In cooperation with the Texas Commission on Environmental Quality

Occurrence, Trends, and Sources in Particle-Associated Contaminants in Selected Streams and Lakes in Fort Worth, Texas

Water-Resources Investigations Report 03–4169

U.S. Department of the Interior
U.S. Geological Survey

Cover:

Fosdic Lake with Texas Department of Health posting of fish possession ban, January 2001 (photograph by B.J. Mahler, U.S. Geological Survey).

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By Peter C. Van Metre, Jennifer T. Wilson, Glenn R. Harwell, Marcus O. Gary, Franklin T. Heitmuller, and Barbara J. Mahler

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By Peter C. Van Metre, Jennifer T. Wilson, Glenn R. Harwell, Marcus O. Gary, Franklin T. Heitmuller, *and* Barbara J. Mahler

Abstract

Several lakes and stream segments in Fort Worth, Texas, have fish consumption bans because of elevated levels of chlordane, dieldrin, DDE, and polychlorinated biphenyls (PCBs). This study was undertaken to evaluate current loading, trends, and sources in these long-banned contaminants and other particle-associated contaminants commonly found in urban areas. Sampling included suspended sediments at 11 sites in streams and bottom-sediment cores in three lakes. Samples were analyzed for chlorinated hydrocarbons, major and trace elements, and polycyclic aromatic hydrocarbons (PAHs). All four legacy pollutants responsible for fish consumption bans were detected frequently. Concentrations of chlordane, lead, and PAHs most frequently exceeded sediment-quality guidelines. Trends in DDE and PCBs since the 1960s generally are decreasing; and trends in chlordane are mixed with a decreasing trend in Lake Como, no trend in Echo Lake, and an increasing trend in Fosdic Lake. All significant trends in trace elements are decreasing, and most significant trends in PAHs are increasing. Sedimentation surveys were conducted on each of the three lakes and used in combination with sediment core data to compute sediment mass balances for the lakes, to estimate long-term-average loads and yields of sediment, and to estimate recent loads and yields of selected contaminants.

Concentrations of most trace elements in suspended sediments were similar to those at the tops of cores, but concentrations of many hydrophobic organic contaminants were two to three times larger. As a result, for these fluvial systems, sediment cores probably provide a historical record of trace element contamination but could underestimate historical concentrations of organic contaminants. However, down-core profiles suggest that relative concentration histories are preserved in these sediment cores for many organic contaminants (such as chlordane and total DDT) but not for all (such as dieldrin).

Percent urban land use correlates strongly with selected contaminant concentrations in sediments. Organochlorine pesticides had significant correlations to residential land use, whereas PCBs, cadmium, lead, zinc, and PAHs more often correlate significantly with commercial and industrial land uses, which suggests different urban sources for different contaminants. The amount of enrichment in these contaminants associated with urban land use predicted from regression equations, expressed as the ratio of concentrations predicted for 100 percent urban to 30 percent urban, ranges from 3.6 to 6.9 for PCBs and heavy metals to about 15 for chlordane, total DDT, and PAHs. These data indicate that urbanization is having a substantial negative effect on sediment and water quality and that legacy pollutants are being actively transported to streams and lakes 13 to 30 years after their use was restricted or banned. They further suggest that fish in the lakes and these water bodies will continue to be exposed to legacy pollutants in sediment for many years to come.

Table 1. Listing of water-quality impairment in Fort Worth area streams and lakes

[TDH, Texas Department of Health]

Segment no.	Segment name	Reason for inclusion on 303(d) list
0806, lower 35 kilometers only	West Fork Trinity River below Lake Worth	Fish consumption ban issued by TDH in 1990 because of elevated levels of **chlordane** in fish tissue.
0806A	Fosdic Lake	Fish consumption ban issued by TDH in 1995 because of elevated levels of **chlordane, dieldrin, DDE, and PCBs** in fish tissue.
0806B	Echo Lake	Fish consumption ban issued by TDH in 1995 because of elevated levels of **PCBs** in fish tissue.
0829, lower 1.6 kilometers only	Clear Fork Trinity River below Benbrook Lake	Fish consumption ban issued by TDH in 1990 because of elevated levels of **chlordane** in fish tissue.
0829A	Lake Como	Fish consumption ban issued by TDH in 1995because of elevated levels of **chlordane, dieldrin, DDE, and PCBs** in fish tissue.
0841A	Mountain Creek Lake, Dallas	Fish consumption ban issued by TDH in 1996 because of elevated levels of **PCBs** in fish tissue.

INTRODUCTION

Parts of the Trinity River and four urban lakes in and around Fort Worth, Tex. (fig. 1), were included in the State of Texas 1998 Clean Water Act Section 303(d) list because of elevated levels of legacy pollutants in fish tissue (Texas Natural Resource Conservation Commission, 1998). The listings are based on fish consumption advisories issued by the Texas Department of Health in 1990 (Trinity River segments) and 1995–96 (the four lakes) (table 1). The compounds of concern in the Fort Worth streams and lakes are chlorinated hydrocarbons, which include organochlorine pesticides (chlordane, dieldrin, and DDE [a breakdown product of DDT]) and polychlorinated biphenyls (PCBs), a group of closely related organic compounds widely used in industrial applications. These once widely used compounds were banned or withdrawn between 1972 and 1988, hence the name legacy pollutants. Important characteristics of the chlorinated hydrocarbons are low water solubility, high lipid solubility, and chemical persistence. These characteristics lead to their persistence in the environment and their tendency to accumulate in sediments and tissues (Smith and others, 1988). They are still widely distributed in stream and lake sediments and biota (Nowell and others, 1999).

