CONCENTRATION AND TRANSPORT OF POLYCHLORINATED BIPHENYLS IN THE HOUSATONIC RIVER BETWEEN GREAT BARRINGTON, MASSACHUSETTS, AND KENT, CONNECTICUT, 1984-88

by Kenneth P. Kulp

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MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information, write to:

Chief, Connecticut District
U.S. Geological Survey
450 Main St., Rm. 525
Hartford, CT 06103

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
ton (short)	0.9072	megagram (Mg)
pound (lb)	0.4536	kilogram (kg)

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."

Use of tradenames is for identification purposes only, and does not constitute endorsement by the U.S. Geological Survey or the Connecticut Department of Environmental Protection.

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ABSTRACT

Polychlorinated biphenyls (PCBs) have been found in water, sediment, and fish from the Housatonic River in Connecticut and Massachusetts. Most of the PCBs are contained in the bottom sediments of the river and are transported primarily in association with suspended sediment. Data collected during 1984-88 by the U.S. Geological Survey, in cooperation with the Connecticut Department of Environmental Protection, indicate that a low but detectable concentration of PCBs is present in the waters of the Massachusetts reach of the Housatonic River. The concentration decreases with distance downstream and is generally below the minimum detection level of the analysis, 0.1 micrograms per liter, at Kent, Connecticut.

The mean concentration of PCBs in water is 0.32 micrograms per liter at Great Barrington, Massachusetts, and less than 0.1 micrograms per liter at all sites sampled in Connecticut. At Great Barrington, the Housatonic River is estimated to be transporting 312 pounds of PCBs per year. Because the concentration of PCBs at Kent generally was less than the detection level of the analysis, no accurate calculation of transport rate could be made for this site. Rough estimates of the discharge range from 99 to 276 pounds of PCBs per year.

INTRODUCTION

The presence of polychlorinated biphenyls (PCBs) in the Housatonic River has had a substantial effect on recreational fishing in the Connecticut reach of the river. Prior to 1977, the river between Falls Village and Gaylordsville, Connecticut (fig. 1) was a regional center for trout fishing. In 1977, filets from trout and other fish from the river were found to contain concentrations of PCBs in excess of 5 mg/kg (milligrams per kilogram), which was the U.S. Food and Drug Administration (FDA) tolerance level for human consumption at that time. Consequently, the Connecticut Department of Environmental Protection (DEP) and the Connecticut Department of Health Services posted the river with warnings not to eat the fish. In 1984, the FDA lowered the PCB limit to 2 mg/kg, a concentration that fish in the river may continue to exceed for an indefinite period.

PCBs are a manmade group of toxic organic compounds that are similar in structure to DDT (Connecticut Academy of Science and Engineering, 1978). PCBs were manufactured in the United States from 1929 to 1977 and were used primarily as a coolant in electrical transformers, capacitors, and heat exchangers. Various mixtures of PCBs were marketed commercially under the tradename Aroclor, followed by a four-digit number that identified the mixture (example: Aroclor 1248). PCBs are extremely stable and have a low solubility in water, causing them to be persistent in the environment.

Frink and others (1982) reported that the primary source of PCBs to the Housatonic River was a transformer-manufacturing facility located at Pittsfield, Massachusetts, and that concentrations of PCBs in the river generally decreased with distance downstream from this point. They also reported that most of the PCBs have accumulated in the bottom sediments of the river and are transported primarily in association with suspended sediment.

The DEP began a program in 1984 to improve the understanding of the extent and nature of the PCBs problem in the Connecticut reach of the river and to determine what relations might exist between the concentration of PCBs in fish and invertebrates and the concentration in water. This program includes a cooperative study with the U.S. Geological Survey (USGS) to determine the concentration and transport rate of PCBs in the Housatonic River, conducted during 1984-88, and routine monitoring of concentration of PCBs in fish and invertebrates collected from the river.

Purpose and Scope

This report describes the results of the cooperative study between the USGS and the DEP to determine the concentration and transport rate of PCBs in the Housatonic River. The primary objectives of the study were to determine the concentration of PCBs in water in the river in Connecticut, and to determine the rate that they were being transported downstream. Another objective was to evaluate changes in concentration and transport rate of PCBs that occurred since the previous study conducted in 1979-80 by Frink and others (1982). To meet the objectives, data were collected on streamflow and water samples were collected and analyzed for concentrations of suspended-sediment and PCBs.

