS IN THE UPPER FLORIDAN AQUIFER, SEMINOLE COUNTY, GEORGIA, OCTOBER 1981 TO NOVEMBER 1987

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CONVERSION FACTORS

For those readers who may prefer to use SI (metric) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound units	By	To obtain Metric units
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	0.09294	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
	0.003785	cubic meter (m^3)
	Mass	
pound (lb)	0.4536	kilogram (kg)
ounce (oz)	28.35	gram (g)
	28,350	milligram (mg)
	28,350,000	microgram (g)
	Rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Transmissivity	
square foot per day (ft^2/d)	0.09290	square meter per day (m^2/d)

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 both the United States and Canada, formerly called "Sea Level Datum of 1929."

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ABSTRACT

The persistence of ethylene dibromide (EDB) in the Upper Floridan aquifer in Seminole County, Georgia was investigated in November 1987 by the U.S. Geological Survey in cooperation with the U.S Environmental Protection Agency. Previous studies conducted in 1983, 1984, and 1985 indicated that EDB, which was used as a soil fumigant, had contaminated ground water in a 4-square-mile area in central Seminole County.

Analyses of water from five of nine wells sampled in November 1987 indicated that EDB still was present in the Upper Floridan aquifer in central Seminole County four years after it was last applied. EDB was detected in samples from one domestic well and four irrigation wells. Concentrations ranged from less than 0.01 micrograms per liter to 3.3 micrograms per liter.

Ground-water contamination remains limited to the 4-square-mile area in the vicinity of Buck Hole, a sinkhole in a swampy depression in the central part of the county. In three of the five wells in which EDB was detected, concentrations have not changed substantially since August 1983. However, in one irrigation well near Buck Hole the concentration decreased from 110 to 0.7 micrograms per liter since October 1981. In another irrigation well near Buck Hole, the concentration decreased from 26 to about 2.5 micrograms per liter during that period.

Ground-water-level data indicate that from the area of relatively high EDB concentration near Buck Hole, the hydraulic gradient in the Upper Floridan is about 2.8 feet per mile to the east. However, the easterly movement of EDB from the area of highest concentrations is not apparent. The movement of water induced by pumping the two irrigation wells near Buck Hole produced short-term fluctuations in EDB concentrations in those wells.

INTRODUCTION

Ethylene dibromide (EDB) initially was detected in ground water from the Upper Floridan aquifer in Seminole County, Ga., in September 1981 and was confirmed in October 1981 (McConnell and others, 1984). Subsequent sampling for EDB in ground water from the Upper Floridan aquifer in Seminole County was conducted by the U.S. Geological Survey in cooperation with the U.S. Environmental Protection Agency during 1982-85. In an earlier report, McConnell and others (1984) reported detectable concentrations of EDB in the aquifer only in 4-mi^2 area in the central part of the county. The area of contamination was in the vicinity of Buck Hole, a sinkhole in a swampy depression about 7 mi south of Donalsonville (fig. 1).

Seminole County is a highly productive agricultural area of southwest Georgia. Prior to suspension of its use in September 1983, EDB was applied semi-annually or annually as a soil fumigant to control nematodes on vegetable, peanut, and soybean crops in the County. It was applied several inches below the soil surface at a rate of 1 to 2 gal (15 to 30 lbs of active ingredients) per acre. Generally, ground-water contamination in the 4-mi^2 area was attributed to soil fumigation with EDB, but high concentrations of the pesticide in a localized area adjacent to Buck Hole may have resulted from a spill (McConnell and others, 1984, p. 20). Ground-water samples collected in 1985 indicated that although EDB concentrations were declining, the pesticide was still present in the aquifer 2 years after it was last applied as a soil fumigant (McConnell, 1987).

EDB is a moderately water-soluble compound that is mobile in soils, and which may be persistent for years in ground water. The half-life of EDB at ambient ground-water temperature and pH could be greater than 6 years under some conditions (Cohen and others, 1984). However, studies of EDB in ground waters in Florida has shown that the pesticide has a chemical half-life of 1.5 to 2 years (Weintraub and others, 1986). In soils fumigated with EDB, residual amounts in concentrations of 1 µg/L or less may be retained in the soil and slowly leached to the ground water over many years (Steinberg and others, 1987).

