QUALITY OF WATER AND BED MATERIAL IN STREAMS OF LOGAN TOWNSHIP, GLOUCESTER COUNTY, NEW JERSEY, 1984

By Joseph J. Hochreiter, Jr. and Jane Kozinski

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CONVERSION OF INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

The following factors may be used to convert the inch-pound units published herein to the International System of Metric Units (SI).

Multiply Inch-Pound Unit	By	To Obtain SI Unit
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	30.48	centimeter (cm)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	Specific Conductance	
micromho per centimeter (umho/cm) at 25° Celsius	1.000	microsiemens per centimeter (uS/cm) at 25° Celsius
ton (short, 2,000 lb)	0.9072	megagrams (Mg)

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ABSTRACT

The surface water and surficial-bed material at seven stations on three streams in Logan Township, Gloucester County, New Jersey, were sampled in the fall of 1984. Samples of water were analyzed for volatile organic compounds, trace metals, and organochlorine and organophosphorous compounds. Surficial-bed material was analyzed for extractable trace metals and organochlorine compounds.

Water samples from two closely spaced sampling locations along Raccoon Creek contained elevated concentrations of methylene chloride (455 and 1800 ug/L, respectively), a volatile organic solvent.

Bed-material samples taken from Little Timber and Birch Creeks contained elevated levels of trace metals and organochlorine compounds, including polychlorinated biphenyls (PCB's). Contaminant concentrations in bed-material samples taken from Raccoon Creek were much lower than those found previously by the U.S. Geological Survey in 1980. Only a trace of PCB's was detected in any bed-material sample taken from Raccoon Creek.

Gas chromatographic flame-ionization detector scans, performed on solvent-extracts of all water and sediment samples, were useful in characterizing the presence or absence of organic contaminants in those samples. Changes in the character of organic contamination along the reaches of two streams were apparent when the fingerprints of chromatograms representing upstream sites were compared to those representing downstream sites.

INTRODUCTION

In Logan Township, as in other communities along the Delaware River estuary, several industrial facilities are situated along tributaries of the estuary. Treated effluent resulting from processes at these facilities are sometimes discharged to local receiving streams. For example, Rollins Environmental Services, Inc. has a permit to discharge wastewater into Raccoon Creek, while the EPA has used Little Timber Creek to discharge treated wastewater from the Bridgeport Rental and Oil Services (BROS) Superfund site.

The geohydrologic system that underlies most of Logan Township includes an outcrop area of a major sand and gravel aquifer system. Hydrologic interactions exist between this

Coastal Plain aquifer system and the surface-water bodies overlying it (George Farlekas, U.S. Geological Survey, oral commun., 1985). It is necessary, therefore, to assess the quality of water and bed material of streams which flow through the aquifer outcrop.

The water quality and aquatic life of any stream is dependent not only on the chemical character of the water, but on the chemical composition of its channel deposits and any interactions between these deposits and the stream. Some contaminants, including certain organic substances, remain undetected in water because of their low concentrations, erratic distribution patterns, and generally low aqueous solubilities. Many constituents are sorbed by suspended-sediment particles which are later deposited on the streambed (Feltz, 1980). Subsequently, these contaminants may accumulate in the bed material at concentrations many times greater than those in stream water. There is a potential for long-term accumulation of contaminants sorbed onto sediments and deposited in streambeds.

Purpose and Scope

The U.S. Geological Survey, in cooperation with the Township of Logan, Gloucester County, New Jersey, is investigating the chemical quality of streams and ground water in Logan Township as part of a detailed investigation of the Township's water resources. The study began in June 1983 and is scheduled to continue through September 1986.

This report discusses the occurrence and distribution of selected chemical-quality constituents, including U.S. Environmental Protection Agency (EPA) "priority pollutants" (Keith and Telliard, 1979), in surface water and associated surficial bed materials of streams near hazardous-waste disposal facilities in Logan Township. Seven surface-water and surficial-bed-material sampling sites on three streams were sampled from October 31, 1984 through November 8, 1984 (see fig. 1). The study provides baseline data on the quality of water and surficial-bed material at one location on Birch Creek, and adds to the data base available for Raccoon and Little Timber Creeks.

This report also presents results of a study to assess the usefulness of gas chromatographic-flame-ionization detector scans in a surface-water-quality study. Gas chromatograms of water and bed-material extracts were used to determine whether streams in the Township were grossly contaminated. The chromatograms were also used to graphically represent variations in contaminant concentrations along the Little Timber and Raccoon Creeks.

Previous Investigations

Several water-quality studies of limited scope were made on Little Timber and Raccoon Creeks. Except for some limited sampling done by Monsanto Chemical Company, no evidence exists of any other water-quality data on Birch Creek (Ed Jamro, Monsanto Industrial Chemicals Co., and Esther Slusarski, Logan Township Environmental Commission, oral commun., 1985).

During the period July 1982 through October 1982, Camp, Dresser and McKee, Inc. studied the quality of water (volatile organic compounds, trace metals, and common ions) at four locations on Little Timber Creek immediately adjacent to the Bridgeport Rental and Oil Services facility (fig. 1). In July 1983, NUS Corporation conducted a more detailed study of organic substances in water and bed material at the same four locations on Little Timber Creek. NUS analyzed for total organic halides, polychlorinated biphenyls (PCB's), organochlorine insecticides, and volatile organic compounds. The results of both studies are summarized in an NUS Corporation (1984a) report.

In 1982, the only organic contaminant detected in the water of Little Timber Creek was 1,2-trans-dichloroethylene at a concentration of 15 ug/L. In 1983, NUS found organic contaminants in both the water and bed material. Contaminants in water included total organic halides (TOX), which ranged from 300 to 720 µg/L; total petroleum hydrocarbons, found to be 4400 µg/L at one location; and methylene chloride and PCB's, detected at several locations. Contaminants reported in bed material included PCB's, bis(2-ethylhexyl) phthalate, and methylene chloride (NUS Corporation, 1984a).

The marshes of Raccoon Creek were investigated in 1968-69 as part of a study on the effects of pollution at Tinicum Marsh (located across the Delaware River and upstream from Logan Township), conducted by the Academy of Natural Sciences of Philadelphia ([The] Conservation Foundation, 1970). Water samples from Raccoon Creek were analyzed for biological components, as well as inorganic chemical constituents. Raccoon Creek was selected as an example of an unpolluted wetlands environment in contrast to the relatively contaminated Tinicum Marsh wetlands.

Prior to the startup of its hazardous-waste treatment plant in the spring of 1970, Rollins Environmental Services, Inc. sampled water from Raccoon Creek at five locations between U.S. Route 130 and Interstate 295 at various tide conditions. The analysis list included field-measured characteristics, common ions, nutrients, and trace metals (Rollins Environmental Services, Inc. written commun., 1970). In the early 1970's, Rollins implemented a program of monthly water-quality sampling at the U.S. Route 130 and Interstate 295 bridges. Water samples are collected at both high and low tide. This sampling program continues today (1985) and includes all of the constituents studied in 1970 in addition to phenol, PCB's, and total organic carbon (Gerald Jordan, Rollins Environmental Services, Inc., oral commun., 1985). An analysis of the first few years of data indicated that the water quality of Raccoon Creek both upstream and downstream from the Rollins Environmental Services plant is "poor" (Rollins Environmental Assessment Action Group, 1978a).

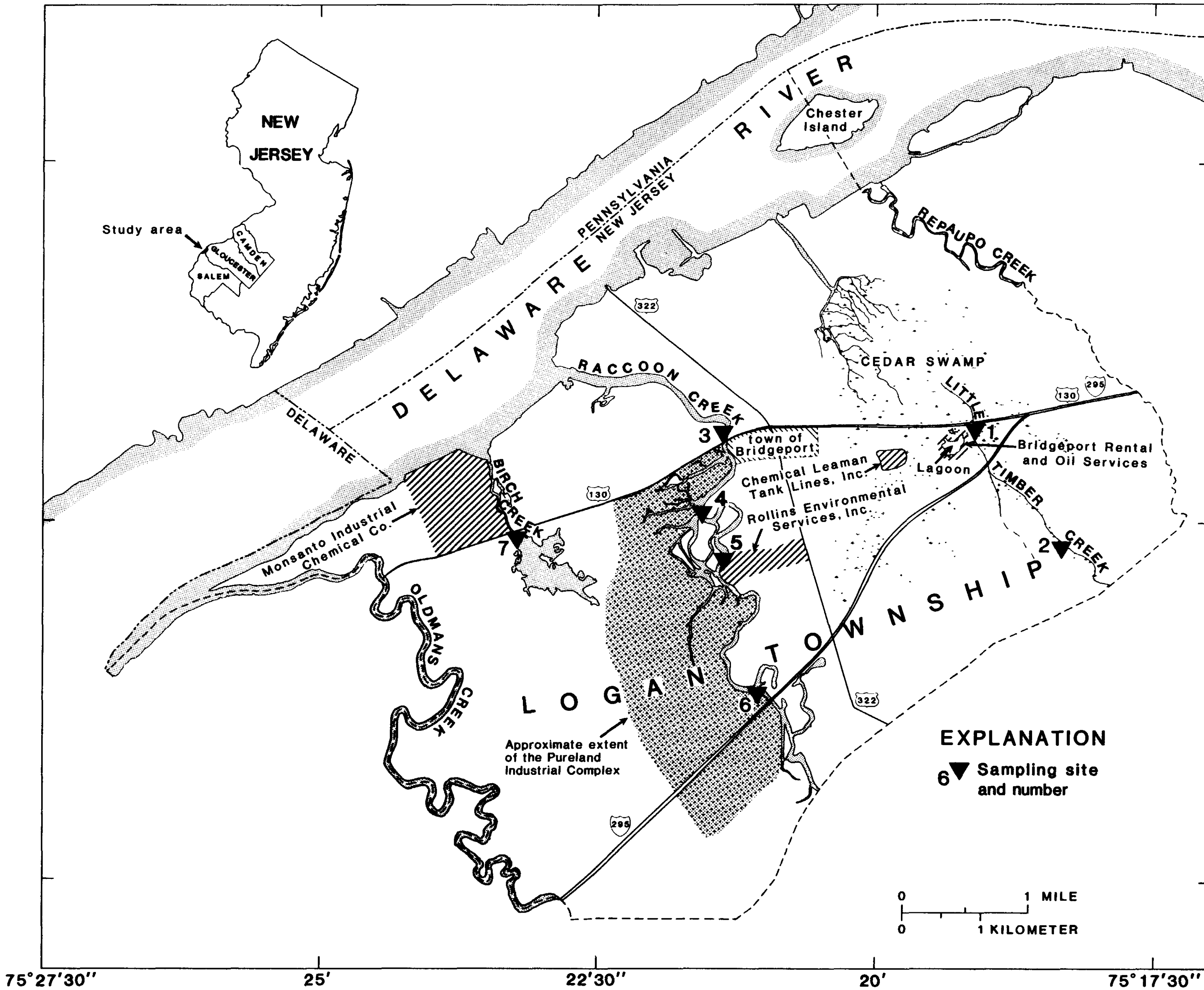


Figure 1.--Map showing surface-water sampling sites in Logan Township.

