SEMIVOLATILE ORGANIC COMPOUNDS IN STREAMBED SEDIMENT FROM THE RICHLAND CREEK BASIN, ARKANSAS, 1999

by James C. Petersen

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Semivolatile Organic Compounds in Streambed Sediment from the Richland Creek Basin, Arkansas, 1999

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ABSTRACT

Streambed-sediment samples were collected from 11 sites in the Richland Creek Basin and 3 sites on the Buffalo River and Bear Creek in 1999 for analysis of semivolatile organic compounds. The sites were sampled to better characterize the distribution of semivolatile organic compounds after 23 compounds were detected in a sample collected from Richland Creek in 1992.

In 1999, the highest numbers of detected semivolatile organic compounds and the highest total concentrations of semivolatile organic compounds generally occurred in samples collected at sites on Richland Creek and Falling Water Creek just upstream and downstream from the confluence of Falling Water Creek and Richland Creek. Total concentrations in samples from these sites and another site on Falling Water Creek (about 6 river miles upstream) ranged from 115 to 323 µg/kg. Twelve to 22 compounds were detected.

The numbers of detected compounds and total concentration of semivolatile organic compounds in the samples from the Buffalo River and Bear Creek generally were lower than in samples from the area near the confluence of Falling Water and Richland Creeks. However, 746 µg/kg of *p*-cresol was detected in one sample from the Buffalo River just upstream from the confluence with Richland Creek.

Total concentrations of semivolatile organic compounds at the sites on Falling Water Creek, on Richland Creek near the confluence with Falling Water Creek, and on the Buffalo River just upstream from Richland Creek ranged from approximately 1/2 to 1/17 of the concentrations at two sites downstream from major urban areas sampled in 1992. Concentrations did not exceed aquatic-life criteria. However, criteria do not exist for 18 compounds detected in samples from Richland Creek, Falling Water Creek, Buffalo River, and Bear Creek.

Three phthalate compounds were found in all samples collected in 1999. These three compounds are commonly detected in laboratory blanks.

Most of the detected compounds are polycyclic aromatic hydrocarbons. Sources and uses of detected semivolatile organic compounds include plasticizers, solvents, resins, dyes, oils, coal, and combustion products. Parts of the study area are underlain by geologic formations containing carbonaceous shales and thin coal beds.

INTRODUCTION

This report describes analytical results of a study of semivolatile organic compound (SVOC) concentrations in streambed sediment from the Richland Creek Basin in northern Arkansas. It was prepared in cooperation with the National Park Service.

SVOCs (which include phthalates, phenols, and polycyclic aromatic hydrocarbons) are present in many products. Sources and uses of SVOCs include plasticizers, solvents, resins, dyes, oils, coal, and combustion products. Polycyclic aromatic hydrocarbons (PAHs) are produced primarily by burning gasoline, oil, wood, and other fuels (Lopes and Dionne, 1998). Petroleum hydrocarbons, oil and grease, and PAHs in crankcase oil and vehicle emissions are the major SVOCs detected in highway runoff and urban stormwater (Lopes and Dionne, 1998).

Streambed-sediment samples were previously collected and analyzed for SVOCs by the U.S. Geological Survey (USGS) as part of a National Water-Quality Assessment (NAWQA) Program study of the Ozark Plateaus (Bell and others, 1997; Petersen and others, 1998; 1999). During that study, samples were collected in 1992-95 from 27 sites, including one site on Richland Creek.

The site on Richland Creek was one of three sites at which more than 16 SVOCs were detected in samples collected during the NAWQA study. The other two

sites were downstream from major urban areas (Center Creek, downstream from Joplin, Mo.; James River, downstream from Springfield, Mo.). The estimated concentration of the 23 compounds detected at the Richland Creek site was 654 micrograms per kilogram (µg/kg), and estimated concentrations from the two urban area sites each totaled about 1,900 µg/kg.

The distribution of concentrations of SVOCs at other sites sampled throughout the Ozark Plateaus are shown in Petersen and others (1998, p. 27-29). National ranges (from samples collected as part of the NAWQA Program) are also shown for comparison.

Purpose and Scope

The number of compounds detected at the Richland Creek site during the NAWQA Program study (Bell and others, 1997) was a concern to the National Park Service. As a result, the USGS and National Park Service cooperatively began a study to better characterize the distribution and concentration of SVOCs in streambed sediment from the Richland Creek Basin. The purposes of this report are to document the concentrations of SVOCs in samples from the Richland Creek Basin area, and to compare concentrations in samples collected in 1992 and 1999 from the Richland Creek Basin with concentrations in samples from three nearby sites sampled in 1999 and in samples collected from two sites downstream from urban areas in 1992.

Eleven sites were sampled on Richland Creek and its largest tributary, Falling Water Creek (fig. 1). Nine sites were sampled along Richland Creek, usually spaced about 2 to 4 river miles apart; one of these sites (RC4) was the same site sampled in 1992. Two sites were sampled on Falling Water Creek. These 11 sites were sampled to investigate the distribution of SVOCs upstream and downstream from the site sampled in 1992.