The study focused on the Connecticut reach of the Housatonic River in the vicinity of the town of Kent in Litchfield County (fig. 1). This reach was selected because it is an area of prime concern to the fish and invertebrate investigation and had the greatest potential for collecting transport data during storm events. Supplemental data also were collected at several sites on the river located upstream of this reach.

Data-Collection Sites

The primary data-collection station for the study was established at Kent, Connecticut (USGS station 01199290), at a point about 1.2 mi (miles) upstream from the Connecticut Route 341 bridge and 1.6 mi upstream from the confluence with Macedonia Brook. Supplemental data were also collected at the Housatonic River near Great Barrington, Massachusetts (station 01197500), the Housatonic River at Ashley Falls, Massachusetts (station 01198130), the Housatonic River near Canaan, Connecticut (station 01198550), and the Housatonic River near Falls Village, Connecticut (station 01199105). The locations of these sites are shown in figure 1, and relevant information about the sites is given in table 1.

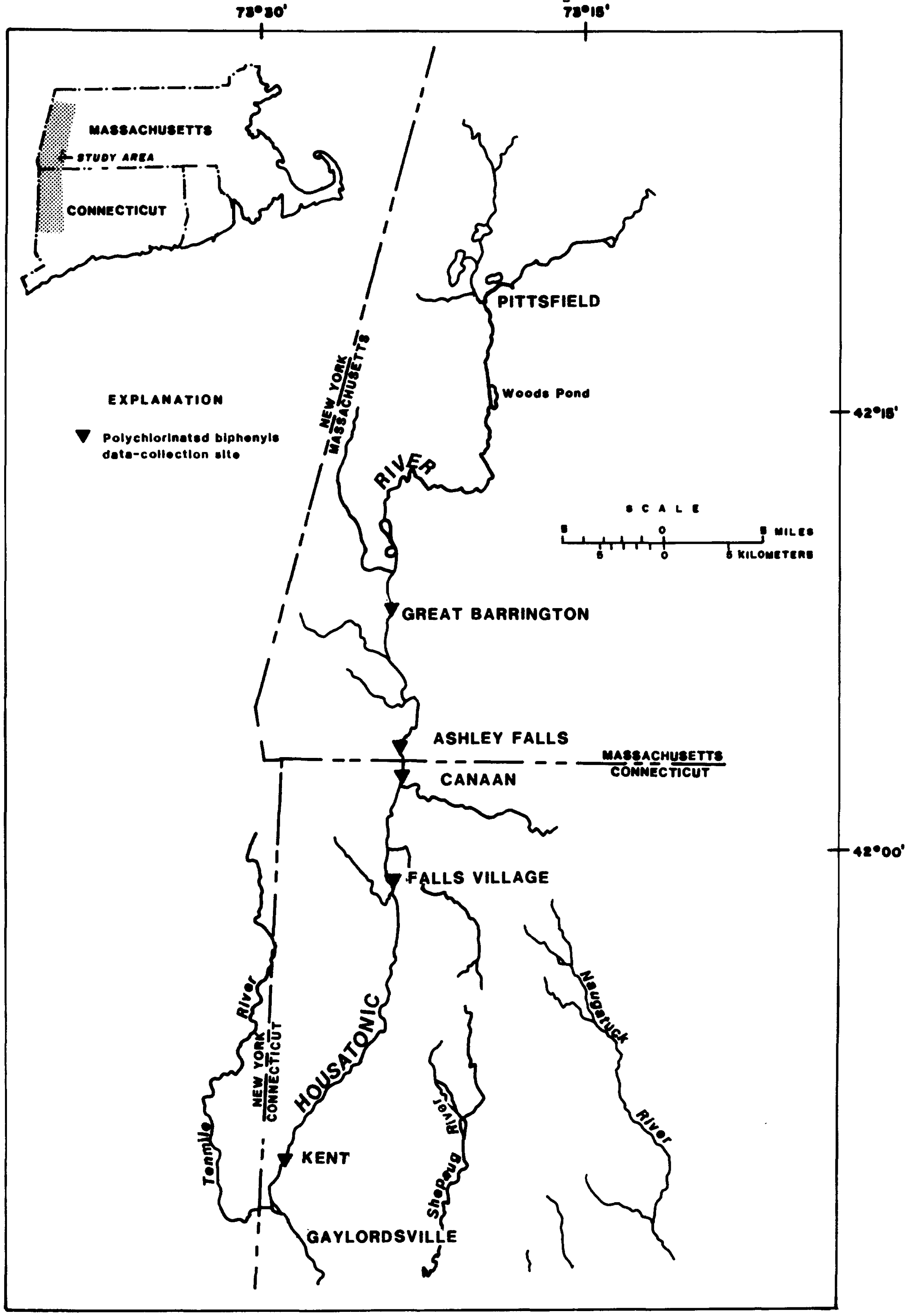

Figure 1.--Locations of polychlorinated biphenyls data-collection sites on the Housatonic River.