Fellows, Read, and Weber, Inc. and Hires (1972) issued a report on flow measurements and dye studies made on Raccoon Creek in Logan Township. The purpose of this study was to find ways to minimize any adverse effects of the Rollins wastewater discharge on the quality of water in the creek. They made recommendations on the timing and quantity of discharges relative to periodic changes in the direction of tidal flow in the creek.

The Delaware River Basin Commission (1977) issued a report on the effects of wastewater discharges from the Rollins plant on the water quality of Raccoon Creek. Water samples were collected from five stations on Raccoon Creek immediately adjacent to the Rollins plant from March through September 1976. Samples were analyzed for field-measured characteristics, common ions, nutrients, trace metals, and aquatic invertebrates. The Commission was unable to conclude whether Rollins' effluent had an adverse effect on the quality of Raccoon Creek, although it found Raccoon Creek to be in a generally degraded biological condition (Delaware River Basin Commission, 1977, p.v-1).

From 1980 to 1981 the U.S. Geological Survey conducted a study of the water and bed-material quality of the Delaware River estuary and selected New Jersey tributaries, including Raccoon Creek. Two samples of bed material collected 7 months apart at the U.S. Route 130 Bridge yielded different results. The first sample contained the highest concentrations of certain trace metals, PCB's, and organochlorine insecticides found in the study. The second sample contained most of the same contaminants, but at concentrations that were typically one or two orders of magnitude lower (Hochreiter, 1982).

Acknowledgments

The authors are grateful to Michael Gregor of Rollins Environmental Services, Inc. and Anthony Velnich of the U.S. Geological Survey for assistance in the collection of samples.

DESCRIPTION OF STUDY AREA

Geography and Geology

Logan Township, Gloucester County, New Jersey, borders the Delaware River estuary (fig. 1). The township is approximately 24 square miles in area and is entirely within the Delaware River basin. Maximum elevation in the Township is less than 60 feet above sea level, and maximum relief is 40 feet. One major stream, Raccoon Creek, and two smaller streams, Little Timber and Birch Creeks, drain large parts of the Township. Segments of the township boundaries are defined by Oldmans and Repaupo Creeks, two streams which drain the rest of the township.

Most of Logan Township is agriculturally developed. However, a large complex of firms consisting of "light industry", the Pureland Industrial Complex, extends west of Raccoon Creek.

Additional industrial facilities are found primarily between Routes 130 and 295. Although Logan Township is a sparsely populated, rural community, it is within 22 miles of an urban and industrialized region that includes the cities of Camden, N.J., Philadelphia, and Chester, Pa.

The study area is in the Atlantic Coastal Plain, a terrane regionally characterized by unconsolidated marine, littoral, and nonmarine deposits of Early Cretaceous to late Miocene age. The sediments of the Coastal Plain form a wedge that trends approximately northeast and dips and thickens toward the southeast. These sediments include gravel, sand, silt, and clay. A variety of fluvial and deltaic facies are represented in the wedge (Owens and Sohl, 1969). The sedimentary sequence unconformably overlies crystalline rocks of Paleozoic age. In Logan Township, a thin veneer of Quaternary deposits overlies deposits of Cretaceous age. The Cretaceous sedimentary units in Logan Township are (from youngest to oldest) the Merchantville Formation, the Magothy and Raritan Formations, and the Potomac Group (Jean Lewis and Joseph Hochreiter,U.S. Geological Survey, written commun., 1985).

The Potomac Group and the Raritan and Magothy Formations comprise the basal units of the Coastal Plain section and together form the Potomac-Raritan-Magothy aquifer system (Zapecza, 1984). These formations crop out throughout most of Logan Township. Depth to bedrock in the township varies from about 50 feet in the Delaware river to almost 500 feet in the southeast (Pierre LaCombe and Jean Lewis, U.S. Geological Survey, written commun., 1985).

Industrial Facilities

The industrial sites situated along the streams included in this study are the Bridgeport Rental and Oil Services, Chemical Leaman Tank Lines, Monsanto Chemical Company, and Rollins Environmental Services (fig. 1).

Bridgeport Rental and Oil Services, Inc (BROS) is an abandoned waste-oil-processing operation. The facility consists of an 11.8-acre lagoon that holds an approximately 40-foot-thick layer of oil, gasoline, water, and other petroleum-type products. Also, the facility includes more than 50 holding tanks which contain a variety of waste liquids and sludges. Since its closure in 1980, the BROS facility has been under the control of the U.S. Environmental Protection Agency. State and Federal agencies constructed an earthen dike around the perimeter of the lagoon after a breach in the north wall resulted in a release of fluid to Little Timber Creek. In 1984, several feet of lagoon water was drained from the lagoon and treated prior to discharge into Little Timber Creek to prevent another spillover (NUS Corporation, 1984b).

Chemical Leaman Tank Lines is a chemical transportation service, and tank trucks are cleaned at its Logan Township site. Materials used in the cleaning process include hot and cold water, steam, detergents, caustic soda, and hot kerosene (New Jersey Department of Environmental Protection, 1982). Until 1975, Chemical Leaman disposed of wastewater by discharging into a tributary to Cedar Swamp after treatment in a series of lagoons (New Jersey Departmen of Environmental Protection, 1982). Wastewater and sludge is now (1985) transported to a treatment plant outside the Township.

Monsanto Industrial Chemicals Co. manufactures many organic compounds used by the plastics manufacturing industry. Wastewater generated in the manufacturing processes, along with other wastewaters, are treated on the premises and discharged into the Delaware River estuary. Solid waste is disposed of in a lined landfill on the property. Three previously used landfills have been capped. One of these former disposal areas contains hazardous materials, including PCB's, and is surrounded by a slurry wall (Geraghty and Miller, 1983).

Rollins Environmental Services, Inc. (RES) operates a hazardous-waste treatment plant located within the 10-year flood plain of Raccoon Creek (Delaware River Basin Commission, 1977). RES formerly treated various organic and inorganic wastes by chemical and biological processes and by incineration. Only the incinerator remains operational. Onsite waste-disposal basins are being excavated (1985) to remove and chemically immobilize some of the waste materials that have leached into the subsurface. Waste water generated by the aquifer decontamination and incineration processes is treated on site, stored in settling lagoons, and subsequently discharged into Raccoon Creek.

Streams

The streams of interest in this study are Little Timber, Raccoon, and Birch Creeks. Each is a tributary to the Delaware River estuary.

Little Timber Creek

Little Timber Creek is located in northeastern Logan Township (fig.1). The stream flows into Cedar Swamp, and surface water from the swamp is channelled to the Delaware River estuary through a manmade conduit. Velnich (1982) calculated the area of the drainage basin at the mouth of Little Timber Creek to be 4.31 mi^2. Little Timber Creek passes within 500 feet of the waste-oil lagoon at the BROS facility. No long-term point-source discharge into Little Timber Creek is permitted by the New Jersey Department of Environmental Protection (NJDEP), although the creek has intermittently received treated wastewater from the BROS lagoon during the 1980's. Nonpoint sources of discharge include surface-water runoff from agricultural land and from the BROS facility. Organic contaminants found in surface water and bed material from

Cedar Swamp have been linked to episodes of spillover at the BROS lagoon in the early 1970's (NUS Corporation, 1984a).

Head of tide for Little Timber Creek, as determined from aerial photographs and confirmed by field survey, is approximately one mile upstream from the confluence with the Delaware River (Robert Cubberly, NJDEP, oral commun., 1985). Thus, it is downstream from the two sampling sites selected for this investigation.

Raccoon Creek

Raccoon Creek flows through the middle of Logan Township (fig 1). The western edge of the Rollins Environmental Services facility abuts Raccoon Creek, about 3.3 miles upstream from the stream's confluence with the Delaware River estuary. The drainage basin of Raccoon Creek at its mouth is 46.5 mi^2 (Velnich, 1982). The head of tide is to the southeast and well upstream of the study area; the sampling sites for this study are located in the tidal reach of this stream.

The U.S. Geological Survey operates a continuous-record stream-gaging station on the nontidal reach of Raccoon Creek about 3 miles upstream from Swedesboro. The average discharge of the stream at this station is 44.6, ft^3/s (period of record is 1967-75) with maximum and minimum values of 1,260 and 7.3 ft^3/s respectively (Gillespie and Schopp, 1982). The 7-consecutive day, 10-year low flow at the station is 8.4 ft^3/s (Gillespie and Schopp, 1982). Peak discharges at the confluence with the Delaware estuary for 10-, 50-, and 100- year recurrence intervals were estimated to be 3,220, 5,720, and 7,130 ft^3/s respectively (Rollins Environmental Assessment Action Group, 1978b).

Contaminants introduced from point and nonpoint sources contribute to the discharge of Raccoon Creek. Approximately 15 minutes after flood slack water arrives in the Delaware River at Marcus Hook, Rollins Environmental Services is permitted by the New Jersey Department of Environmental Protection (NJDEP) to discharge 1.1 million gallons of treated effluent into the creek for a period of 2 1/2 hours (Kathy Davies, NJDEP, oral commun., 1985). Nonpoint sources of discharge include runoff from agriculural land, new housing construction, and the Pureland Industrial Complex.

Birch Creek

Birch Creek flows through northwestern Logan Township (fig. 1). The drainage area of the creek at the mouth is 2.17 mi^2 (Velnich, 1982). A tide gate, situated approximately 1,500 feet upstream from the confluence with the Delaware River, restricts the area of tidal influence on Birch Creek. Sampling for this study was upstream of the tide gate in the nontidal reach. Occasional problems with the tide gate have caused periods of upstream flooding (Esther Slusarski, Logan Township Environmental

Commission, oral commun., 1985). The Monsanto Chemical Company, Pureland Water Company, and the Birch Creek Meadow Commission (a citizens group) jointly own and maintain the tide gate. The gate was built sometime between 1902 and 1908. Sources of runoff into Birch Creek are from new construction areas, agricultural land, established residential properties, and the Pureland Industrial Complex. The stream flows through the Monsanto Chemical Company property, where it passes within 600 feet of Monsanto's active landfill.

METHODS OF INVESTIGATION

Sampling Procedures

Table 1 lists all sites where water and surficial-bed material samples were collected; it includes their locations and tidal characteristics. Figure 1 shows the location of each sampling site in the Township.

To collect a representative sample of water or bed material from a stream, several samples are collected along a cross section of the stream and composited. In addition, water samples are collected and integrated over the depth of the stream. Water and bed-material samples in this study are composites of three verticals, where possible, along a single cross section at each site. The four sampling sites along Raccoon Creek were sampled by boat, whereas the two sites on Little Timber Creek and the site on Birch Creek were sampled from nearby bridges.