Two sites were sampled on the Buffalo River (one immediately upstream and one immediately downstream from the mouth of Richland Creek) and one site was sampled on Bear Creek downstream from Marshall, Arkansas (fig. 1). The two sites on the Buffalo River were sampled to allow comparison of SVOC concentrations in streambed sediment upstream and downstream from Richland Creek. The site on Bear Creek was sampled so that the sediment quality of Richland Creek and the Buffalo River could be compared to that of a more populated basin.

Sites were each sampled once during May-June 1999. Two separate duplicate samples were collected at two of the sites (RC4 and RC8).

Description of the Study Area

Richland Creek (fig. 1) is one of the largest tributaries of the Buffalo River. Richland Creek has a drainage area of approximately 131 square miles (Sullavan, 1974). Much of the drainage area is within the Ozark National Forest or the Buffalo National River. At site RC4 land use is approximately 97 percent forest (Femmer, 1997). Few wild fires or prescribed burns have occurred in the area upstream of RC4 since 1989 and the largest (a prescribed burn of about 110 acres) occurred in 1992 about 2 miles southeast of RC4 (Craig Hilburn, U.S. Forest Service, oral commun., 1999). The area is sparsely populated; there are only a few unincorporated communities (including Ben Hur, Eula, Lurton, Pelsor, and Witts Springs) within the Richland Creek Basin. Nine streambed-sediment sampling sites are located on Richland Creek (fig. 1, table 1). Falling Water Creek (fig. 1) is the largest tributary of Richland Creek and has a drainage area of approximately 23 square miles (Sullavan, 1974). Two sites are located on Falling Water Creek (fig. 1, table1).

Two sites are located on the Buffalo River, immediately upstream and downstream from the mouth of Richland Creek (fig. 1, table 1). Just upstream from the mouth of Richland Creek, the Buffalo River has a drainage area of approximately 601 square miles (Sullavan, 1974). Land use is approximately 88 percent forest (Femmer, 1997).

One site is located on Bear Creek (fig. 1, table1), another tributary of the Buffalo River. At this site, Bear Creek has a drainage area of approximately 64 square miles (Sullavan, 1974). The site is about 4 river miles downstream from Marshall, Arkansas, a town of about 1,300 (Mary McFarland, Census State Data Center, written commun., 1999) that lies partially within the Bear Creek Basin. About 64 percent of the basin is forested; most of the remainder is pasture (Steele and Mott, 1998).

Most of the Falling Water Creek Basin and the upstream parts of Richland and Bear Creek Basins is primarily underlain by the Bloyd Shale and to a lesser extent by the Atoka Formation (Haley, 1993). Falling Water Creek drains an area underlain by a greater extent of the Atoka Formation. Croneis (1930)