Table 1.-- Descriptions of data-collection sites

Site name	USGS station number	Drainage area (square miles)	Latitude (north)	Longitude (west)	Location
Housatonic River near Great Barrington, Massachusetts	01197500	282	42°13'55"	73°21'19"	At Division Street bridge, 2 miles north of Great Barrington, Massachusetts.
Housatonic River at Ashley Falls, Massachusetts	01198130	471	42°03'31"	73°20'57"	At Andrus Road bridge, 0.75 miles west of Ashley Falls, Massachusetts.
Housatonic River near Canaan, Connecticut	01198550	586	42°00'17"	73°21'27"	At U.S. Highway 44 bridge, 2 miles southwest of Canaan, Connecticut.
Housatonic River near Falls Village, Connecticut	01199105	675	41°55'59"	73°21'43"	At U.S. Highway 7 bridge, 1.5 miles south of Falls Village, Connecticut.
Housatonic River at Kent, Connecticut	01199290	756	41°44'30"	73°28'10"	1.2 miles upstream from Connecticut Route 341 bridge and 1 mile northwest of Kent, Connecticut.

METHODS OF DATA COLLECTION AND ANALYSIS

The Kent station was equipped with a continuous stream-stage recorder and a remote-controlled cableway across the river. The cableway was used to measure the streamflow of the river and to collect suspended-sediment and water samples. Suspended-sediment and water samples were collected at all sites by the equal-width-increment method described by Edwards and Glysson (1988). Samples at Kent were collected with a US D-74 sampler (Edwards and Glysson, 1988) suspended from the cableway. Samples were collected at the supplemental sites with a US D-76 sampler (Edwards and Glysson, 1988) suspended from a handline. The sampler was washed with certified reagent-grade hexane and rinsed with native water prior to the collection of each sample. The samples were analyzed by the USGS for suspended-sediment concentration using the methods described by Guy (1969) and for dissolved and total recoverable concentration of individual PCBs by the methods described by Wershaw and others (1987). In this report, the total recoverable concentration of each Arochlor is referred to as the "total" concentration, and the sum of all the individual Aroclor concentrations in a sample is referred to as the "gross" concentration. The "gross" concentration of PCBs was calculated using the larger of the total or the dissolved concentration of the individual PCBs.

Data collection began in June 1984 and continued through September 1988. Previous data (Frink and others, 1982) indicated that the primary mechanism of PCB transport in the river was in association with suspended-sediment. Consequently, most samples were collected during periods of high streamflow when suspended-sediment concentration was greatest. Several samples were also collected during periods of low and moderate streamflow to determine the concentration and transport rate of PCBs during periods without appreciable suspended sediment.

SELECTED HYDROLOGIC CHARACTERISTICS OF THE HOUSATONIC RIVER AT KENT, CONNECTICUT

Streamflow and suspended-sediment characteristics of the Housatonic River are essential factors in evaluating and determining the concentration and transport rate of PCBs. The quantity of PCBs being transported by the river in the suspended and dissolved phases is largely controlled by streamflow. Because most PCBs are transported in association with suspended sediment, the suspended-sediment characteristics of the river are also important.

Streamflow

The streamflow of the Housatonic River at Kent is primarily controlled by the hydropower plant located about 21 mi upstream at Falls Village, Connecticut. Comparisons of the stream-stage records from the gaging stations at Falls Village (01199000) and Kent (01199290) show that the effects of regulation at Falls Village are normally detected at Kent about 6 to 8 hours later. This can be seen in figure 2, which shows the plots of stream stage at the two stations over a typical 3-day period when no precipitation occurred in the drainage basin. Because of the regulation, the streamflow at Kent generally does not reflect natural hydrologic conditions in the drainage basin. Storm-related streamflows upstream of the Falls Village power plant have little effect on streamflow at Kent, except during those periods when streamflows at Falls Village exceed 6,000 ft^3/s (cubic feet per second). Frequency analysis of data from the Falls Village gaging station shows that streamflows exceed 6,000 ft^3/s less than 1 percent of the time. During the period of this study (June 1984 to September 1988), the mean daily streamflow at Kent was 1,319 ft^3/s. The maximum average daily streamflow is estimated to have been 15,800 ft^3/s on June 1, 1984, and the minimum average daily streamflow was 171 ft^3/s on August 26, 1987.