All bed-material samples were sieved through a 2-millimeter sieve at the time of collection. Water samples were collected with U.S. Geological Survey depth-integrating suspended-sediment samplers (Guy and Norman, 1970). All samples from Racoon Creek were collected during ebb tide. Very little, if any, flow was detected while sampling the two stations on Little Timber Creek.

Water samples were collected for analysis of volatile organic compounds, organochlorine and organophosphorous insecticides, trace metals, and a gas-chromatograpic scan for methylene chloride extractable organic substances (table 2). Bed-material samples were collected for analysis of organochlorine insecticides, gross PCB's, trace metals, and a gas-chromatographic scan for methylene chloride-extractable organic substances (table 3). Bed material from Raccoon Creek was analyzed for individual aroclors.

The samples for analysis of volatile organic compounds were collected in 40-milliliter glass septum bottles. These samples were hermetically sealed and chilled to 4°C. Samples for insecticide analysis and gas-chromatographic scans were collected in heat-treated 1-liter glass bottles. These samples were also chilled to 4°C.

Table 1.--Characteristics of sample collection sites

Site Number (fig. 1)	USGS identification number	Name	Latitude	Longitude	Influence of regular tidal cycle*	Point of collection
1	01477040	Little Timber Creek near Bridgeport, N.J.	39°47'24"	075°19'08"	None	Bridge
2	01477038	Little Timber Creek at Repaupo, N.J.	39°47'25"	075°18'22"	None	Bridge
3	01477160	Raccoon Creek at Bridgeport, N.J.	39°48'04"	075°21'22"	Strong	Boat
4	01477158	Raccoon Creek at Prospect, N.J.	39°47'36"	075°21'33"	Strong	Boat
5	01477156	Raccoon Creek near Center Square, N.J.	39°47'17"	075°21'21"	Strong	Boat
6	01477154	Raccoon Creek at Springers Wharf near Swedesboro, N.J.	39°46'21"	075°21'12"	Strong	Boat
7	01477196	Birch Creek at Rt. 130 at Nortonville, N.J.	39°47'25"	075°23'16"	None	Bridge

*Source: Robert Cubberly, New Jersey Department of Environmental Protection, written communication, 1985

Table 2.--Constituents analyzed in water samples

INORGANIC	VOLATILE ORGANIC COMPOUNDS
Dissolved oxygen	Benzene
pH	Bromoform
Arsenic	Carbon tetrachloride
Beryllium	Chlorobenzene
Cadmium	Chlorodibromomethane
Chromium	2-Chloroethyl vinyl ether
Cobalt	Chloroform
Copper	Dichlorobromomethane
Iron	1,1-Dichloroethane
Lead	1,2-Dichloroethane
Manganese	1,1-Dichloroethylene
Nickel	1,2-*trans*-dichloroethylene
Zinc	1,2-Dichloropropane
Selenium	1,3-Dichloropropene
	Ethylbenzene
	Methylene chloride
	1,1,2,2-Tetrachloroethane
	Tetrachloroethylene
	Toluene
	1,1,1-Trichloroethane
	1,1,2-Trichloroethane
	Trichloroethylene

ORGANOCHLORINE COMPOUNDS	ORGANOPHOSPHOROUS INSECTICIDES
Naphthalenes, polychlorinated (gross PCN's)	Diazinon
Biphenyls, polychlorinated (gross PCB's)	Endrin
Aldrin	Malathion
Chlordane	Methylparathion
Dichlorodiphenyldichloroethane (DDD)	Methyltrithion
Dichlorodiphenyldichloroethylene (DDE)	Parathion
Dichlorodiphenyltrichloroethane (DDT)	Trithion
Dieldrin	
Endosulfan	
Endrin	
Heptachlor	
Heptachlorepoxide	
Lindane	
Methoxychlor	
Mirex	
Perthane	
Toxaphene	

Table 3.--Constituents analyzed in bed-material samples

Organochlorine Compounds

Aroclor 1221	Dieldrin
Aroclor 1232	Endosulfan
Aroclor 1242	Endrin
Aroclor 1248	Heptachlor
Aroclor 1254	Heptachlorepoxide
Aroclor 1260	Lindane
Aroclor 1016	Methoxychlor
Gross PCB's	Mirex
Gross PCN's	Perthane
Aldrin	Toxaphene
Chlordane	
DDD	
DDE	
DDT	

Trace Metals

Arsenic
Cadmium
Chromium
Cobalt
Iron
Lead
Manganese
Mercury
Selenium
Zinc

Unfiltered samples for total recoverable metals analysis were acidified with nitric acid to pH 2.0 or below. The samples analyzed for nitrogen, phosphorous, and organic compounds were stored at 4°C. Nutrients were also preserved with mercuric chloride. Temperature, dissolved oxygen, specific conductance, and pH were determined in the field using a Hydrolabs* 4041 multi-parameter meter with an instream probe chamber.

Analytical Procedures

The U.S. Geological Survey National Water Quality Laboratory in Doraville, Ga. performed all laboratory analyses. Volatile organic compounds were analyzed on a gas chromatrography-mass spectrometry (GC-MS) system using a "vapor stripping" technique (U.S. Environmental Protection Agency, 1979a).

Gas Chromatographic-Flame Ionization Detector (GC-FID) scans of solvent-extractable organic compounds were performed in accordance with procedures established by Cardinali and others (1985). This technique is performed as follows: Approximately 10-35 grams of sediment sample or 1 liter of water sample are extracted with methylene chloride. Prior to extraction, surrogate spikes are added at random as a quality-assurance procedure. The methylene chloride extracts, with internal standards added, are concentrated and analyzed by gas chromatography using a flame-ionization detector. A 25-meter, 0.33 mm inside diameter fused silica capillary column coated with Se-54 is used; the column is maintained at 45°C for 3 minutes following injection and programmed to 295°C at 8°C/min. All samples representing water or bed material from a single stream were analyzed during the same GC-FID run, thus insuring that chromatographic conditions remained identical.

Each sample was extracted with methylene chloride within 48 hours of receipt at the laboratory. The solvent extraction procedures for bed-material samples are described in Wershaw and others (1983). Insecticides and polychlorinated biphenyls were analyzed on a gas chromatograph utilizing an electron capture detector (U.S. Environmental Protection Agency, 1979b). The gross PCB's analysis includes all nondifferentiated aroclor compounds. All trace metal analyses were performed by induction-coupled plasma spectrometry (Garbarino and Taylor, 1979).

Quality Assurance of Data

All water-and bed-material-quality data in this report were subject to standard Geological Survey quality-assurance procedures

*The use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

in effect at the time of analysis. The data in the computerized National Water Data Storage and Retrieval System (WATSTORE) were compared with laboratory-generated data tables to insure that data were properly reported and stored. Any values considered to be unusual were verified by the analyst. The techniques used in the field for collecting data and handling samples are outlined in the project's written quality assurance and work plan, on file in the USGS office in West Trenton, N.J.

DISCUSSION OF CHEMICAL ANALYSES

Water Quality

The results of all quantitative chemical analyses of water samples from the seven sampling sites are listed in table 4. Values for dissolved oxygen ranged from 12 to 67 percent of saturation for the entire data set. With the exceptions of copper and iron, all values for trace metals were below any recommended guidelines and applicable EPA standards for both drinking-water supplies and for protecting freshwater aquatic life. The only organic compounds detected were found in Raccoon Creek. High concentrations of methylene chloride were found at two sampling sites, and a trace of dieldrin was found at one location. Because of the highly volatile nature of methylene chloride in surface water, the source of this organic solvent was probably close to the sampling sites.

Bed-Material Quality

Table 5 contains the results of all semi-quantitative analyses performed on surficial-bed material samples from the seven sampling sites. Although no regulatory standards apply to contaminants extracted from bed material, the sample from Birch Creek contained concentrations of trace metals that were consistently higher than those observed in samples from other sites.

Organochlorine insecticides that were detected in one or more samples include Aldrin, Chlordane, DDD, DDE, DDT, and Dieldrin. These compounds were mostly found in the Little Timber and Birch Creek samples. Gross PCB's were detected in each stream sampled, although concentrations were higher in samples from Little Timber and Birch Creeks. Except for a trace amount (2 μg/kg) found in one sample, gross PCB concentrations were below the limits of detection in samples taken from Raccoon Creek.

A comparison of the reconnaissance data collected from Raccoon Creek during 1980-81 (table 6) and in 1984 (table 5), indicates that the occurrence and distribution of certain organic contaminants in surficial-bed material are highly variable.

Table 4.--Chemical analyses of surface-water samples.

INORGANIC CONSTITUENTS

[Units:°C, degree celsius; μs/cm, microsiemen per centimeter at 25° celsius; mg/L, milligrams per liter; μg/L, micrograms per liter; <, less than. All concentrations represent total recoverable values unless otherwise specified]

Date (1984)	Time	Temperature (°C)	Specific conductance (μS/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Arsenic (μg/L)	Beryllium (μg/L)	Cadmium (μg/L)	Chromium (μg/L)
01477038 - Little Timber Creek at Repaupo, N.J.									
Nov 06	1115	12.5	206	5.6	6.5	2	<10	<1	<10
01477040 - Little Timber Creek near Bridgeport, N.J.									
Nov 06	1300	14.0	174	1.2	6.2	2	<10	<1	10
01477154 - Raccoon Creek at Springers Wharf near Swedesboro, N.J.									
Oct 31	1340	19.0	687	6.1	6.9	2	<10	1	10
01477156 - Raccoon Creek near Center Square, N.J.									
Oct 31	1230	19.0	1030	6.2	7.1	2	<10	1	20
01477158 - Raccoon Creek at Prospect, N.J.									
Oct 31	1100	18.5	1340	6.2	7.1	2	<10	1	10
01477160 - Raccoon Creek at Bridgeport, N.J.									
Oct 31	0930	18.5	1490	5.4	6.9	2	<10	1	<10
01477196 - Birch Creek at Route 130 at Nortonville, N.J.									
Nov 08	1235	8.5	306	2.8	6.4	2	<10	<1	<10

Cobalt (μg/L)	Copper (μg/L)	Iron (μg/L)	Lead (μg/L)	Manganese (μg/L)	Nickel (μg/L)	Zinc (μg/L)	Selenium (μg/L)	Mercury (μg/L)
01477038 - Little Timber Creek at Repaupo, N.J.								
<1	3	500	10	150	4	40	<1	<.1
01477040 - Little Timber Creek near Bridgeport NJ								
<1	6	2100	12	270	3	30	<1	<.1
01477154 - Raccoon Creek at Springers Wharf near Swedesboro, N.J.								
2	8	3300	16	280	5	30	<1	.1
01477156 - Raccoon Creek near Center Square, N.J.								
1	6	2400	10	230	7	20	<1	<.1
01477158 - Raccoon Creek at Prospect, N.J.								
2	5	2800	11	210	7	30	<1	<.1
01477160 - Raccoon Creek at Bridgeport, N.J.								
<1	11	1900	31	120	6	30	<1	.1
01477196 - Birch Creek at Route 130 at Nortonville, N.J.								
1	5	4500	12	360	5	40	<1	<.1