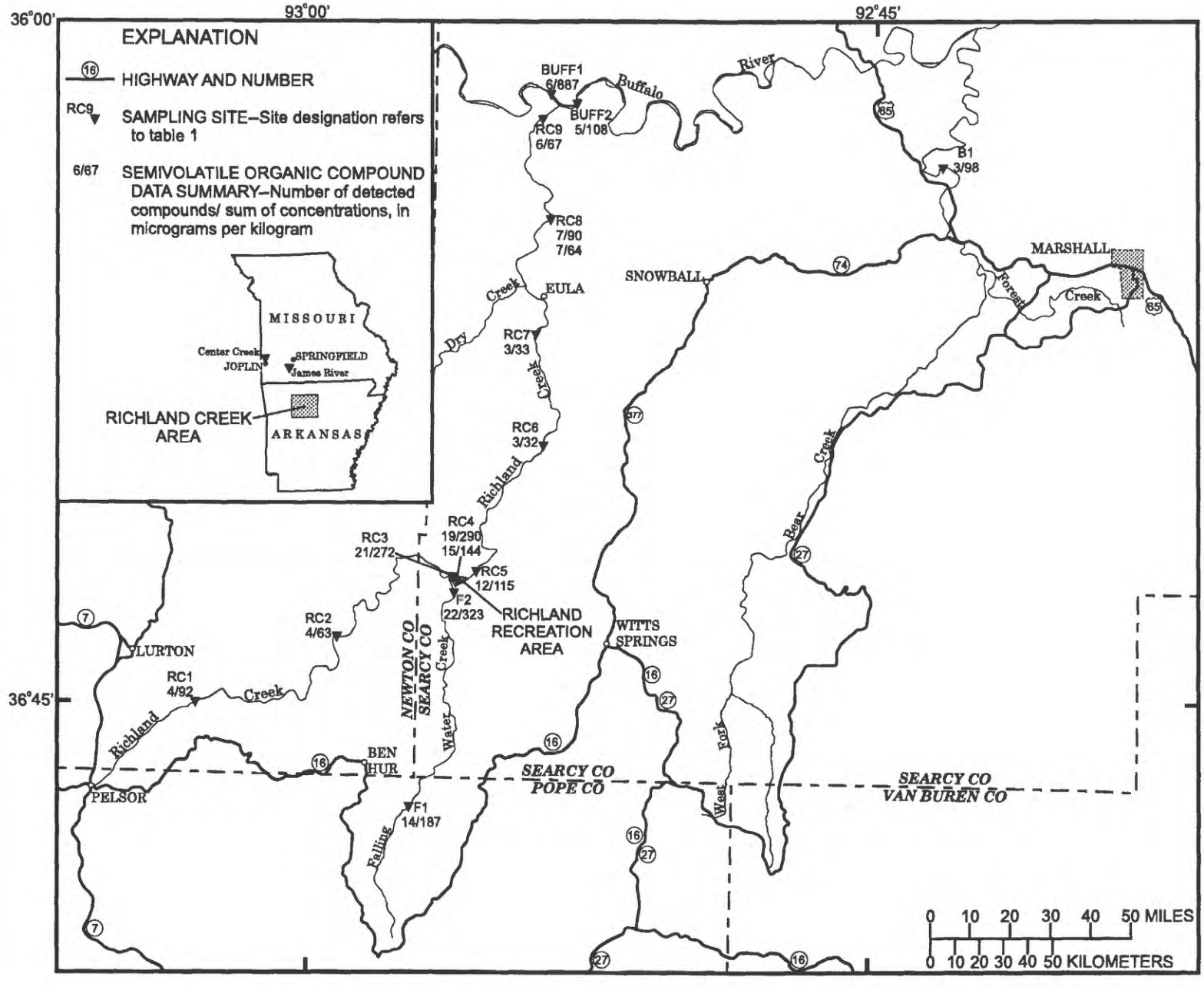

Figure 1. Location of streambed-sediment sampling sites and summary of semivolatile organic compound data, 1999.

Table 1. Streambed-sediment sample site information

Site designation (see figure 1)	USGS station identification number	Station name	Location (Township, Range, Section)
RC1	07055867	Richland Creek near Lurton	T. 13 N., R. 19 W., sec. 30
RC2	07055868	Richland Creek near Ben Hur	T. 13 N., R. 19 W., sec. 15
RC3	07055869	Richland Creek upstream of Richland Recreation Area	T. 13 N., R. 18 W., sec. 6
RC4	07055875	Richland Creek near Witts Springs	T. 13 N., R. 18 W., sec. 6
RC5	07055876	Richland Creek downstream of Richland Recreation Area	T. 13 N., R. 18 W., sec. 5
RC6	07055878	Richland Creek near Magic Springs	T. 14 N., R. 18 W., sec. 21
RC7	07055881	Richland Creek near Snowball	T. 14 N., R. 18 W., sec. 4
RC8	07055885	Richland Creek at Eula	T. 15 N., R. 18 W., sec. 23
RC9	07055887	Richland Creek north of Eula	T. 15 N., R. 18 W., sec. 9
F1	07055872	Falling Water Creek near Ben Hur	T. 12 N., R. 19 W., sec. 1
F2	07055874	Falling Water Creek near Witts Springs	T. 13 N., R. 18 W., sec. 7
BUFF1	07055865	Buffalo River near Eula	T. 15. N., R. 18 W., sec. 4
BUFF2	07055888	Buffalo River just downstream from Richland Creek near Eula	T. 15 N., R. 18 W., sec. 3
B1	07056510	Bear Creek near Marshall	T. 15 N., R. 16 W., sec. 17
Center	07186480	Center Creek near Smithfield, Mo.	T. 28 N., R. 34 W., sec.14
James	07052250	James River near Boaz, Mo.	T. 27 N., R. 22 W., sec.32

describes the Atoka Formation as a series of beds of sandstone and ordinarily black and carbonaceous shale. Thin beds of coal occur in the shaly parts of the Atoka Formation. Croneis (1930) describes the shale of the Bloyd Shale as consisting mostly of black, carbonaceous shale and including some coal seams. The remaining parts of the study area are underlain by formations composed mostly of sandstone, limestone, and dolomite (Croneis, 1930; Haley, 1993).

METHODS

Samples were collected and processed using the same procedures (Shelton and Capel, 1994) used in the previous NAWQA Program study (Bell and others, 1997). Streambed sediment was collected and composited from more than 25 locations at each site using a beveled teflon cylinder as a scoop. Care was taken to avoid areas where the sediment appeared to be from local bank erosion. Composited samples were placed in a glass bowl, thoroughly mixed, and then sieved through a 2-millimeter mesh stainless steel sieve. The teflon cylinder, glass bowl, sieve, and other materials were washed using phosphate-free detergent, native water, and residue-grade methanol prior to sampling. Samples were then chilled on ice to 4 degrees Celsius and shipped for analysis.

Samples were analyzed at the USGS National Water Quality Laboratory in Denver, Colorado using a method described by Furlong and others (1996). The reporting limit for each compound was 50 µg/kg, however, most compounds can often be reliably detected at lower concentrations. Detected concentrations less than the nominal reporting limit of 50 µg/kg are reported as "estimated concentrations" in this report.