Purpose and Scope

The purpose of this study was to evaluate the persistence and changes in the concentration of EDB in the contaminated area of the Upper Floridan aquifer in central Seminole County. Ground-water samples were collected in November 1987 to determine changes in the concentration of EDB since 1985. Analysis of these samples and analyses of samples from previous years were used to determine trends in EDB concentrations since 1981, when EDB initally was detected. This report presents the data collected in November 1987 and describes trends in EDB concentrations since sampling began.

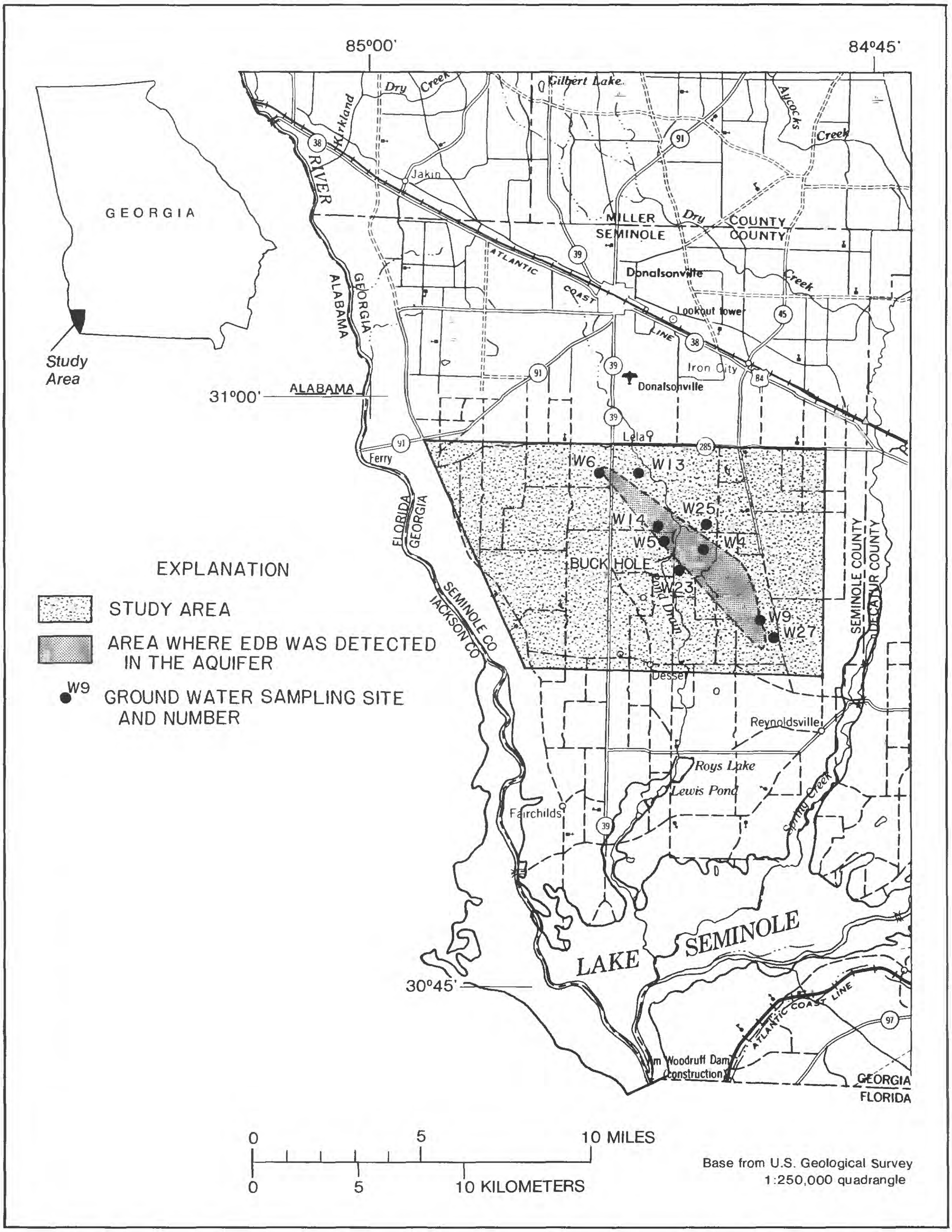

Figure 1.--Location of sampling sites and approximate area where EDB was detected in ground water.