Table 4.--Chemical analyses of surface-water samples--Continued

VOLATILE ORGANIC COMPOUNDS

Toluene (μg/L)	Benzene (μg/L)	Chloro- benzene (μg/L)	Ethyl- benzene (μg/L)	Di- Chloro- bromo- methane (μg/L)	Carbon- tetra- chlo- ride (μg/L)	1,2-Di- chloro- ethane (μg/L)	Brom- oform (μg/L)	Chloro- di- bromo- methane (μg/L)	Chloro- form (μg/L)	Methyl- ene chlo- ride (μg/L)	Tetra- chloro- ethyl- ene (μg/L)
01477038 - Little Timber Creek at Repaupo, N.J.											
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3	<3.0	<3.0
01477040 - Little Timber Creek near Bridgeport, N.J.											
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3	<3.0	<3.0
01477154 - Raccoon Creek at Springers Wharf near Swedesboro, N.J.											
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3	<3.0	<3.0
01477156 - Raccoon Creek near Center Square, N.J.											
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3	455	<3.0
01477158 - Raccoon Creek at Prospect, N.J.											
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3	1,800	<3.0
01477160 - Raccoon Creek at Bridgeport, N.J.											
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3	<3.0	<3.0
01477196 - Birch Creek at Route 130 at Nortonville, N.J.											
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3	<3.0	<3.0

1,1-di- chloro- ethane (μg/L)	1,1-di- chloro- ethyl- ene (μg/L)	1,1,1- tri- chloro- ethane (μg/L)	1,1,2- tri- chloro- ethane (μg/L)	1,1,2,2 tetra- chloro- ethane (μg/L)	1,2-di- chloro- propane (μg/L)	1,2- trans-di- chloro- ethyl- ene (μg/L)	1,3-di- chloro- propene (μg/L)	2- chloro- ethyl- vinyl- ether (μg/L)	Tri- chloro- ehyl- ene (μg/L)
01477038 - Little Timber Creek at Repaupo, N.J.									
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
01477040 - Little Timber Creek Near Bridgeport, N.J.									
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
01477154 - Raccoon Creek at Springers Wharf Near Swedesboro, N.J.									
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
01477156 - Raccoon Creek near Center Square, N.J.									
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
01477158 - Raccoon Creek at Prospect, N.J.									
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
01477160 - Raccoon Creek at Bridgeport, N.J.									
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
01477196 - Birch Creek at Route 130 at Nortonville, N.J.									
<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Table 4.--Chemical analyses of surface-water samples--Continued

ORGANOCHLORINE AND ORGANOPHOSPHOROUS COMPOUNDS

Perthane (µg/L)	Aldrin (µg/L)	Lindane (µg/L)	Chlordane (µg/L)	DDD (µg/L)	DDE (µg/L)	DDT (µg/L)	Dieldrin (µg/L)	Endosulfan (µg/L)	Endrin (µg/L)	Toxaphene (µg/L)	Heptachlor (µg/L)
01477038 - Little Timber Creek at Repaupo, N.J.											
<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010	<.010	<.010	<1	<.010
01477040 - Little Timber Creek near Bridgeport, N.J.											
<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010	<.010	<.010	<1	<.010
01477154 - Raccoon Creek at Springers Wharf near Swedesboro, N.J.											
<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010	<.010	<.010	<1	<.010
01477156 - Raccoon Crekk near Center Square, N.J.											
<.1	<.010	<.010	<.1	<.010	<.010	<.010	.010	<.010	<.010	<1	<.010
01477158 - Raccoon Creek at Prospect, N.J.											
<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010	<.010	<.010	<1	<.010
01477160 - Raccoon Creek at Bridgeport, N.J.											
<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010	<.010	<.010	<1	<.010
01477196 - Birch Creek at Route 130 at Nortonville, N.J.											
<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010	<.010	<.010	<1	<.010

Heptachlorepoxide (µg/L)	Methoxychlor (µg/L)	Mirex (µg/L)	Ethion (µg/L)	Malathion (µg/L)	Parathion (µg/L)	Diazinon (µg/L)	Methyl parathion (µg/L)	Trithion (µg/L)	Methyl trithion (µg/L)	Gross PCN's (µg/L)	Gross PCB's (µg/L)
01477038 - LIttle Timber Creek at Repaupo, N.J.											
<.010	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.10	<.1
01477040 - Little Timber Creek near Bridgeport, N.J.											
<.010	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.10	<.1
01477154 - Raccoon Creek at Springers Wharf near Swedesboro, N.J.											
<.010	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.10	<.1
01477156 - Raccoon Creek near Center Square, N.J.											
<.010	<.01	<.01	--	--	--	--	--	--	--	<.10	<.1
01477158 - Raccoon Creek at Prospect, N.J.											
<.010	<.01	<.01	<.01	<.01	<.01	.02	<.01	<.01	<.01	<.10	<.1
01477160 - Raccoon Creek at Bridgeport, N.J.											
<.010	<.01	<.01	<.01	<.01	<.01	.03	<.01	<.01	<.01	<.10	<.1
01477196 - Birch Creek at Route 130 at Nortonville, N.J.											
<.010	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.10	<.1

Table 5.--Chemical Analyses of Surficial-Bed Material
[Units: µg/kg, micrograms per kilogram;
µg/G, micrograms per gram. All values are
total recoverable]

ORGANOCHLORINE COMPOUNDS

Date (1984)	Time	Aldrin (µg/kg)	Lindane (µg/kg)	Chlor-dane (µg/kg)	DDD (µg/kg)	DDE (µg/kg)	DDT (µg/kg)	Di-eldrin (µg/kg)	Endo-sulfan (µg/kg)	Endrin (µg/kg)	Toxa-phene (µg/kg)	Hepta-chlor (µg/kg)
01477038 - Little Timber Creek at Repaupo, N.J.												
Nov 06	1115	15	<.1	12	14	14	4.0	24	<.1	<.1	<10	<.1
01477040 - Little Timber Creek near Bridgeport, N.J.												
Nov 06	1300	<.1	<.1	<1.0	<.1	<.1	<.1	<.1	<.1	<.1	<10	<.1
01477154 - Raccoon Creek at Springers Wharf near Swedesboro, N.J.												
Oct 31	1340	<.1	<.1	<1.0	.3	<.1	<.1	<.1	<.1	<.1	<10	<.1
01477156 - Raccoon Creek near Center Square, N.J.												
Oct 31	1230	<.1	<.1	<1.0	<.1	<.1	<.1	<.1	<.1	<.1	<10	<.1
01477158 - Raccoon Creek at Prospect, N.J.												
Oct 31	1100	<.1	<.1	<1.0	<.1	<.1	<.1	<.1	<.1	<.1	<10	<.1
01477160 - Raccoon Creek at Bridgeport, N.J.												
Oct 31	0930	<.1	<.1	<1.0	.2	<.1	<.1	<.1	<.1	<.1	<10	<.1
01477196 - Birch Creek at 130 at Nortonville, N.J.												
Nov 08	1235	<.1	<.1	14	39	9.8	1.7	<.1	<.1	<.1	<10	<.1

Hepta-chlor epoxide (µg/kg)	Metho-oxy-chlor (µg/kg)	Gross PCN's (µg/kg)	Gross PCB's (µg/kg)	Per-thane (µg/kg)	Mirex (µg/kg)	Aroclor 1221 (µg/kg)	Aroclor 1232 (µg/kg)	Aroclor 1242 (µg/kg)	Aroclor 1248 (µg/kg)	Aroclor 1254 (µg/kg)	Aroclor 1260 (µg/kg)	Aroclor 1016 (µg/kg)
01477038 - Little Timber Creek at Repaupo, N.J.												
<.1	<.1	<1.0	17	<1.00	<.1	--	--	--	--	--	--	--
01477040 - Little Timber Creek near Bridgeport, N.J.												
<.1	<.1	<1.0	86	<1.00	<.1	--	--	--	--	--	--	--
01477154 - Raccoon Creek at Springers Wharf near Swedesboro, N.J.												
<.1	<.1	<1.0	<1	<1.00	<.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
01477156 - Raccoon Creek near Center Square, N.J.												
<.1	<.1	<1.0	2	<1.00	<.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
01477158 - Raccoon Creek at Prospect, N.J.												
<.1	<.1	<1.0	<1	<1.00	<.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
01477160 - Raccoon Creek at Bridgeport, N.J.												
<.1	<.1	<1.0	<1	<1.00	<.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
01477196 - Birch Creek at Route 130 at Nortonville, N.J.												
<.1	<.1	<1.0	600	<1.00	<.1	--	--	--	--	--	--	--

Table 5.--Chemical analyses of surficial-bed material--Continued

TRACE METALS

Cadmium (µg/L)	Chromium (µg/G)	Cobalt (µg/G)	Copper (µg/G)	Lead (µg/G)	Manganese (µg/G)	Zinc (µg/G)	Selenium (µg/G)	Iron (µg/G)	Mercury (µg/G)	Arsenic (µg/G)
01477038 - Little Timber Creek at Repaupo, N.J.										
4	6	<10	5	50	240	7	<1	7300	.14	2
01477040 - Little Timber Creek near Bridgeport, N.J.										
2	3	<10	4	60	4	8	<1	570	<.01	<1
01477154 - Raccoon Creek at Springers Wharf near Swedesboro, N.J.										
<1	10	<10	5	10	250	30	<1	8700	<.01	<1
01477156 - Raccoon Creek near Center Square, N.J.										
<1	30	<10	20	40	180	140	<1	6000	.52	6
01477158 - Raccoon Creek at Prospect, N.J.										
<1	10	<10	6	<10	170	20	<1	8700	.12	<1
01477160 - Raccoon Creek at Bridgeport, N.J.										
<1	9	<10	2	10	1000	30	<1	960	<.01	<1
01477196 - Birch Creek at Route 130 at Nortonville, N.J.										
6	40	20	39	80	160	300	<1	18000	.43	2

Table 6.--Results of a previous U.S.G.S. investigation of the chemical data on surficial-bed material from Raccoon Creek, 1980-81.

(01477160 - Raccoon Creek at Bridgeport, N.J.)
[Units: µg/kg, micrograms per kilogram; µg/G, micrograms per gram. All values are total recoverable.]