RESULTS

Streambed-sediment samples were analyzed for a total of 64 compounds (tables 2 and 3). Thirty compounds were detected in 1992 or 1999 at one or more sites in the Richland Creek Basin (table 2). Compounds not detected at any of the Richland Creek, Falling Water Creek, Buffalo River, or Bear Creek sites are listed in table 3. The concentration and number of

Table 2. List of semivolatile compounds detected in streambed-sediment samples from Richland Creek, Falling Water Creek, Buffalo River, and Bear Creek

[All of these compounds were detected in samples from the Richland Creek Basin (includes Falling Water Creek); some compounds were also detected in samples from the other streams. CAS, chemical abstract system; PAH, polycyclic aromatic hydrocarbon]

Compound name	CAS number	Compound class	Compound name	CAS number	Compound class
acenaphthene	83-32-9	PAH	1,6-dimethylnaphthalene	575-43-9	PAH
benz[*a*]anthracene	56-55-3	PAH	2,6-dimethylnaphthalene	581-42-0	PAH
benzo[*b*]fluoranthene	205-99-2	PAH	di-*n*-octylphthalate	117-84-0	phthalate
benzo[*k*]fluoranthene	207-08-9	PAH	fluoranthene	206-44-0	PAH
benzo[*ghi*]perylene	191-24-2	PAH	9-H fluorene	86-73-7	PAH
benzo[*a*]pyrene	50-32-8	PAH	indeno[1,2,3-*cd*]pyrene	193-39-5	PAH
bis(2-ethylhexyl)phthalate	117-81-7	phthalate	2-methylanthracene	613-12-7	PAH
butylbenzylphthalate	85-68-7	phthalate ester	1-methyl-9H-fluorene	1730-37-6	PAH
chrysene	218-00-9	PAH	1-methylphenanthrene	832-69-9	PAH
p-cresol	106-44-5	phenol	1-methylpyrene	2381-21-7	PAH
dibenz[*a,h*]anthracene	53-70-3	PAH	naphthalene	91-20-3	PAH
dibenzothiophene	132-65-0	PAH	phenanthrene	85-01-8	PAH
di-*n*-butylphthalate	84-74-2	phthalate ester	phenol	108-95-2	phenol
diethylphthalate	84-66-2	phthalate ester	pyrene	129-00-0	PAH
1,2-dimethylnaphthalene	573-98-8	PAH	2,3,6-trimethylnaphthalene	829-26-5	PAH

Table 3. List of semivolatile compounds not detected in streambed-sediment samples from Richland Creek, Falling Water Creek, Buffalo River, and Bear Creek

[CAS, chemical abstract system; PAH, polycyclic aromatic hydrocarbon; MAH, monocyclic aromatic hydrocarbon]

Compound name	CAS number	Compound class	Compound name	CAS number	Compound class
[1]acenaphthylene	208-96-8	PAH	*o*-dichlorobenzene	95-50-1	MAH
acridine	206-94-6	araarene	*p*-dichlorobenzene	106-46-7	MAH
C8-alkylphenol	--	phenol	3,5-dimethylphenol	108-68-9	phenol
[1]anthracene	120-12-7	PAH	dimethylphthalate	131-11-3	phthalate ester
[1]anthraquinone	84-65-1	PAH	2,4-dinitrotoluene	121-14-2	MAH
[1]azobenzene	103-33-3	mono-aromatic nitrogen	2,6-dinitrotoluene	606-20-2	MAH
benzo[*c*]cinnoline	230-17-1	PAH	isophorone	78-59-1	base neutral acid
2,2-biquinoline	119-91-5	PAH	isoquinoline	119-65-3	araarene
bis(2-chloroethoxy)methane	111-91-1	ether	4,5-methylenephenanthrene	203-64-5	PAH
bis(2-chloroethyl)ether	111-44-4	ether	[1]nitrobenzene	98-95-3	MAH
[1]4-bromophenylphenylether	101-55-3	ether	[1]*n*-nitrosodiphenylamine	621-64-7	nitrosamine
[1]carbazole	86-74-8	PAH	*n*-nitrosodi-*n*-propylamine	86-30-6	nitrosamine
4-chloro-3-methylphenol	59-50-7	phenol	pentachloroanisole	1827-21-4	MAH
2-chloronaphthalene	91-58-7	PAH	pentachloronitrobenzene	82-68-8	MAH
2-chlorophenol	95-57-8	phenol	phenanthridine	229-87-8	PAH
[1]4-chlorophenylphenylether	7005-72-3	ether	quinoline	91-22-5	araarene
m-dichlorobenzene	541-73-1	MAH	1,2,4-trichlorobenzene	120-82-1	MAH

[1]Compounds among those detected at Center Creek or James River.

detected compounds at each site are listed in table 4. Similar information is listed for samples from the sites on Center Creek (downstream from Joplin, Mo.) and the James River (downstream from Springfield, Mo.). Unless specifically noted, the following summary of results applies only to the samples collected in 1999.

In general, the highest number of detected compounds and the highest total concentrations (values at all 16 sites are estimated values) of SVOCs were from samples collected just upstream and downstream from the confluence of Falling Water and Richland Creeks (fig. 1, table 4). The number of compounds detected ranged from 3 (at sites RC6, RC7, and B1) to 22 (at site F2). The total concentration of SVOCs ranged from 32 µg/kg (at site RC6) to 887 µg/kg (at site BUFF1). Total concentrations at sites F2, RC3, RC4, and RC5 just upstream or downstream from the confluence of Falling Water and Richland Creeks ranged from 115 to 323 µg/kg. The total concentration of SVOCs at site F1, about 6 river miles upstream from the mouth of Falling Water Creek, was 187 µg/kg.

The number of detected compounds and total concentrations of SVOCs collected at site RC4 (in 1999) are less than they were in 1992. The numbers of compounds detected in 1999 were 15 and 19 compared to 23 in 1992. The total concentrations of SVOCs in 1999 were 144 and 290 compared to 654 µg/kg in 1992.