Acknowledgments

The author wishes to acknowledge Robert Spitalera, Univeristy of Georgia, Seminole County Extension Office, Donalsonville, Ga., for his help in contacting landowners for permission to sample their wells. The author's appreciation also is extended to the land owners in Seminole County who allowed the installation of monitor wells on their property and permitted the use of their wells for the collection of ground-water samples.

DATA COLLECTION

In this study, samples for the determination of EDB were collected on November 9-10, 1987, during the nonirrigation season, from nine wells (five irrigation and four domestic wells) that tapped the Upper Floridan aquifer (fig. 1). The wells, which ranged in depth from 150 to 200 ft, were cased to the top of the limestone, and were open-hole below the top of the limestone.

Prior to sampling, the wells were pumped to insure that samples were representative of the aquifer. The irrigation wells were pumped at a rate of several hundred gallons per minute for at least 5 min prior to sample collection. Some irrigation wells that were sampled previously were not resampled because the pumps could not be operated or because the wells were no longer suitable for sampling. Domestic wells were pumped at a rate of 3 to 4 gal/min for about 30 min prior to sampling. Samples were collected from spigots near the well heads at the irrigations wells, and from water spigots between the wells and pressure-storage tanks at domestic wells. Samples of ground water were collected after 5, 15, and 25 min of pumping at irrigation wells W4 and well W5, to observe the effect of pumping on EDB concentration. Specific conductance and pH were monitored at all wells during pumping, and were used to indicate stable water chemistry prior to sample collection.

The water samples were collected in 40-mL glass, screw-cap vials that contained Teflon[1]-lined, silicon rubber septums. Water was delivered to the vials through a small-diameter silicon tube that was attached to the spigots. Care was taken to ensure that the water samples were free of air bubbles. The samples were stored on ice until analyzed in the laboratory. Analyses were provided by a U.S. Geological Survey contract laboratory. The laboratory reporting limit for EDB determinations was 0.010 micrograms per liter (µg/L). Analytical methods for determination of EDB in water consisted of U.S. Environmental Protection Agency methods promulgated in the Code of Federal Regulations, Chapter 40, Part 136 (Method 624) and the methods published in SW-846, 2nd edition, 1984 (Method 8240). The methodologies used for sample collection and analysis in this study were similar to the methods used in previous studies by the U.S. Geological Survey.

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[1]The use of brand and trade names in this report is for identification purposes only and does not constitute endorsment by the U.S. Geological Survey.

Water-level data were collected from 40 wells in the study area in November 1987, and the data were used to construct a potentiometric surface map of the Upper Floridan aquifer. The potentiometric surface represents the altitude at which the water level would have stood in tightly cased wells that penetrate the aquifer. The water-level altitudes used to construct the potentiometric surface map were determined by measuring the depth from land surface to the water in each well, and subtracting that depth from the land-surface altitude. Flow lines drawn perpendicular to the potentiometric contours represent idealized flow paths of water as it moves through the aquifer.

GEOHYDROLOGY

The Upper Floridan aquifer is the major source of water used for irrigation, domestic, municipal, and industrial supplies in Seminole County. It is part of the Floridan aquifer system that underlies the Coastal Plain of Georgia, adjacent parts of South Carolina and Alabama, and all of Florida. In Seminole County, the Upper Floridan aquifer is made up mainly of limestone. The limestone ranges in thickness from about 125 ft in the northern part of the county to about 300 ft in the southern part (McConnell and others, 1984, p. 4). In most of the area, the limestone is highly fractured, and carbonate dissolution has created a labyrinth of subterranean channels. As a result, transmissivities range from 75,000 to 300,000 ft^2/d (Hayes and other, 1983, p. 45). Natural rates of flow have not been determined, but according to Hayes (1983), flow rates probably are highly variable because the aquifer acts as both a free-flow (channel flow) and a diffuse-flow system.

The Upper Floridan aquifer in Seminole County is overlain by unconsolidated material that ranges in thickness from about 50 to 100 ft (McConnell and others, 1984, p. 7). The overburden generally consists of sand, sandy clay, and clay, which contains little organic matter. Permeable sand lenses are common in the upper half of the overburden, and generally are underlain by less permeable, clayey material that forms a semiconfining layer over the Upper Floridan aquifer.