Date	Time	Arsenic (µg/G)	Cadium (µg/G)	Chromium (µg/G)	Cobalt (µg/G)	Copper (µg/G)	Iron (µg/G)	Lead (µg/G)	Manganese (µg/G)	Mercury (µg/G)	Zinc (µg/G)	Selenium (µg/G)
May 23, 1980	1130	4	20	190	50	230	29000	590	500	.01	2100	0
Jan 8, 1981	1100	--	--	--	--	--	--	--	--	--	--	--

Date	Aldrin (µg/kg)	Lindane (µg/kg)	Chlordane (µg/kg)	Mirex (µg/kg)	Perthane (µg/kg)	DDD (µg/kg)	DDE (µg/kg)	DDT (µg/kg)	Dieldrin (µg/kg)	Endosulfan (µg/kg)	Endrin (µg/kg)	Ethion (µg/kg)
May 23, 1980	<.1	<.1	190	<.1	<.1	4000	300	150	10	<.1	<.1	<.1
Jan 8, 1981	<.1	<.1	2	<.1	<.1	3.9	1.6	<.1	.3	<.1	<.1	--

Date	Toxaphene (µg/kg)	Heptachlor (µg/kg)	Heptachlor epoxide (µg/kg)	Methoxychlor (µg/kg)	Gross PCB's (µg/kg)	Gross PCN's (µg/kg)	Malathion (µg/kg)	Parathion (µg/kg)	Diazinon (µg/kg)	Methyl parathion (µg/kg)	Trithion (µg/kg)	Methyl trithion (µg/kg)
May 23, 1980	<1	<.1	1.6	<.1	830	<1	<.1	<.1	1.6	<.1	<10	<.1
Jan 8, 1981	<1	<.1	<.1	<.1	11	<1	--	--	--	--	--	--

Variations in occurrence and distribution result from one or more of the following reasons:

a.) changes in the rates of contaminant-loading to the stream;

b.) changes in the rate of sediment transport;

c.) changes in the configuration of the stream bottom over time;

d.) variations in particle-size distribution and organic carbon content of the sediments;

e.) technical problems inherent in obtaining consistently representative samples of bed material; and

f.) variations in laboratory-extraction efficiencies.

Variations in contaminant concentrations are particularly evident when comparing surficial-bed material analyses for Raccoon Creek at Bridgeport. Concentrations of organochlorine insecticides, gross PCB's and trace metals varied by as much as several orders of magnitude during the 4-year period.

Table 7 contains information on the chemical properties and the environmental significance of constituents detected in water and bed-material samples. The main purpose of this table is to provide current toxicological information on contaminants that might affect stream quality.

CHROMATOGRAPHIC DATA

Figure 2 represents a typical GC-FID chromatogram as received from the laboratory. It consists of a series of peaks, each representing at least one organic substance. Certain peaks represent surrogate or internal standard compounds that are added to the sample by the laboratory prior to analysis. Blank peaks are believed to represent contaminants introduced by the analyst that also show up on quality-control chromatograms of reagent-grade water. The remaining substances show up as peaks identified as unknowns.

In general, only those unknown peaks that are about 20 percent of detector response or greater represent concentrations high enough to permit confirmation by GC-MS. Because of the effects of the solvent used during extraction and its impurities, peaks with retention times of less than 5 minutes are not significant in the chromatogram (Jacob Gibs, U.S. Geological Survey, written commun., 1985). For these reasons, particular emphasis is placed on unidentified peaks with peak heights that are at least 20 percent of detector response and have retention times exceeding 5 minutes.

Table 7. Chemical properties and environmental significance of selected constituents.

Compound name	Formula	Selection criteria and EPA suggested limiting values in water	Remarks
Aldrin	$C_{12}H_8Cl_6$	B = 3.0 µg/L D = 1.3 µg/L E = 0 µg/L F = .00074 µg/L	Aldrin is a brown to white crystalline solid used as a pesticide and a fumigant.*7; it is insoluble in water. LD50 (oral) is 39-60 mg/kg*4.
Chlordane	$C_{10}H_6Cl_8$	A = 0.0043 µg/L B = 2.4 µg/L C = 0.0040 µg/L D = 0.09 µg/L E = 0 µg/L F = 0.0046 µg/L	Chlordane is a polycyclic chlorinated hydrocarbon insecticide. It has been used for over 30 years in termite control*6. Its solubility in water is low (9 PPB).*5 Oral LD50 is 457-590 mg/kg.*4
DDT (Dichloro-diphenyl trichloro-ethane)	$C_{14}H_9Cl_5$	A,C = 0.0010 µg/L B = 1.1 µg/L D = 0.13 µg/L E = 0 µg/L F = 0.00024 µg/L	DDT, and its metabolites DDE (C14H8Cl4) and DDD (C14H10Cl4) are broad spectrum chlorinated hydrocarbon insecticides, which are collectively identified as DDT-T. DDD (also known as TDE) is also formulated independently as an insecticide. DDT-T (particularly DDE) is accumulated in body fat.*4*5 Oral LD50 (male rats) for DDT = 113 mg/kg; for DDE = 800 mg/kg; for DDD = 3,400 mg/kg.*3 DDT and DDE are slightly soluble in water (1.3 PPB). DDD has separate limiting values for the protection of freshwater and saltwater aquatic life of 0.6 and 3.6 µg/L respectively as values not to be exceeded.*1
Dieldrin	$C_{12}H_8Cl_6O$	A,C = 0.0019 µg/L B = 2.5 µg/L D = 0.71 µg/L E = 0 µg/L F = 0.00071 µg/L	Dieldrin is a cyclodiene chlorinated hydrocarbon insecticide. Dieldin has a very low vapor pressure and is slightly soluble in water (186 µg/L at 25°C).*1 Dieldrin is stored in animal fat and is subject to bio-magnification in the food cycle. Manufacture of dieldrin in the U.S. was suspended in 1974. Oral LD50 = 46 mg/kg.*4*5
Diazinon	$C_{18}H_{15}Cl_3O_2$	G = 0.014 µg/L	Diazinon is a clear liquid pesticide used on crops, domestic animals, lawns, gardens, and household pets.*1 Acceptable daily intake = .002 mg/kg.*1 Oral LD50 = 76 mg/kg*9.
Methylene Chloride	CH_2Cl_2	E = 0 µg/L F = 1.9 µg/L	Methylene chloride is a colorless liquid used as a solvent for oil, fats, waxes, bitumen, cellulose acetate and esters; it is also used in paint stripping and solvent degreasing.*12 It is considered slightly soluble in water.*2 LD50 (oral) = 167 mg/kg*9.

Table 7. Chemical properties and environmental significance of selected constituents.--Continued

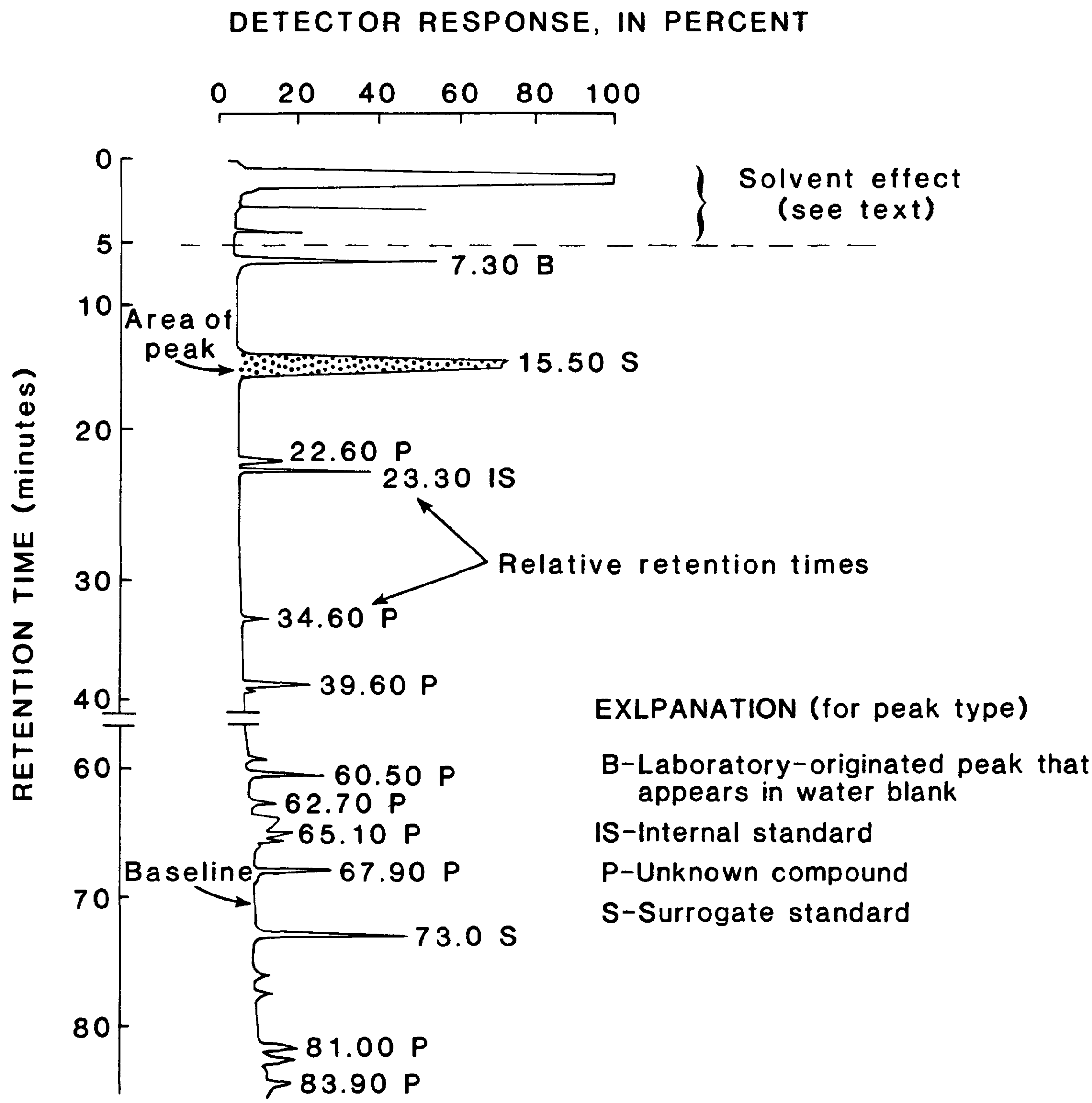
Name	Formula	Selection criteria and EPA designated limiting values in water	Remarks
PCB's (Poly-chlorinated biphenyls)	$C_{12}H_{10-x}Cl_x$	A = 0.014 µg/L C = 0.030 µg/L E = 0.00 µg/L F = 0.00079 µg/L	PCB's (aroclors) are joined by the chlorination of diphenyl rings (C12). Although 209 possible substitutions of chlorine for hydrogen are possible (including all isomers), the industrially significant products are those containing 21, 42, 48, 54, and 60 percent chlorine by weight.*3 Technical PCB can also include such contaminants as chlorinated napthalenes and chlorinated dibenzofurans. PCB's were introduced more than 45 years ago and are known to be almost chemically inert.*1 Their principal vehicle for movement in the environment is believed to be water*3, and strong evidence indicates they accumulate in food chains.*1 Current research suggests that PCB's might biodegrade in the environment through co-metabolic processes *8 They are generally low in acute toxicity (Oral LD50 (mice) = 2,0000 mg/kg), however they are considered to be toxic after chronic long term exposure.*3 PCB's are useful as electrical insulating mediums and as a heat-transfer fluid. The solubilities of PCB's in water vary from 2 to 250 PPB depending on the specific aroclor.