Suspended Sediment

The regulation of streamflow also has a significant effect on suspended-sediment concentration and transport in the Housatonic River. In an unregulated river, increased streamflow is normally related to runoff from precipitation or snow melt; the runoff increases suspended-sediment concentration, primarily by erosion, and increases water velocity and turbulence. Under regulated conditions, such as at Kent, increased streamflows are usually caused by the generation cycle of the upstream hydropower plant and suspended-sediment concentration may or may not increase, depending on the suspended-sediment concentration of the water being released by the hydropower plant, and the quantity of sediment in the river channel available for resuspension. Because there is no natural relation between streamflow and suspended-sediment concentration at Kent, the calculation of mean daily suspended-sediment concentration and sediment discharge was not possible within the scope of the study, and only instantaneous values were determined. These data are published in the annual report series "Water Resources Data, Connecticut" for the water-years 1985, 1986, and 1987 (Cervione and others, 1987, 1988, 1989). During the period of investigation, instantaneous concentration of suspended sediment ranged from 1 to 713 mg/L (milligrams per liter), with a median of 16 mg/L and a mean of 46 mg/L. Instantaneous suspended-sediment discharges ranged from 1 to 16,100 tons/d (tons per day), with a median of 54 tons/d and a mean of 190 tons/d.

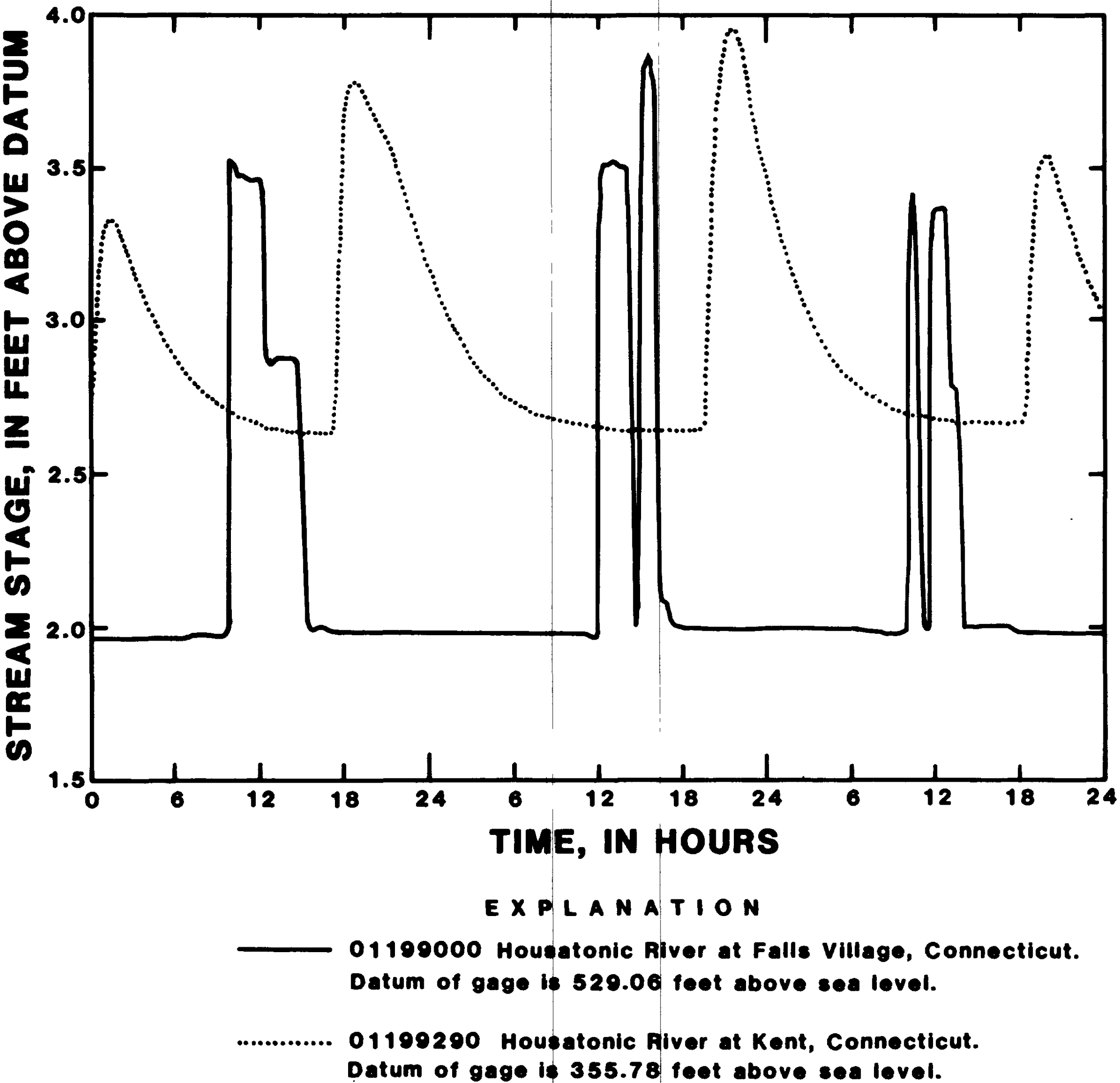

Figure 2.--Stream stage of the Housatonic River at Falls Village and Kent, Connecticut, July 22-24, 1987.

CONCENTRATION AND TRANSPORT OF POLYCHLORINATED BIPHENYLS

The PCB data collected during this study are listed in table 2. The first samples for PCB analysis were collected at the Kent and Great Barrington sites on June 1 and 2, 1984. These samples were collected during extremely high streamflows--about 15,800 ft^3/s at Kent and 7,700 ft^3/s at Great Barrington--caused by a massive rainstorm that occurred during May 28-June 1, 1984. The data from these samples showed that a low, but detectable, concentration of PCBs was present at Great Barrington, but that the concentration at Kent was below the minimum detection level of the analysis, 0.1 μg/L (micrograms per liter). Subsequent samples collected at Kent during moderately high streamflows on August 1 and September 28, 1985, and during low streamflow on August 27, 1985, also contained less than a detectable concentration of PCBs.