In the study area, analyses of core samples from the overburden indicate the presence of clay layers near well W4 (McConnell and others, 1984, p. 18). The clayey material underlying the sand causes infiltrating ground water to form a perched water table above the Upper Floridan aquifer during late winter and spring. Locally, sinkholes breach the overburden, as occurs at Buck Hole near wells W4 and W5. The sinkholes provide a direct hydraulic connection between the land surface and the aquifer. During summer and fall, local pumping temporarily lowers the water level in the aquifer. Lowering the water level may accelerate the downward movement of water and contaminants from the overburden into the aquifer. Thus, the presence or absence of sand lenses, the depth to the perched water table, and the occurrence of sinkholes could have a substantial effect on the movement of contaminants through the overburden and into the Upper Floridan aquifer.

The configuration of the potentiometric surface of the aquifer and the direction of ground-water flow in November 1987 (fig. 2) are similar to those determined in December 1984 and June 1985 (McConnell, 1987). Small differences in the potentiometric surface for the three measurement periods indicate that the ground-water-flow system in the study area generally is stable. The potentiometric surface in figure 2 indicates the hydraulic gradient is about 2.8 ft/mi from Buck Hole to the east.

ETHYLENE DIBROMIDE TRENDS

Analyses of ground-water samples collected in November 1987 show that EDB was present in the Upper Floridan aquifer in the vicinity of Buck Hole 4 years after it was last applied as a soil fumigant. EDB was detected in samples from one domestic well and from four irrigation wells. Concentrations ranged from 0.02 μg/L in wells W9 and W14 to 3.3 μg/L in well W5. Concentrations were less than the detection level of 0.01 μg/L in wells W13, W23, W25, and W27 (table 1).

Table 1.--Concentration of ethylene dibromide in ground-water samples

[a, domestic well; number in parentheses, time that elapsed, in minutes, from start of pumping to collection of sample; ND, EDB less than detection level of 0.01 micrograms per liter; --, no samples]

Well no.	Oct. 1981 (μg/L)	May 1982 (μg/L)	June 1982 (μg/L)	Aug. 1983 (μg/L)	Sept. 1983 (μg/L)	Oct. 1984 (μg/L)	June 1985 (μg/L)	Nov. 1987 (μg/L)
W4	110	90	11	7.1(5)	3.9	1.9	1.5	0.82(5)
W4	--	--	--	5.4(15)	--	--	--	.67(15)
W4	--	--	--	4.5(25)	--	--	--	.72(25)
W5	27	36	27	12	13	1.2(1)	8.8	.65(5)
W5	--	--	--	--	--	1.8(5)	--	2.5(15)
W5	--	--	--	--	--	3.0(10)	--	3.3(25)
W6	--	--	--	0.06	--	0.10	--	.07
W9	--	--	--	.03	--	--	--	.02
W13(a)	--	--	--	ND	--	ND	--	ND
W14(a)	--	--	--	.03	--	.02	--	.02
W23(a)	--	--	--	--	ND	--	--	ND
W25(a)	--	--	--	--	--	ND	--	ND
W27	--	--	--	--	--	ND	--	ND