Selection criteria: A = to protect freshwater aquatic life - 24-hour average value
B = to protect freshwater aquatic life - value not to be exceeded
C = to protect saltwater aquatic life - 24-hour average value
D = to protect saltwater aquatic life - value not be exceeded
E = preferred limit to protect human health
F = this concentration poses an additional lifetime cancer risk of 1 in 100,000
G = the "no-adverse-affect level" in drinking water as calculated by NAS/NRC (National Research Council, 1977).

References: All EPA limiting values are referenced in Sittig (1985).

*1 - Sittig (1985)
*2 - Hawley (1981)
*3 - Sax (1974)
*4 - Windholz and others (1976)
*5 - National Research Council (1977)
*6 - Meister Publishing Co. (1981)
*7 - Verschueren (1983)
*8 - Derra (1985)
*9 - U.S. Department of Health and Human Services (1980)

Notes: LD50 (lethal dose, 50 percent): the orally-administered dose of a substance that is fatal to animals (usually rats) in 50 percent of test cases.



Retention time	Area of peak	Peak type	Concentration	Identification of Compound
7.3	192.0	B	14.00	
15.5	239.0	S	18.25	1-Flouronaphthalene
23.3	132.3	IS	12.75	2-2 Diflourobenzene
34.6	42.0	P	7.11	
60.5	101.1	P	10.46	
73.0	170.9	S	12.92	Chrysene D-12

Figure 2.--Features of a typical gas chromatography-flame ionization detector chromatogram.

Water Samples

Four chromatograms of extracts from water samples taken from Raccoon Creek are presented in figure 3. They are in downstream order, from left to right. All have very similar chromatographic fingerprints, indicating that the samples possess few contaminants detectable by the method. Peaks A and B in figure 3 are the only unknown peaks that exceed 20 percent of detector response for these four chromatograms. These two peaks have retention times between 5 and 15 minutes.

Chromatograms of extracts taken from Little Timber Creek samples are given in figure 4. The chromatographic fingerprints from the two sampling sites are virtually identical. There are no unidentified peaks in either chromatogram indicating concentrations quantifiable by GC-MS.

The chromatogram of the water sample extract taken from Birch Creek is shown in figure 5. It contains one full-scale unidentified peak (A), with a retention time of 11.5 to 12 minutes. This peak represents at least one unknown contaminant in the lower molecular weight range, at a concentration thought to exceed 40 µg/l.

Bed-Material Samples

The four chromatograms of extracts from bed-material samples taken from Raccoon Creek are shown in figure 6. No unidentified peaks are greater than or equal to 20 percent of detector response, so quantification of the unknowns in these samples would probably be impossible using solvent-extraction techniques on a GC-MS. The largest single peak has a retention time of about 63 minutes and is approximately 10 to 15 percent of full scale height in all four chromatograms. To the extent that each chromatogram has a discernable chromatographic fingerprint, the fingerprints are similar. Many compounds appear at sub-microgram-per-liter levels in the higher molecular weight range (compounds with retention times exceeding 60 minutes).

Two chromatograms of bed-material sample extracts from Little Timber Creek are shown in figure 7. The chromatographic fingerprints for each sample are similar in the region of retention times that range from 5 to about 45 minutes. The region represented by retention times that range from about 45 minutes to the end of the runs (about 80 minutes), however, reveal chromatographic fingerprints with strikingly different characteristics. Most peaks in the upstream sample (site 2 in fig. 1) are larger than corresponding peaks in the downstream sample (site 1 in fig. 1). In addition, many more peaks are evident in the upstream sample, particularly in the 80-minute retention-time range. These results are consistent with the results of the quantitative organic analyses done on bed-material extracts from the two sites. The upstream sample contained a predominance of high-molecular-weight organic compounds at

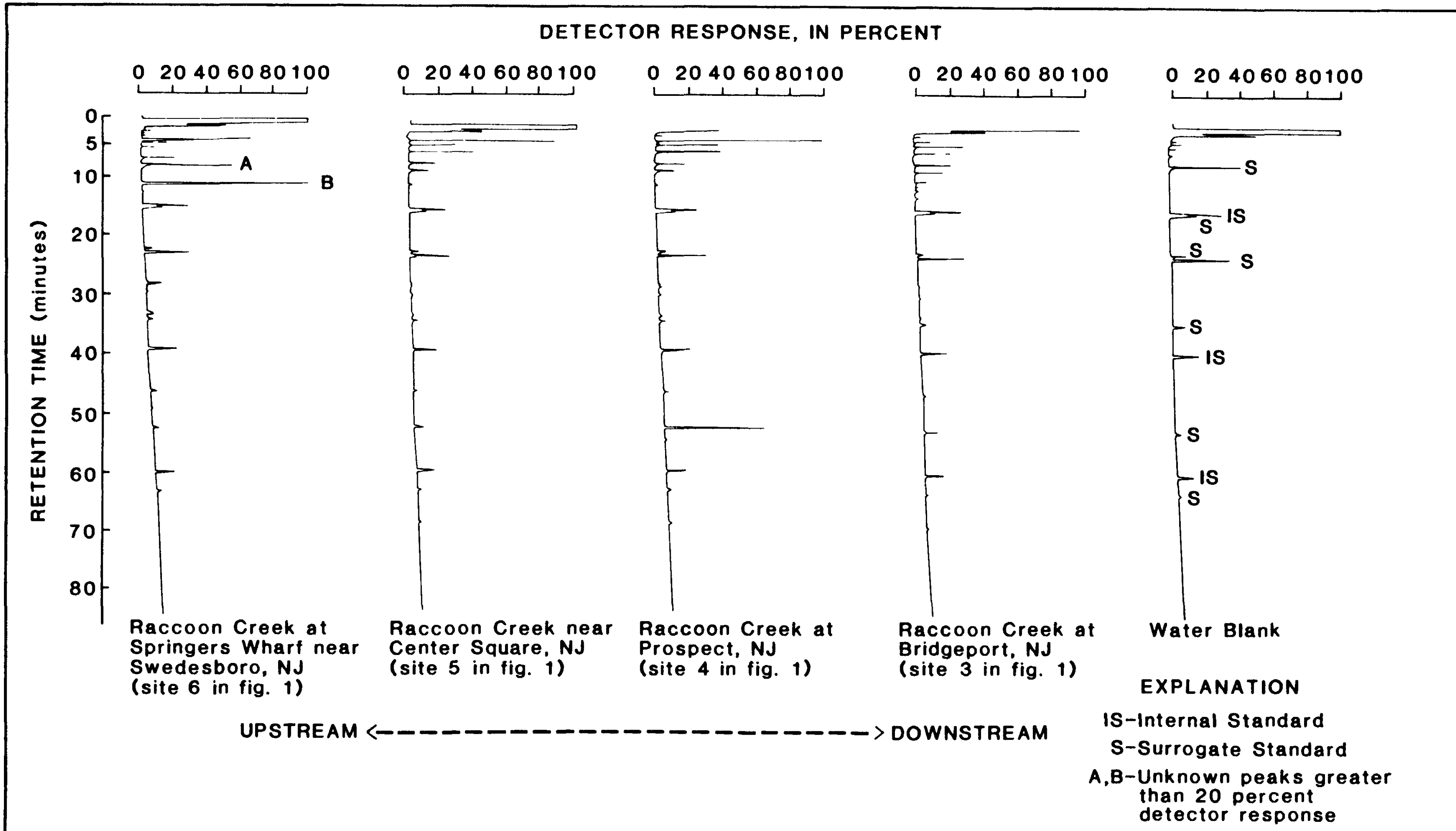


Figure 3.--Chromatograms of water samples from Raccoon Creek.

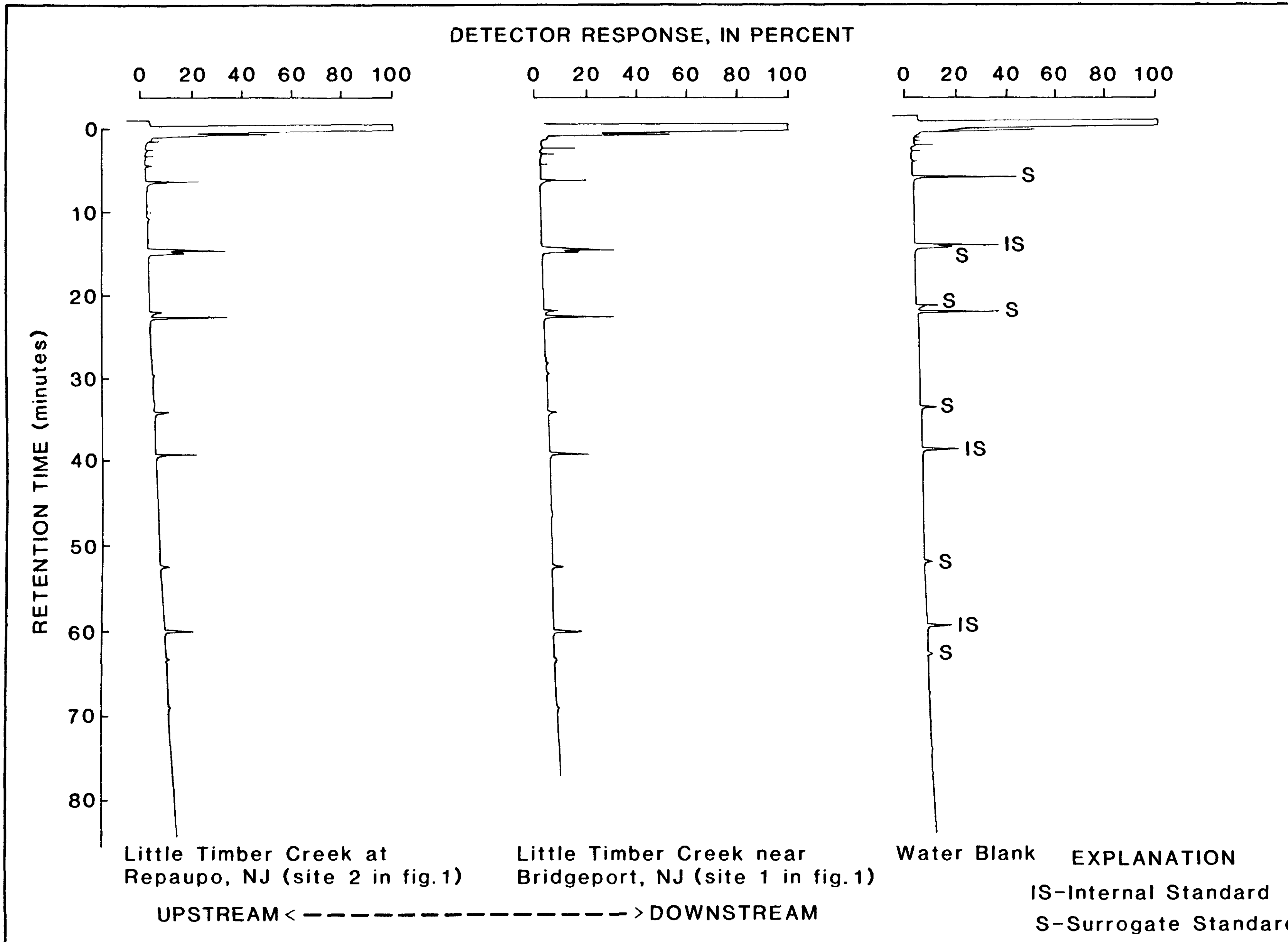


Figure 4.--Chromatograms of water samples from Little Timber Creek.