Because the concentration of PCBs at Kent was below the minimum detection level during high and low streamflow conditions, while a detectable concentration was found upstream at Great Barrington during high streamflow, additional samples were collected at Great Barrington and several other points upstream from Kent (stations 01198130, 01198550, and 01199105) during various streamflow conditions. The results of subsequent sampling at Kent and the supplemental upstream sites show that the concentration of PCBs decreases with increasing distance downstream from Great Barrington to the point where the concentration is either at or below the minimum detection limit at Kent.

There are several possible reasons for the observed decrease in concentration of PCBs with distance downstream from Great Barrington. Frink and others (1982) reported that concentrations of PCBs in the bottom sediments of the Housatonic River decreased with distance downstream, and that about 60 percent of the total PCBs in the bottom sediments of the river are in the Massachusetts reach of the river, predominantly in the Woods Pond area upstream from Great Barrington. Because these bottom sediments are now the only significant source of PCBs to the river, the concentration of PCBs in the water may relate directly to the concentration found in the bottom sediments near each sampling site. Other possible reasons for the decrease in concentration are dilution by incremental increases in streamflow, adsorption, and deposition of sediment containing PCBs as the water flows downstream. It is likely that a combination of all these factors is responsible for the decrease. Because the streamflow at Kent is normally more than twice that at Great Barrington, dilution alone could reduce the concentration of PCBs at Kent to near or below the minimum detection level, assuming that all the PCBs measured at Great Barrington are transported downstream to Kent. Areas of sediment deposition, such as the Falls Village impoundment, probably trap some of the PCBs that are being transported in the suspended phase, and some of the PCBs in the dissolved phase are probably adsorbed to sediment that is subsequently deposited as the water moves downstream. Because the primary source of PCBs, the bottom sediments, contain a decreasing concentration of PCBs with distance downstream from Woods Pond, a limited amount of PCBs are available to reenter the water column by suspension or desorption.

A similar decrease in the concentration of PCB in water with distance downstream was reported by Frink and others (1982) based on water samples collected in 1979 and 1980 at Great Barrington, Massachusetts, and Falls Village and Gaylordsville, Connecticut. Comparisons of the 1979-80 data with the 1984-88 data show other similarities and some notable differences.