The numbers of detected compounds, concentrations of individual detected compounds and total concentrations of semivolatile organic compounds in samples at the two sites on the Buffalo River (BUFF1 and BUFF2) and Bear Creek (B1) generally were lower than in samples from sites near the confluence of Falling Water and Richland Creeks, but higher than samples from many of the other sites on Richland Creek. However, the sample from the Buffalo River site (BUFF1) just upstream from Richland Creek contained 746 µg/kg of *p*-cresol; this site had the highest total concentration of SVOCs.

The total concentrations of SVOCs at the sites on Center Creek and the James River (downstream from Joplin and Springfield, Mo., respectively) range from approximately 3 to 17 times higher than total concentrations at sites F1, F2, RC3, RC4 (1992 and 1999), and RC5. The total concentrations at the sites on Center Creek and the James River are approximately two times higher than the total concentration at site BUFF1.

Three phthalate compounds, bis(2-ethylhexyl)phthalate, di-*n*-butylphthalate, and butylbenzylphthalate were found in all samples collected in 1999. Bis(2-ethylhexyl)-phthalate and di-*n*-butylphthalate were detected in every sample collected as part of the previous NAWQA Program study and "... are probably laboratory or field processing contaminants" (Bell and others, 1997). Gilliom and others (1998) report that the 95th percentile concentration of these three compounds in laboratory blanks associated with samples from 226 NAWQA sampling sites (including those sites discussed by Bell and others, 1997) were:

bis(2-ethylhexylphthalate)100 µg/kg
di-*n*-butylphthalate54 µg/kg
butylbenzylphthalate64 µg/kg.

Although criteria were not determined for 18 of the compounds detected in samples from Richland Creek, Falling Water Creek, Buffalo River, and Bear Creek, concentrations did not exceed aquatic-life criteria (table 5) used by the NAWQA Program to evaluate concentrations of SVOCs in bed sediment (Gilliom and others, 1998). Gilliom and others (1998) determined criteria using a method described by the U.S. Environmental Protection Agency (1996) for establishing concentrations that have a high probability of adverse effects on aquatic life.

Most of the detected compounds are PAHs. Sources and uses of detected SVOCs include plasticizers, solvents, resins, dyes, oils, coal, and combustion products (table 6).

Table 4. Concentrations and numbers of detected semivolatile organic compounds in streambed-sediment samples

[Refer to figure 1 and table 1 for site locations. Shaded columns correspond with compounds detected only at Center Creek or James River. Concentrations are in micrograms per kilogram, dry weight. <, less than; E is estimated]

Site	Acenaphthene	Acenaphthylene	Anthracene	Anthraquinone	Azobenzene	Benz[*a*]anthracene	Benzo[*b*]fluoranthene	Benzo[*k*]fluoranthene	Benzo[*g,h,i*]perylene	Benzo[*a*]pyrene
RC1	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
RC2	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
RC3	<50	<50	<50	<50	<50	<50	E5.8	<50	E28	<50
F1	<50	<50	<50	<50	<50	<50	<50	<50	E4.5	<50
F2	<50	<50	<50	<50	<50	<50	E7.3	<50	E30	E5.5
RC4	<50	<50	<50	<50	<50	<50	<50	<50	E29	<50
RC4	<50	<50	<50	<50	<50	<50	<50	<50	E27	E14
RC4[1]	E9.2	<50	<50	<50	<50	E41	E35	E37	<50	<50
RC5	<50	<50	<50	<50	<50	<50	E7.2	<50	E27	<50
RC6	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
RC7	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
RC8	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
RC8	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
RC9	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
BUFF1	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
BUFF2	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
B1	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Center[1]	<50	<50	E11	<50	<50	E34	E42	E18	<50	<50
James[1]	E11	E22	E34	E44	E29	84	110	94	88	91

Site	Bis(2-ethylhexyl)phthalate	4-bromophenyl-phenylether	Butylbenzylphthalate	Carbazole	4-chlorophenyl-phenylether	Chrysene	p-cresol	Dibenz[a,h]anthracene	Dibenzothiophene	*Di-n*-butylphthalate
RC1	E33	<50	E29	<50	<50	<50	<50	<50	<50	E19
RC2	E9.8	<50	E32	<50	<50	<50	<50	<50	<50	E16
RC3	E6.8	<50	E22	<50	<50	E1.2	E13	E29	E16	E12
F1	E26	<50	E42	<50	<50	E19	<50	E7.9	<50	E13
F2	E14	<50	E38	<50	<50	E2.6	E13	E30	E18	E31
RC4	E14	<50	E35	<50	<50	E2.3	E45	E30	E17	E22
RC4	E9.7	<50	E17	<50	<50	E2.6	E14	<50	<50	E12
RC4[1]	66	<50	50	<50	<50	E39	E18	<50	<50	E44
RC5	E8.2	<50	E16	<50	<50	<50	E23	<50	<50	E11
RC6	E9.5	<50	E9.8	<50	<50	<50	<50	<50	<50	E13
RC7	E4.2	<50	E17	<50	<50	<50	<50	<50	<50	E12
RC8	E13	<50	E36	<50	<50	<50	E11	<50	<50	E21
RC8	E9.5	<50	E23	<50	<50	<50	E8.8	<50	<50	E16
RC9	E15	<50	E34	<50	<50	E2.9	<50	<50	<50	E6.7
BUFF1	E13	<50	E23	<50	<50	<50	746	<50	<50	E20
BUFF2	50	<50	E21	<50	<50	<50	E17	<50	<50	E15
B1	50	<50	E31	<50	<50	<50	<50	<50	<50	E17
Center[1]	50	<50	<50	<50	<50	65	1,300	<50	E11	E36
James[1]	76	E26	54	E20	E24	120	130	64	E19	E49

[1]Sample collected in August 1992.