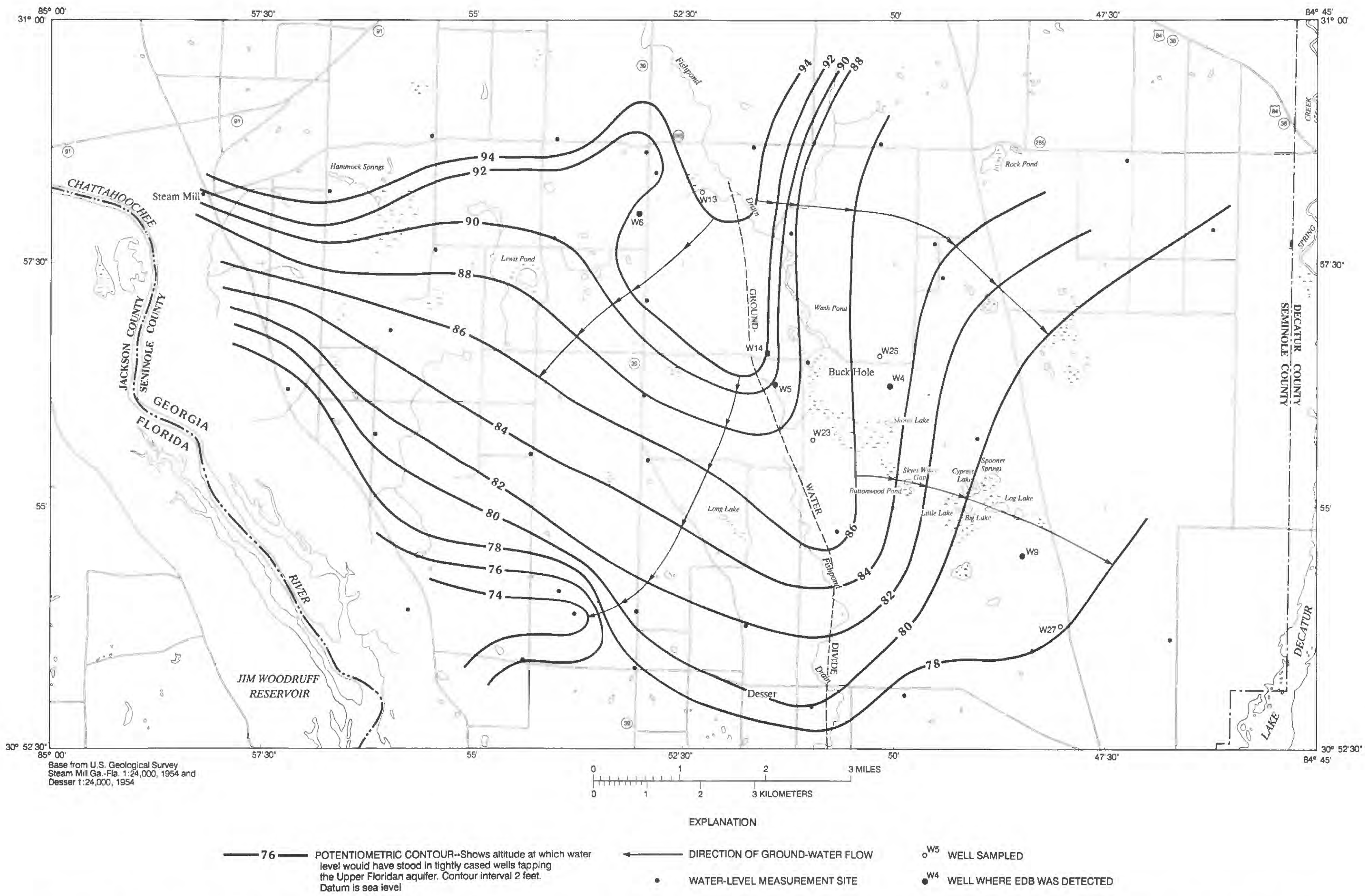

Figure 2.--Potentiometric surface, direction of ground-water flow, and location of sampling sites in the Upper Floridan aquifer, November 1987.

Contamination of the aquifer by EDB was limited to a 4-mi^2 area in the vicinity of Buck Hole. The highest concentrations of EDB were found in wells W4 and W5 (fig. 1). With the exception of wells W4 and W5, concentrations did not change substantially from August 1983 to November 1987 (table 1). Although the potential exists for EDB to move from the area of highest concentrations near Buck Hole, to the east along inferred ground-water-flow paths, down-gradient movement from wells W4 and W5 was not evident from the concentration data.

Concentration Trends in Wells W4 and W5

Concentrations of EDB have decreased substantially in wells W4 and W5 since EDB was first detected in the two wells in October 1981. The concentrations in well W4 decreased more than 100-fold between October 1981 and November 1987 (fig. 3). Concentrations in three samples collected from well W4 in November 1987 ranged from 0.72 to 0.82 µg/L (table 1). In well W5, concentrations decreased about 10-fold since October 1981 (fig. 4). In November 1987, the concentration of EDB in three samples from well 5 ranged from 0.65 to 3.3 µg/L (table 1). These concentrations were less than the concentrations found in June 1985, but slightly higher than the concentrations found in October 1984 (fig. 4). Also, in November 1987 concentrations in well W5 were about four times higher than those in well W4. The data for well W5 suggest that the concentration of EDB may not be declining as rapidly in this part of the Upper Floridan aquifer as in the part tapped by well W4.