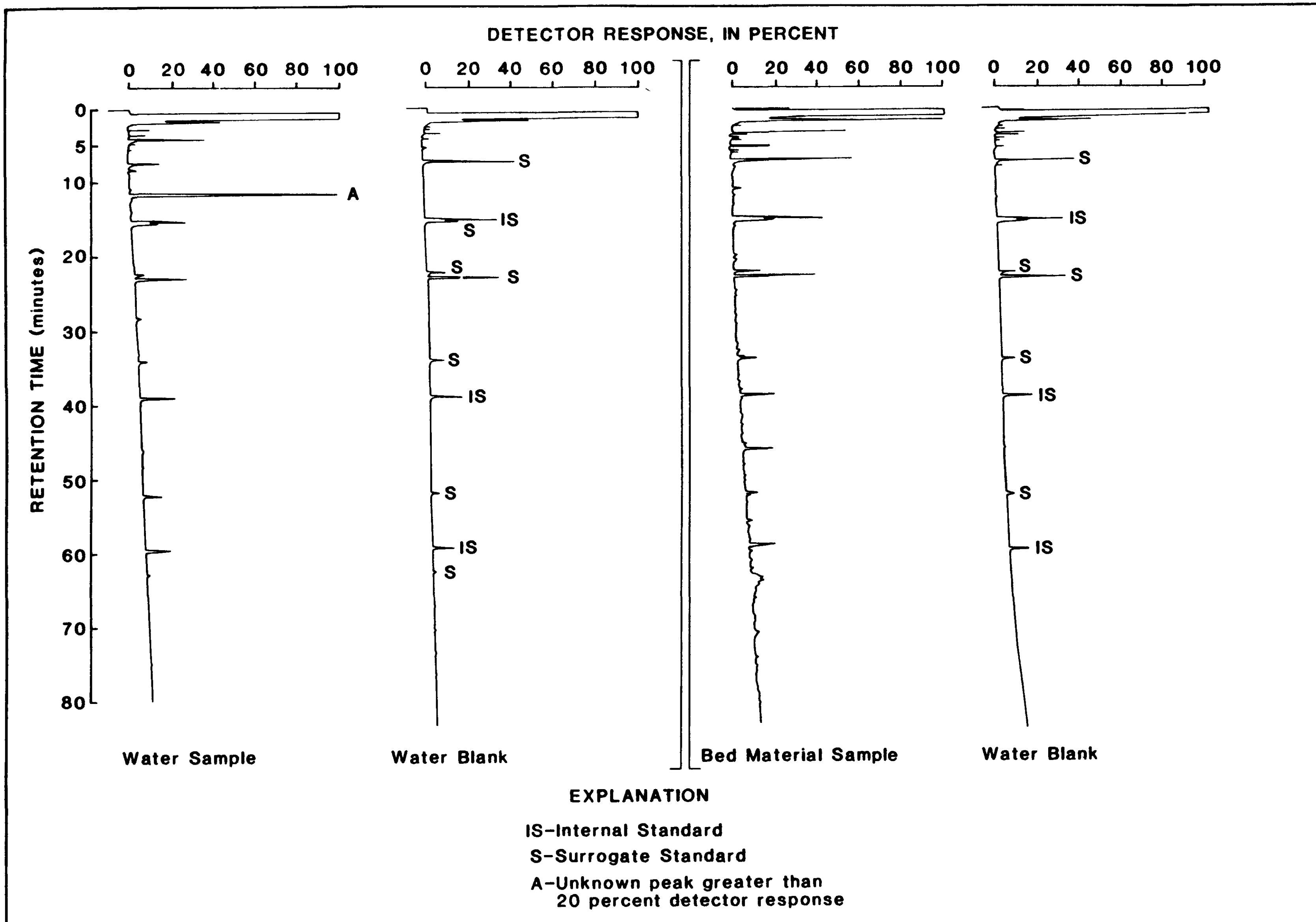


Figure 5.--Chromatograms of water samples and surficial-bed material from Birch Creek (site 7 in fig. 1).

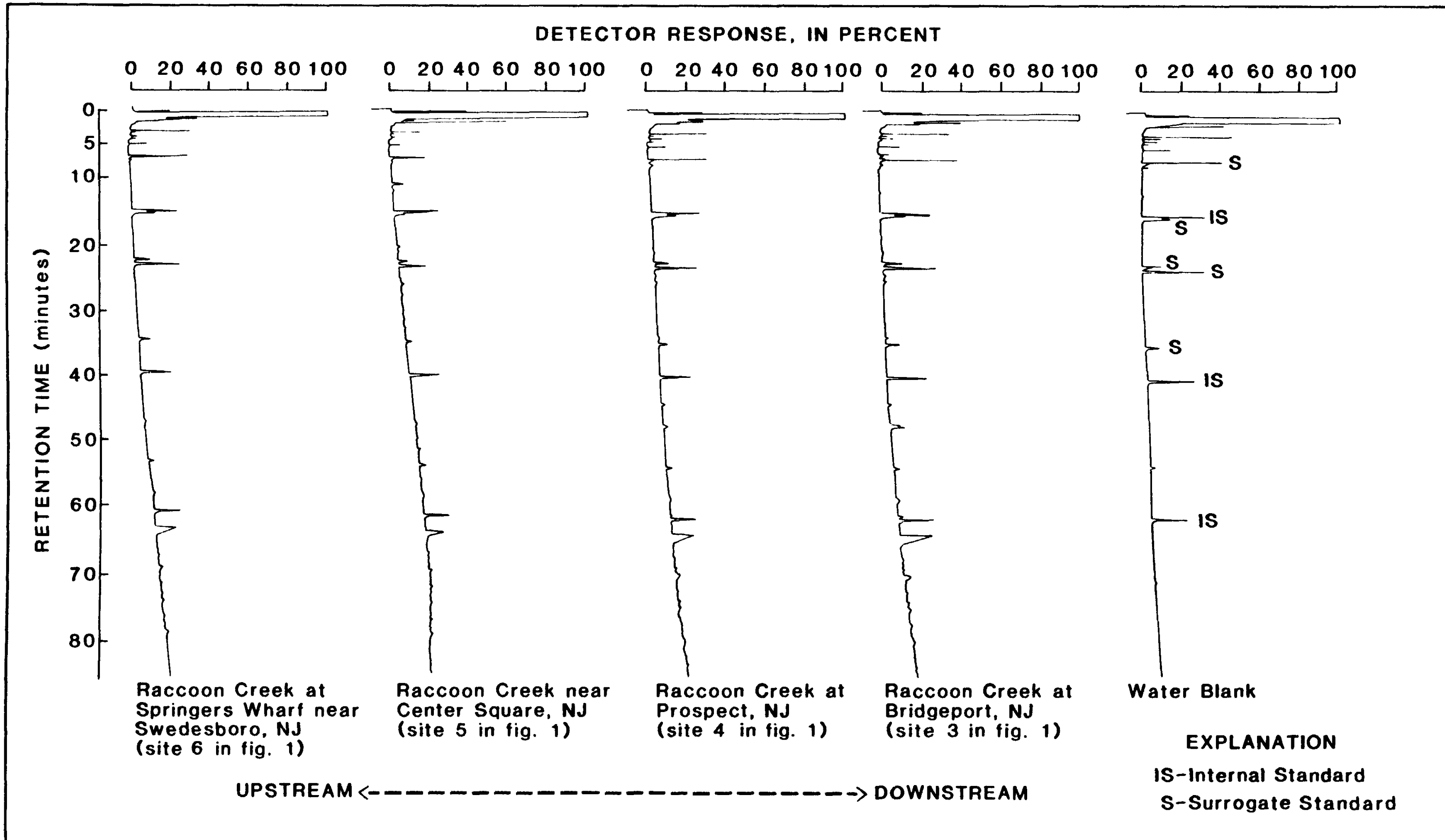


Figure 6.--Chromatograms of surficial-bed material from Raccoon Creek.