Table 4. Concentrations and numbers of detected semivolatile organic compounds in bed-sediment samples from the Richland Creek Basin and other nearby sites--Continued

Site	Diethyl-phtha-late	1,2-di-methyl-naptha-lene	1,6-di-methyl-naptha-lene	2,6-di-methyl-naptha-lene	Di-*n*-octyl-phtha-late	Fluo-ran-thene	9H-fluo-rene	Indeno-[1,2,3-*cd*]-pyrene	2-methyl-anthra-cene	1-methyl-9H-fluorene	1-methyl-phenan-threne
RC1	<50	<50	<50	<50	E11	<50	<50	<50	<50	<50	<50
RC2	<50	<50	<50	<50	E5.3	<50	<50	<50	<50	<50	<50
RC3	<50	<50	E18	E24	E13	<50	E1.5	E25	<50	E19	E6.4
F1	E7.0	<50	<50	E7.0	E8.4	E10	E2.0	<50	<50	<50	E3.3
F2	<50	<50	E5.9	E15	E18	<50	E5.3	E27	<50	E21	E5.6
RC4	<50	<50	E3.4	E14	<50	<50	E.3	E26	<50	E17	E5.1
RC4	<50	<50	E4.7	E14	<50	<50	E1.2	<50	<50	<50	E4.7
RC4[1]	E16	E5.4	E16	E16	<50	E32	E18	<50	E32	E20	E29
RC5	<50	<50	<50	<50	<50	<50	E1.0	<50	<50	<50	E3.4
RC6	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
RC7	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
RC8	<50	<50	<50	E5.5	<50	<50	<50	<50	<50	<50	E1.0
RC8	<50	<50	<50	E3.7	<50	<50	<50	<50	<50	<50	E.5
RC9	E4.8	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
BUFF1	<50	<50	<50	E30	<50	<50	<50	<50	<50	<50	<50
BUFF2	<50	<50	<50	E5.5	<50	<50	<50	<50	<50	<50	<50
B1	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Center[1]	<50	<50	E33	71	<50	77	<50	E19	<50	<50	<50
James[1]	E18	E6	E16	E12	<50	130	E20	110	E31	<50	E34

Site	4,5-methylene-phenan-threne	1-methyl-pyrene	Naptha-lene	Nitro-ben-zene	*n*-nitro-sodi-phenyl-amine	Phen-an-threne	Phenol	Pyrene	2,3,6-tri-methyl-naphtha-lene	Number of detected compounds	Total esti-mated concen-tration
RC1	<50	<50	<50	<50	<50	<50	<50	<50	<50	4	92
RC2	<50	<50	<50	<50	<50	<50	<50	<50	<50	4	63
RC3	<50	E7.3	<50	<50	<50	E12	E3.8	E.7	E7.0	21	272
F1	<50	<50	<50	<50	<50	E30	<50	E7.3	<50	14	187
F2	<50	E7.6	<50	<50	<50	E21	E.5	E1.8	E4.9	22	323
RC4	<50	E7.5	<50	<50	<50	E11	E6.6	E.9	E4.4	19	290
RC4	<50	<50	E6.4	<50	<50	E12	E4.2	E1.2	<50	15	144
RC4[1]	<50	E37	E6.3	<50	<50	E29	<50	E36	E22	23	654
RC5	<50	<50	E5.2	<50	<50	E8.5	E3.9	E.5	<50	12	115
RC6	<50	<50	<50	<50	<50	<50	<50	<50	<50	3	32
RC7	<50	<50	<50	<50	<50	<50	<50	<50	<50	3	33
RC8	<50	<50	<50	<50	<50	<50	E2.5	<50	<50	7	90
RC8	<50	<50	<50	<50	<50	<50	E.6	<50	<50	7	64
RC9	<50	<50	<50	<50	<50	E3.2	<50	<50	<50	6	67
BUFF1	<50	<50	<50	<50	<50	<50	55	<50	<50	6	887
BUFF2	<50	<50	<50	<50	<50	<50	<50	<50	<50	5	108
B1	<50	<50	<50	<50	<50	<50	<50	<50	<50	3	98
Center[1]	<50	<50	<50	<50	<50	65	E32	58	E10	17	1,932
James[1]	E35	E47	E6	E14	E26	54	E17	120	E22	38	1,907

Table 5. Aquatic-life criteria used for semivolatile organic compounds in streambed sediment

[Table modified from Gilliom and others, 1998. --, not detected; E, estimated; USEPA, U.S. Environmental Protection Agency; SQC, sediment-quality criterion; SQAL, sediment-quality advisory level; ER-M, effects range-median; PEL, probable effect level. µg/kg, microgram per kilogram]