The concentration of EDB in wells W4 and W5 was affected by short-term pumping. Samples collected from well W4 in August 1983 and November 1987 at 5-, 15-, and 25-min of pumping showed a decrease in the concentration of EDB with pumping time (fig. 3). Samples collected from well W5 in October 1984 after 1-, 5-, and 10-min of pumping and in November 1987 after 5-, 15-, and 25-min of pumping showed an increase in the concentration of EDB with pumping time (fig. 4). Specific conductance of the ground water did not change during pumping, which indicated that the concentrations of the major dissolved constituents were stable even though EDB concentrations were not.

The increased concentrations of EDB at well W5 during short-term pumping and the generally higher concentrations observed at well W5 compared to well W4 since June 1982, suggest that well W5 either may be tapping a zone of higher concentrations of EDB in the aquifer or may be located nearer to a source of EDB. Pumping well W5 also may have caused ground water containing EDB to move laterally to the well from areas of higher concentration in the aquifer, or caused perched water containing EDB to infiltrate through the overburden to the aquifer. Because the altitude of the perched water table in the overburden usually is higher than the potentiometric surface of the Upper Floridan aquifer (McConnell, 1987), and that EDB was detected in core samples collected at several depths in the overburden near well W4 in August 1983 (McConnell and others, 1983) suggest that EDB is being leached from the overburden and transported to the aquifer. Furthermore, irrigation pumping could increase the head gradient between the overburden and the Upper Floridan aquifer and thereby accelerate the infiltration of EDB-contaminated water into the aquifer.

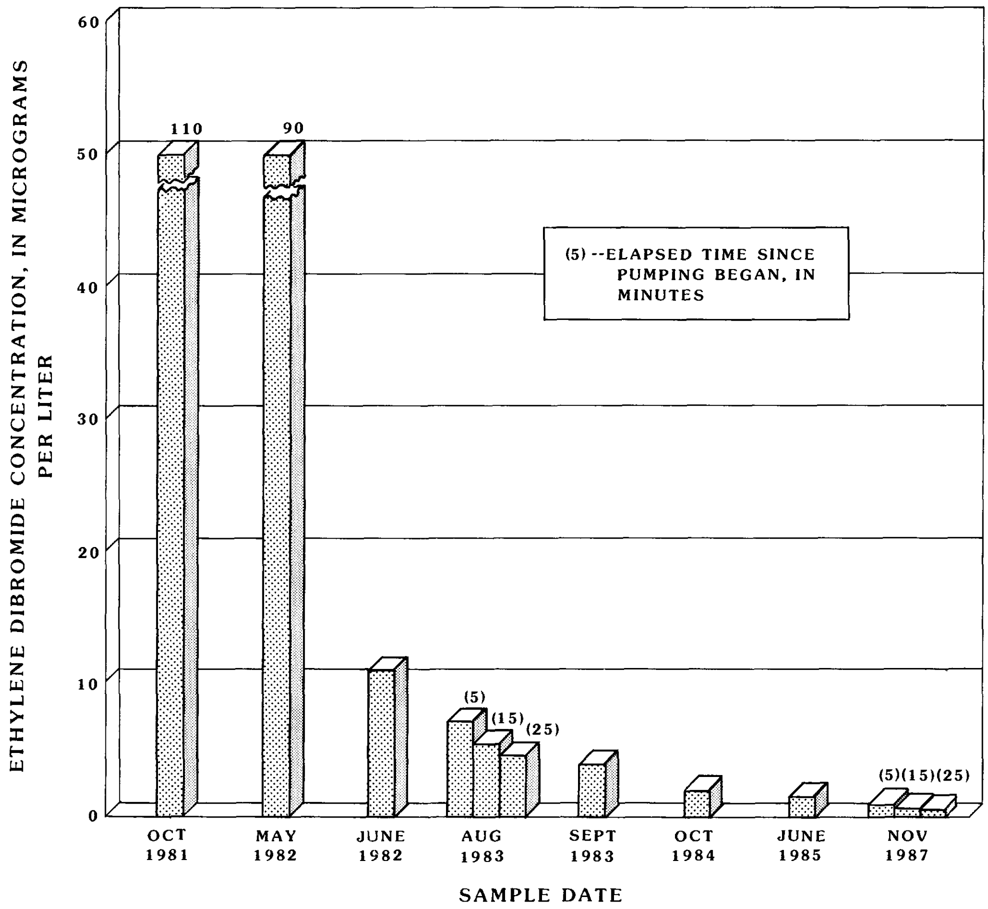

Figure 3.--Trend in concentration of EDB in well W4.