Table 2.--Dissolved, total, and gross polychlorinated biphenyl concentrations for sites on the Housatonic River, June 1984 through September 1988

[--, no data available; PCB, polychlorinated biphenyl; µg/L, micrograms per liter; mg/L, milligrams per liter; <, less than]

Date of sample collection	Time (hours)	Aroclor 1016 PCB dissolved (µg/L)	Aroclor 1016 PCB total (µg/L)	Aroclor 1221 PCB dissolved (µg/L)	Aroclor 1221 PCB total (µg/L)	Aroclor 1232 PCB dissolved (µg/L)	Aroclor 1232 PCB total (µg/L)	Aroclor 1242 PCB dissolved (µg/L)	Aroclor 1242 PCB total (µg/L)
01197500 - Housatonic River near Great Barrington, Massachusetts									
06-01-84	1730	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
01-27-86	1145	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
03-31-87	1315	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
04-05-87	1100	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
08-19-88	0800	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
01198130 - Housatonic River at Ashley Falls, Massachusetts									
01-27-86	1315	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
03-31-87	1410	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
04-05-87	1145	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
08-19-88	1000	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
01198550 - Housatonic River near Canaan, Connecticut									
01-27-86	1400	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
03-31-87	1445	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
04-05-87	1215	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
01199105 - Housatonic River near Falls Village, Connecticut									
01-27-86	1430	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
03-31-87	1530	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
04-05-87	1300	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
08-19-88	1200	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
01199290 - Housatonic River at Kent, Connecticut									
06-02-84	1530	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
08-01-85	1200	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
08-27-85	1115	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
09-28-85	1100	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
09-28-85	1330	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
01-27-86	1115	--	< .1	--	< .1	--	< .1	--	< .1
06-06-86	1300	--	< .1	--	< .1	--	< .1	--	< .1
03-31-87	1645	< .1	< .1	< .1	--	< .1	< .1	< .1	< .1
04-03-87	1630	< .1	< .1	< .1	< .1	< .1	< .1	< .1	.1
04-05-87	1100	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
04-05-87	1520	< .1	< .1	.1	.2	< .1	< .1	< .1	< .1
07-23-87	1455	< .1	< .1	< .1	< ..1	< .1	< .1	< .1	< .1
07-23-87	2130	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
07-23-87	2245	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
08-19-88	1400	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
09-07-88	1500	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1

Table 2.--Dissolved, total, and gross polychlorinated biphenyl concentrations for sites on the Housatonic River, June 1984 through September 1988--Continued

Date of sample collection	Aroclor 1248 PCB dissolved (μg/L)	Aroclor 1248 PCB total (μg/L)	Aroclor 1254 PCB dissolved (μg/L)	Aroclor 1254 PCB total (μg/L)	Aroclor 1260 PCB dissolved (μg/L)	Aroclor 1260 PCB total (μg/L)	Gross PCB (μg/L)	Streamflow, instantaneous (cubic feet per second)	Sediment, suspended (mg/L)
				01197500 - Housatonic River near Great Barrington, Massachusetts					
06-01-84	<0.1	<0.1	0.2	0.1	0.2	0.1	0.4	7,650	67
01-27-86	< .1	< .1	< .1	< .1	< .1	.2	.2	2,200	62
03-31-87	< .1	< .1	< .1	.1	< .1	.2	.3	1,940	41
04-05-87	< .1	< .1	.1	.2	< .1	.3	.5	5,290	113
08-19-88	< .1	< .1	< .1	< .1	.2	.2	.2	153	12
				01198130 - Housatonic River at Ashley Falls, Massachusetts					
01-27-86	< .1	< .1	< .1	< .1	< .1	.1	.1	--	123
03-31-87	< .1	< .1	.1	.1	< .1	< .1	.1	--	91
04-05-87	< .1	< .1	< .1	< .1	< .1	< .1	< .1	--	47
08-19-88	< .1	< .1	< .1	< .1	< .1	.1	.1	--	3
				01198550 - Housatonic River near Canaan, Connecticut					
01-27-86	< .1	< .1	< .1	< .1	< .1	.1	.1	--	186
03-31-87	< .1	< .1	< .1	< .1	< .1	< .1	< .1	--	104
04-05-87	< .1	< .1	< .1	< .1	< .1	< .1	< .1	--	129
				01199105 - Housatonic River near Falls Village, Connecticut					
01-27-86	< .1	< .1	< .1	< .1	< .1	.1	.1	4,980	130
03-31-87	< .1	< .1	< .1	< .1	< .1	< .1	< .1	3,770	92
04-05-87	< .1	< .1	< .1	< .1	< .1	< .1	< .1	9,280	235
08-19-88	< .1	< .1	< .1	< .1	< .1	< .1	< .1	985	10
				01199290 - Housatonic River at Kent, Connecticut					
06-02-84	.1	< .1	< .1	< .1	< .1	< .1	.1	1/15,800	116
08-01-85	< .1	< .1	< .1	< .1	< .1	< .1	< .1	2,550	114
08-27-85	< .1	< .1	< .1	< .1	< .1	< .1	< .1	264	48
09-28-85	< .1	< .1	< .1	< .1	< .1	< .1	< .1	3,640	141
09-28-85	< .1	< .1	< .1	< .1	< .1	< .1	< .1	3,930	164
01-27-86	--	< .1	--	< .1	--	< .1	< .1	5,635	150
06-06-86	--	< .1	--	< .1	--	< .1	< .1	3,860	130
03-31-87	< .1	< .1	< .1	< .1	< .1	< .1	< .1	6,960	339
04-03-87	< .1	< .1	< .1	< .1	< .1	< .1	.1	6,460	94
04-05-87	< .1	< .1	.1	.1	< .1	< .1	.1	11,350	529
04-05-87	< .1	< .1	< .1	< .1	< .1	< .1	.2	11,630	290
07-23-87	< .1	< .1	< .1	< .1	< .1	< .1	< .1	235	5
07-23-87	< .1	< .1	< .1	< .1	< .1	< .1	< .1	1,280	27
07-23-87	< .1	< .1	< .1	< .1	< .1	< .1	< .1	1,080	31
08-19-88	< .1	< .1	< .1	< .1	< .1	< .1	< .1	350	2
09-07-88	< .1	< .1	< .1	< .1	< .1	.1	.1	475	7