Compound	Maximum concentration[1] (table 4)	Criterion (µg/kg dry weight)	Type of criterion	Reference
Polycyclic aromatic hydrocarbons (PAH)				
Acenaphthene	E9.2	1,300	USEPA SQC[2]	USEPA (1996)
Acenaphthylene	--	640	ER-M	Long and others (1995)
Anthracene	--	1,100	ER-M	Long and others (1995)
Benz[*a*]anthracene	E41	693	Florida PEL	MacDonald (1994)
Benzo[*a*]pyrene	E14	782	Canada PEL	Environment Canada (1995)
Chrysene	E39	862	Canada PEL	Environment Canada (1995)
Dibenz[*a.h*]anthracene	E30	260	ER-M	Long and others (1995)
Fluoranthene	E32	6,200	USEPA SQC[2]	USEPA (1996)
Naphthalene	--	470	USEPA SQAL[2]	USEPA (1996)
Phenanthrene	E30	1,800	USEPA SQC[2]	USEPA (1996)
Pyrene	E36	1,398	Florida PEL	MacDonald (1994)
Phthalates				
Butylbenzylphthalate	50	11,000	USEPA SQAL[2]	USEPA (1996)
Diethylphthalate	E16	630	USEPA SQAL[2]	USEPA (1996)
Di-*n*-butyl phthalate	E44	11,000	USEPA SQAL[2]	USEPA (1996)
bis (2-Ethylhexyl)phthalate	66	2,650	Florida PEL	MacDonald (1994)
Other semivolatile organic compounds				
1,2-Dichlorobenzene	--	340	USEPA SQAL[2]	USEPA (1996)
1,4-Dichlorobenzene	--	350	USEPA SQAL[2]	USEPA (1996)
1,2,4-Trichlorobenzene	--	9,200	USEPA SQAL[2]	USEPA (1996)

[1]Maximums do not include concentrations from Center Creek and James River.

[2]Value in table assumes 1 percent organic carbon.

Table 6. Potential sources and uses of detected semivolatile organic compounds

[Sources and uses were compiled from Sittig (1985), Sax and Lewis (1987), and Agency for Toxic Substances and Disease Registry (1995)]

Compound	Sources and uses	Compound	Sources and uses
di-*n*-butylphthalate	plasticizer, perfumes, insect repellents, textile lubricating agent, printing ink, resin solvent	phenanthrene	dyestuffs, explosives, drug synthesis, biochemical research, heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires
di-*n*-octylphthalate	plasticizer	1-methylphenanthrene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires
diethylphthalate	solvent, plasticizer, insecticide sprays, perfumes, alcohol denaturant	phenol	resins, disinfectant, solvents, pharmaceuticals, dyes, explosives
1-methylpyrene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	bis(2-ethylhexyl)phthalate	plasticizer, organic pump fluids
benzo[*a*]pyrene	product of incomplete combustion, tarring operations, heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	butylbenzylphthalate	plasticizer, resins
indeno[1,2,3-*cd*]pyrene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	acenaphthene	dyes, plastics, pesticides, pharmaceuticals, heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires
benzo[*k*]fluoranthene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	2-methylanthracene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires
1-methyl-9H-fluorene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	benz[*a*]anthracene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires
9H-fluorene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	chrysene	organic synthesis, heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires
naphthalene	moth repellent, resins, dyes, fungicide, lubricant, synthetic tanning, heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	*p*-cresol	bacteriological activity, creosote, disinfectant, resins, dyes, plastics
1,2-dimethylnaphthalene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	dibenzothiophene	cosmetics and pharmaceuticals, heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires
1,6-dimethylnaphthalene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	benzo[*b*]fluoranthene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires
2,3,6-trimethylnaphthalene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	dibenz[*a,h*]anthracene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires
2,6-dimethylnaphthalene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	fluoranthene	heat and power generation, oil spills, refuse burning, industrial activity, coal, product of plant biosynthesis, forest fires
benzo[*ghi*]perylene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires	pyrene	heat and power generation, oil spills, refuse burning, industrial activity, coal, forest fires

SUMMARY

Streambed-sediment samples from 11 sites in the Richland Creek Basin, 1 site immediately upstream from and 1 site immediately downstream from Richland Creek on the Buffalo River, and 1 site on Bear Creek were collected in 1999 for analysis of SVOCs. Richland Creek is one of the largest tributaries of the Buffalo River and flows through an area of predominantly forest. The sites were sampled to better characterize the distribution of SVOCs after 23 compounds were detected in a sample collected from Richland Creek in 1992.

In 1999, the highest number of SVOCs and the highest total concentration of SVOCs generally occurred in samples collected at sites on Richland Creek and Falling Water Creek just upstream and downstream from the confluence of Falling Water Creek and Richland Creek. Total concentrations in samples from these sites and another site on Falling Water Creek (about 6 river miles upstream) ranged from 115 to 323µg/kg. Twelve to 22 compounds were detected.

The numbers of detected compounds, concentrations of individual detected compounds, and total concentration of SVOCs in the samples from the Buffalo River and Bear Creek generally were lower than in samples from the area near the confluence of Falling Water and Richland Creeks. However, 746 µg/kg of *p*-cresol was detected in one sample from the Buffalo River just upstream from the confluence with Richland Creek.