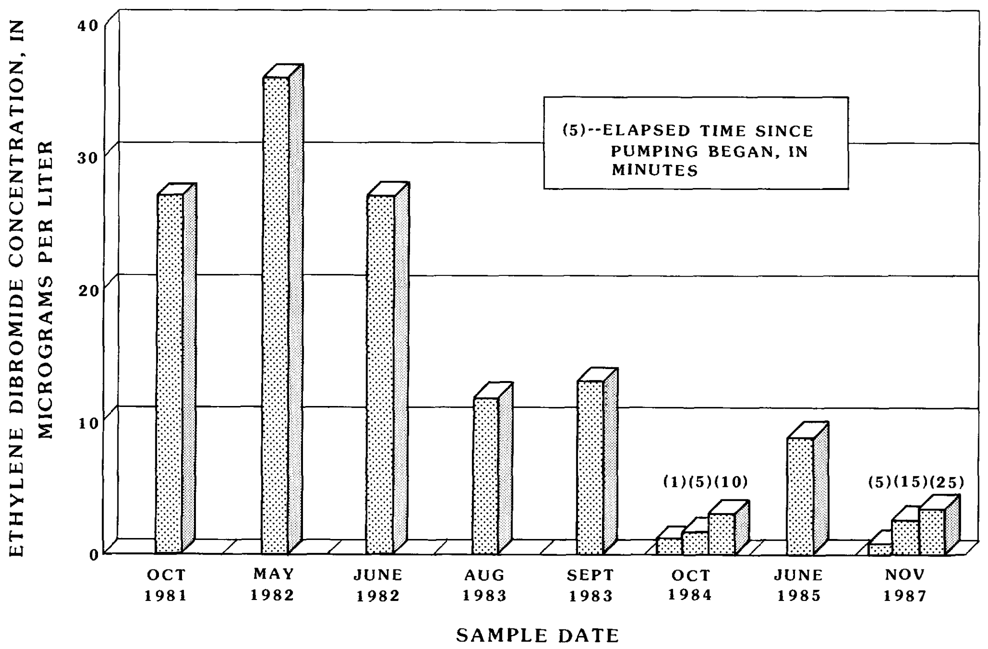

Figure 4.--Trend in concentration of EDB in well W5.

SUMMARY AND CONCLUSIONS

In November 1987, ethylene dibromide (EDB) was detected in water samples collected from five of nine wells that tap the Upper Floridan aquifer in central Seminole County 4 years after the pesticide was last applied as a soil fumigant. The contamination was limited to a 4-mi^2 area near Buck Hole, a sinkhole in a swampy depression 7 mi south of Donalsonville, Ga. The highest concentration of EDB was detected in irrigation wells W4 and W5, which are near Buck Hole. With the exception of wells W4 and W5, the concentration of EDB in the Upper Floridan aquifer showed little or no change since August 1983. The concentration of EDB in wells W4 and W5 decreased greatly since EDB was first detected in those wells in October 1981. Concentrations in wells W4 and W5, when sampled in November 1987, ranged from 0.72 to 0.82 μg/L and 0.65 to 3.3 μg/L, respectively.

Ground-water-level data indicate that the hydraulic gradient in the Upper Floridan is about 2.8 ft/mi from Buck Hole to the east. However, the downgradient movement of EDB from the area of relatively high concentrations near Buck Hole in the direction of inferred flow was not apparent. Although concentration gradients were not detected along flow paths, the movement of water induced by pumping wells W4 and W5 produced short-term, decreasing and increasing trends in EDB concentrations in wells W4 and W5, respectively. At well W5, ground water containing EDB may have been transported laterally from an area of higher concentration within the aquifer, or perched water containing EDB may have infiltrated through the overburden to the aquifer. The observed trend at well W5 suggests that well W5 may be nearer to a source of EDB than well W4.

The presence of EDB in the highly transmissive Upper Floridan aquifer more than 4 years after use of the pesticide was suspended cannot be fully explained. However, the persistence of EDB in the aquifer may be due to the stable nature of EDB under ambient conditions in the aquifer, or may be due to leaching of residual EDB from the overburden to the aquifer in some parts of the study area.

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