1/ Streamflow estimate based on unit-runoff comparisons with gaging stations located upstream and downstream of this site.

The gross concentration of PCBs in water at the Great Barrington and Falls Village sites appears to have remained relatively unchanged. The mean gross PCBs concentration at Great Barrington for the 1979-80 data was 0.25 μg/L, and for the 1984-88 data was 0.32 μg/L. Although the gross concentrations are similar, the Aroclor composition is different. In 1979-80, the predominant PCBs present were 1248 (37 percent) and 1260 (60 percent). In the 1984-88 samples the predominant Aroclors were 1254 (31 percent) and 1260 (69 percent), and Aroclor 1248 was not detected. At Falls Village, PCBs were detected in only one of the four samples collected in 1984-88. The Aroclor present was 1260, at the minimum detection limit of 0.1 μg/L. During the 1979-80 study, concentration of PCBs at Falls Village was also generally at or near the minimum detection level, but it was detected more frequently and Aroclors 1221 and 1248 were present in addition to 1260. Samples for PCBs analyses were not collected at Kent in 1979-80, so no direct comparisons can be made with the 1984-88 data. Data were collected about 6 mi downstream at Gaylordsville in 1979-80, and these data are similar to the data for 1984-88 at Kent with respect to concentration, frequency of detection, and composition of PCBs.

Because the concentration of PCBs in the water samples collected at Kent was generally below the minimum detection level, no accurate calculation of transport rate can be made. Furthermore, estimates of PCB transport made on the basis of relations between concentrations of PCBs and suspended-sediment discharges, such as those used by Frink and others (1982) cannot be made because daily suspended-sediment discharges cannot be calculated because of extensive flow regulation. Only a very rough estimate of the range of annual PCB transport past Kent can be made with the data available from this study, and even these estimates require several assumptions. If it is assumed that all the concentrations of PCB reported as less than the minimum detection level are in fact 0, then the average concentration based on the samples with concentrations at or above the limit is 0.038 μg/L. Using this average concentration and the daily mean streamflow at Kent of 1,319 ft^3/s, the calculated transport rate is 99 lb/yr (pounds per year). This rate would represent the minimum quantity of PCB transported. To estimate the maximum quantity transported, it is assumed that the gross concentration of PCB in each sample reported to contain less than 0.1 μg/L was actually equal to 0.1 μg/L. Based on this assumption, the average PCB concentration is 0.106 μg/L. Again using the daily mean streamflow of 1,319 ft^3/s, the calculated transport rate is 276 lb/yr. The true rate of transport probably lies somewhere between these estimates. The transport rate estimated by Frink and others (1982) for Gaylordsville, based on 1979-80 data, was 265 lb/yr--a rate that falls within the range of these rough estimates.