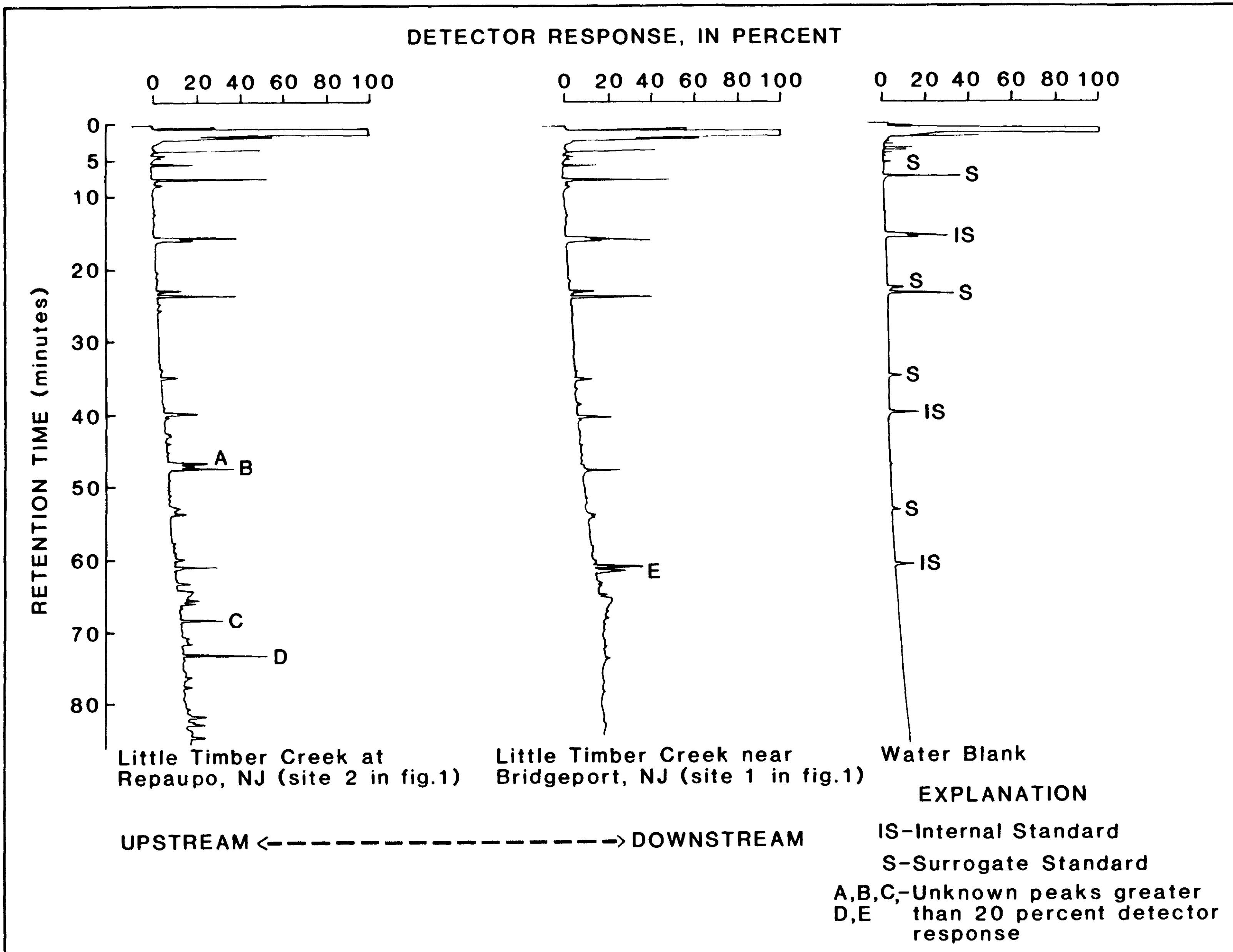


Figure 7.--Chromatograms of surficial-bed material from Little Timber Creek.

apparently higher concentrations. This sample also contained the most organochlorine compounds of any collected during this study. In these chromatograms, however, only those peaks identified as A through E are greater than or equal to 20 percent of detector response. Four of these peaks (A through D) can be found in the upstream sample chromatogram.

The chromatogram of the bed-material extract taken from Birch Creek is shown in figure 5. It contains many unidentified peaks; however, none equals or exceeds 20 percent of detector response. Most of the unidentified peaks have retention times exceeding 40 minutes.

SUMMARY

This report describes the presence of contaminants in water and surficial-bed material of streams in Logan Township. Streams were sampled during October and November of 1984. Elevated concentrations of methylene chloride, a volatile organic solvent, were found in water samples from two closely spaced sampling sites along Raccoon Creek. The GC-FID scan showed the presence of unidentified compounds in the water sample taken from the most upstream sampling point on Raccoon Creek.

The bed-material sample from Little Timber Creek at Repaupo contained the most organochlorine compounds of any sample. The bed-material sample from the downstream sampling location alongside the BROS facility lacked organochlorine insecticides, but contained gross PCB'S. Organic contaminants were not detected in any water samples taken from Little Timber Creek. The GC-FID scans on bed material showed numerous peaks at both sampling locations, but peaks were more numerous in the upstream sampling site.

The bed material in one sample taken from Birch Creek, contained higher concentrations of most trace metals and gross PCB's than did any other site sampled. Concentrations of DDT, DDE, DDD, and chlordane were higher than at other sites in the study. The GC-FID scan on bed material showed several small peaks scattered throughout the chromatogram. No organic contaminants were identified in the water sample, although the GC-FID scan showed one large unidentified peak.

The Gas Chromatographic-Flame-Ionization Detector scans were useful for graphically characterizing contaminants in water and bed-material samples. The chromatograms, when arranged in downstream order, show how contaminant loads change as a function of travel downstream. This inexpensive method responds to many more organic substances than does a typical priority-pollutant analysis done quantitatively on GC-MS. The method's major drawback is an inability to identify or quantify contaminants. However, in reconnaissance studies of this type, where the focus is on identifying the gross magnitude of suspected contamination problems, the GC-FID data is more comprehensive and can be of more value.

NEEDS FOR FURTHER STUDY

Enough reconnaissance data have been collected on Little Timber and Raccoon Creeks to establish that contamination is a problem in the water and bed material. Additional work needs to focus on detailed assessments of each stream to identify the following: 1) the relationship between hydrology (the rate and direction of water movement) and contaminant transport; 2) the fate of organic contaminants sorbed on suspended and bottom sediments; 3) temporal variations in concentrations of certain toxic contaminants; and 4) the source(s) of toxic contaminants in each watershed.

Because water-quality data for Birch Creek are very limited, additional reconnaissance sampling is needed along the length of the stream to determine whether serious water-quality problems exist.

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GLOSSARY

Chromatographic fingerprint. The characteristic shape of an entire chromatogram, which consists of the number of unknown peaks, their relative retention times, the detector response for each peak, and the shape of the peaks and baseline. Two chromatograms are said to have similar "fingerprints" if the chromatographic conditions that generated each chromatogram are identical, and the quantity, size, and location of their unknown peaks are essentially the same.

Delaware River estuary. That segment of the Delaware Estuary, excluding the bay, from river mile 48.23 at the mouth of the Delaware River to river mile 133 at the head of tide at Trenton, N.J.

Dissolved material. That material in a representative water sample which passes through a 0.45-micrometer membrane filter. This is a convenient operational definition used by Federal agencies that collect water data. Determinations of "dissolved" constituents are made on subsamples of the filtrate.

EPA priority pollutants. A list of 129 substances developed by the U.S. Environmental Protection Agency (Keith and Telliard, 1979) to implement parts of the Federal Water Pollution Control Act (Public Law 92-500) that deal with toxic pollutants in water. These substances include purgeable, acid extractable, and base/neutral extractable organic compounds, pesticides, metals, cyanides, asbestos, and polychlorinated biphenyls (PCB's).

Field-measured characteristics. A phrase used to identify data collected and analyzed in the field when the sample is collected. Temperature, specific conductance, pH, and dissolved oxygen are considered field-measured characteristics in this study.

Gas Chromatography (GC). A process in which the components of a mixture are separated by volatilizing the sample into a carrier gas stream that passes through a stationary phase placed inside a column. Different compounds pass through the column at different rates, thus appearing at the end of the column one after another, where they are detected and measured.

Littoral. Belonging to, inhabiting, or taking place in the ocean or near the shore.

Mass Spectrometry (MS). "A method of chemical analysis in which the substance to be analyzed is placed in a vacuum and reduced to low pressure. The resulting vapor is exposed to a beam of electrons which causes ionization to occur, either of the molecules or their fragments. The ions thus produced are accelerated by an electric impulse and then passed through a magnetic field, where they describe curved paths whose directions depend on the speed and mass-to-charge ratio of the ions. This has the effect of separating the ions according to their mass (electromagnetic separation). Because of their greater kinetic energy, the heavier ions describe a wider arc than the lighter ones, and can be identified on this basis. The ions are collected in appropriate devices as they emerge from the magnetic field" (Hawley, 1981). Mass spectrometry is commonly employed as a detector on a gas chromatograph for the analysis of organic substances in water.

Micrograms per liter (µg/L). A unit expressing the concentration of a chemical constituent in solution as the mass (1 microgram = 1 X 10-6 gram) of solute per unit volume (liter) of water. One µg/L is approximately equal to 1 part per billion (PPB) in aqueous solutions of low dissolved-solids concentration.

Micrograms per gram (µg/g) or kilogram (µg/kg). A unit expressing the concentration of a chemical constituent as the mass (microgram) of the substance sorbed per unit mass (gram/kilogram) of sediment.

Milligrams per liter (mg/L). A unit expressing the concentration of chemical constituents in solution as the mass (1 milligram = 1 X 10^{-3} gram) of solute per unit volume (liter) of water. One mg/L is approximately equal to 1 part per million (PPM) in aqueous solutions of low dissolved-solids concentration.

Minimum detection limit. For a given type of sample and analytical procedure, that concentration value below which the presence of the constituent being analyzed cannot be verified or denied. Minimum detection limits can be identified in the tables of this report by a zero (0) or by a" less than" symbol (<) preceding a numerical value. The reported minimum detection limit can vary from analysis to analysis for any single constituent.

Organic compounds, purgeable (EPA priority pollutants). A group of 31 organic compounds which, because of their volatile nature, can be stripped as a vapor from a water sample via the injection of an inert gas prior to analysis by GC-MS. Two compounds (acrolein and acrylonitrile) of this group remain in the water sample after vapor stripping. These two compounds are analyzed by direct aqueous injection GC-MS. As a group, these 31 compounds are of lower molecular weight than acid or base/neutral extractable compounds, and commonly have higher vapor pressures. Their boiling points are below 150°C.

Sampling vertical. A sampling location that represents the depth of a stream at a single point along the horizontal cross section of a stream or estuary.

Sediment. A solid material that originates mostly from disintegrated rocks and is transformed by, suspended in, or deposited from water; it includes chemical and biochemical precipitates and decomposed organic material such as humus. The quantity, characteristics, and cause of the occurrence of sediment in streams are influenced by degree of slope, length of slope, soil characteristics, land use, and quantity and intensity of precipitation.

Specific conductance. A measure of the ability of a water to conduct an electrical current expressed in microsiemens per centimeter at 25°Celsius. Because specific conductance is related to the number and specific chemical types of ions in solution, it may be used for approximating the dissolved solids concentration of water. Commonly, the amount of dissolved solids (in milligrams per liter) is between 55 and 75 percent of the specific conductance (in microsiemens per centimeter at 25°C). This relationship is not constant from stream to stream, and it may even vary in the same source with changes in the composition of the water.

Surficial bed material. The upper layer (0.1 to 0.2 ft) of unconsolidated material that is deposited on the bottom of a streambed, lake, pond, reservoir, or estuary. Only material that passes through a 2-millimeter sieve is accepted for the chemical analyses described in this text.

10-Year flood plain. The land outside of a stream channel inundated on the average once in 10 years.

Total. The amount of a given constituent in a representative water-suspended sediment sample, regardless of the constituents' physical or chemical form. This term is used only if the analytical procedure assures measurement of at least 95 percent of the constituent in both the dissolved and suspended phases of the sample. A knowledge of the expected form of the constituent in the sample, as well as the analytical methodology used, is required to decide whether the results should be reported as "total." Note that "total" indicates both that the sample consists of a mixture of water-suspended sediment and that the analytical method determines all of the constituent in the sample. The results of analytical procedures which measure less than 95 percent of the constituent present are reported as "total recoverable".

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