The total concentration of SVOCs from two samples collected in 1992 downstream from major urban areas in the Ozarks were approximately 3 to 17 times higher than concentrations from sites sampled in the Richland Creek Basin with the highest concentrations of total SVOCs. The total concentrations at the two urban sites were approximately twice the total concentration at the site on the Buffalo River with the sample containing 746 µg/kg of *p*-cresol.

Three phthalate compounds were found in all samples collected in 1999. These three compounds are commonly detected in laboratory blanks.

Concentrations did not exceed aquatic-life criteria. However, criteria do not exist for 18 compounds detected in samples from Richland Creek, Falling Water Creek, Buffalo River, and Bear Creek.

Most of the detected SVOCs are PAHs. Sources and uses of these SVOCs include plasticizers, solvents, resins, dyes, oils, coal, and combustion products. Parts of the study area are underlain by geologic formations containing carbonaceous shales and thin coal beds.

SELECTED REFERENCES

Agency for Toxic Substances and Disease Registry, 1995, Cresols: accessed August 13, 1999 at URL http://www.atsdr.cdc.gov/tfacts34.html.

Bell, R.W., Davis, J.V., Femmer, S.R., and Joseph, R.L., 1997, Water-quality assessment of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma—Organic compounds in surface water, bed sediment, and biological tissue, 1992-95: U.S. Geological Survey Water-Resources Investigations Report 97-4031, 30 p.

Croneis, Carey, 1930, Geology of the Arkansas Paleozoic area: Arkansas Geological Survey Bulletin 3, 457 p.

Davis, J.V., and Bell, R.W., 1998, Water-quality assessment of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma—Nutrients, bacteria, organic carbon, and suspended sediment in surface water, 1993-95: U.S. Geological Survey Water-Resources Investigations Report 98-4164, 56 p.

Environment Canada, 1995, Interim sediment quality guidelines: Ottawa, Ontario, Ecosystem Conservation Directorate, Evaluation and Interpretation Branch, Soil and Sediment Quality Section, Guidelines Division, Environment Canada, 8 p., appendixes.

Femmer, S.R., 1997, Water-quality assessment of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma—Habitat data and characteristics at selected sites, 1993-95: U.S. Geological Survey Open-File Report 97-236, 44 p.

Furlong, E.T., Vaught, D.G., Merten, L.M., Foreman, W.T., and Gates, P.M., 1996, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of semivolatile organic compounds in bottom sediment by solvent extraction, gel permeation chromatographic fractionation, and capillary-column gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report 95-719, 67 p.

Gilliom, R.J., Mueller, D.K., and Nowell, L.H., 1998, Methods for comparing water-quality conditions among National Water-Quality Assessment Study Units, 1992-1995: U.S. Geological Survey Open-File Report 97-589, 54 p.

Haley, B.R., 1993, Geologic map of Arkansas: U.S. Geological Survey, 1 sheet.

Long, E.R., MacDonald, D.D., Smith, S.L., and Calder, F.D., 1995, Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments: Environmental Management, v. 19, no. 1, p.81-97.

Lopes, T.J., and Dionne, S.G., 1998, A review of semivolatile and volatile organic compounds in highway runoff and urban stormwater: U.S. Geological Survey Open-File Report 98-409, 67 p.

MacDonald, D.D., 1994, Development and evaluation of sediment quality assessment guidelines, v. 1 *of* Approach to the assessment of sediment quality in Florida coastal waters: MacDonald Environmental Services (Ladysmith, B.C.) report prepared for the Florida Department of Environmental Protection, Office of Water Policy, Tallahassee, Fla., 123 p.

Petersen, J.C., Adamski, J.C., Bell, R.W., Davis, J.V., Femmer, S.R., Freiwald, D.A., and Joseph, R.L., 1998, Water quality in the Ozark Plateaus, Arkansas, Kansas, Missouri, and Oklahoma, 1992-95: U.S. Geological Survey Circular 1158, 33 p.

——— 1999, Quality of Ozark streams and ground water, 1992-95: U.S. Geological Survey Fact Sheet FS-092-99, 4 p.

Sax, N.I., and Lewis, Richard, Sr., 1987, Hawley's condensed chemical dictionary (11th ed.): Van Nostrand Reinhold Co., New York, 1,288 p.

Shelton, L.R., and Capel, P.D., 1994, Guidelines for collecting and processing samples of stream bed sediment for analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94-458, 20 p.

Sittig, Marshall, 1985, Handbook of Toxic and Hazardous Chemicals and Carcinogens (2d ed.): Noyes Publications, Park Ridge, New Jersey, 950 p.

Steele, K.F., and Mott, D.N., 1998, Storm and base flow water quality for Bear, Calf, and Tomahawk Creeks: Arkansas Water Resources Center Publication No. 255, variously paginated.

Sullavan, J.N., 1974, Drainage areas of streams in Arkansas, White River Basin: U.S. Geological Survey Open-File Report, 123 p.

U.S. Environmental Protection Agency, 1996, Integrated Risk Information System (IRIS) [CD-ROM]: [Enterprise, Fla.], Solutions Software Corporation.

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