A better estimate of the transport rate of PCBs can be made for the Housatonic River at Great Barrington. Although the number of samples collected at this site limits the overall accuracy of the estimate, all the samples contained concentrations of some PCBs at or above the minimum detection level, precluding the need for assumptions about "less than detection level" concentrations for gross concentration of PCBs. Again, the lack of daily suspended-sediment records eliminates the ability to use the same methodology that Frink and others (1982) used to estimate PCB transport at this site with the 1979-80 data. Using the average concentration of PCBs calculated from the 1984-88 samples of 0.32 μg/L and the daily mean streamflow of the Housatonic River during that period of 496 ft^3/s, the estimated PCB transport rate at Great Barrington is 312 lbs/yr. This seems reasonable based on the transport rate of 490 lb/yr estimated by Frink and others (1982) for the 1979-80 period. The apparent decrease in the transport rate of PCBs could be related to a decrease in the quantity of PCBs available for transport from upstream sources such as the Woods Pond area, or it could be caused by inaccuracies in the estimates of transport rate. More data would be necessary to determine the actual transport rate and if it is decreasing.

SUMMARY

Data collected during 1984-88 from the Housatonic River in Connecticut and Massachusetts show that a low but detectable concentration of PCBs are present in the waters of the Massachusetts reach of the river, and that this concentration decreases with increasing distance downstream.

The streamflow of the Housatonic River at Kent was found to be highly controlled by the hydropower plant located upstream at Falls Village. Because of the streamflow regulation, no empirical relation was found between streamflow and suspended-sediment concentration in the river at Kent; such a relation could only be calculated. The instantaneous suspended-sediment concentration ranged from 1 to 713 mg/L, with a median of 16 mg/L and a mean of 46 mg/L. The instantaneous suspended-sediment discharges ranged from 1 to 16,100 tons/d, with a median of 54 tons/d and a mean of 190 tons/d.

At Kent, Connecticut, the site farthest downstream, the concentration of PCBs was generally below or at the minimum detection level of 0.1 μg/L. A similar decrease in the concentration of PCBs in water with distance downstream in the Housatonic River was reported in a previous study on the basis of data collected in 1979 and 1980. The reasons for the decrease are believed to be related to the concentration of PCBs found in the bottom sediments in the immediate vicinity of each sampling site, and to dilution by incremental increases in streamflow, adsorption, and deposition of sediment containing PCBs as the water flows downstream.

The mean concentration of PCBs in water in the Housatonic River at Great Barrington, Massachusetts was 0.32 μg/L in 1984-88 and 0.25 μg/L in 1979-80. Farther downstream in Connecticut, the mean concentration of PCBs in water was less than 0.1 μg/L in both the 1984-88 and 1979-80 samplings. A notable difference between PCBs in samples collected during these two periods is the composition of PCB Aroclors found at Great Barrington, Massachusetts, and at Falls Village, Connecticut. In 1979-80, the predominant PCB Aroclors found at Great Barrington were 1248 and 1260, whereas in 1984-88, the predominant Aroclors were 1254 and 1260. At Falls Village, Aroclors 1221, 1248, and 1260 were found in 1979-80, but only Aroclor 1260 was detected in 1984-88.

The quantity of PCBs being transported in the Housatonic River at Great Barrington is estimated to be 312 lb/yr on the basis of the 1984-88 data. A previous estimate of the transport rate of PCBs was 490 lb/yr at this site for the 1979-80 period. The transport rate of PCBs at Kent cannot accurately be determined from the available data primarily because most of the samples had concentrations of PCBs that were less than the minimum detection level of 0.1 μg/. A rough estimate of the range of PCBs transport is 99 lb/yr to 276 lb/yr. A previous estimate of the PCB transport rate was 265 lb/yr at Gaylordsville, 6 mi downstream from Kent during 1979-80.

REFERENCES CITED

Cervione, M.A., Jr., Weiss, L.A., Bohr, J.R., and Bingham, J.W., 1987, Water resources data, Connecticut, water year 1985: U.S. Geological Survey Water-Data Report CT-85-1, 279 p.

_____1988, Water resources data, Connecticut, water year 1986: U.S. Geological Survey Water-Data Report CT-86-1, 263 p.

_____1989, Water resources data, Connecticut, water year 1987: U.S. Geological Survey Water-Data Report, CT-87-1, 295 p.

Connecticut Academy of Science and Engineering, 1978, PCB and the Housatonic River, a review and recommendations: Hartford, Connecticut, Connecticut Academy of Science and Engineering, 24 p.

Edwards, T.K., and Glysson, G.D., 1988, Field methods for measurement of fluvial sediment: U.S. Geological Survey Open-File Report 86-531, 118 p.

Frink, C.R., Sawhney, B.L., Kulp, K.P., and Fredette, C.G., 1982, Polychlorinated biphenyls in Housatonic River sediments in Massachusetts and Connecticut; determination, distribution, and transport: Connecticut Agricultural Experiment Station Bulletin 800, 20 p.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter C1, 58 p.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., editors, 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter A3, 80 p.

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