In addition to the chlorinated hydrocarbons, other particle-associated contaminants (PACs), which include major and trace elements and polycyclic aromatic hydrocarbons (PAHs), were measured in this study. The presence and distribution of PAHs in the environment is caused largely by the incomplete combustion of coal, oil, wood, and petroleum. Numerous chlorinated hydrocarbons, trace elements, and PAHs are of concern in aquatic systems as indicated by their inclusion on the Agency for Toxic Substances and Disease Registry (2001) priority list of hazardous substances and the development of sediment-quality guidelines for them by various governmental agencies (MacDonald and others, 2000).

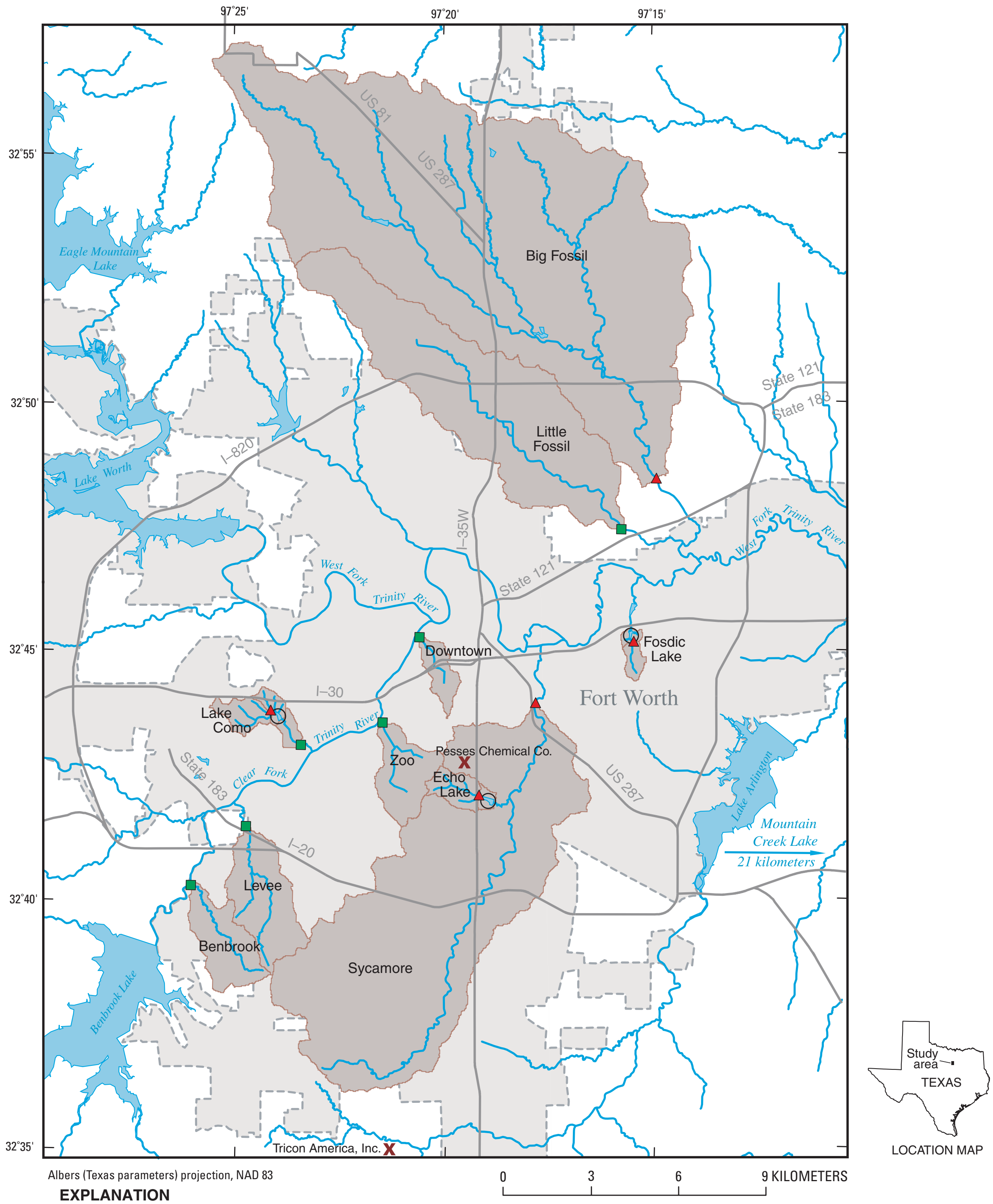
Purpose and Scope

This study was conducted by the U.S. Geological Survey (USGS) in cooperation with the Texas Commission on Environmental Quality (TCEQ). The purpose of this report is to

1. Describe temporal trends in selected PACs, including the legacy pollutants chlordane, dieldrin, DDT, DDD, DDE, and PCBs in Lake Como, Echo Lake, and Fosdic Lake in Fort Worth;

2. Present estimated loads and yields and identify possible sources of selected PACs at the watershed scale for the three lakes, Clear Fork Trinity River, and West Fork Trinity River in Fort Worth; and

3. To the extent possible, provide information useful for the evaluation of alternative strategies for



EXPLANATION

Study watershed

Lake where sediment cores collected—coring sites shown on figure 2

Stream suspended-sediment sampling site

Automated

Passive

National Priorities List (Superfund) site

Figure 1. Locations of suspended-sediment sampling sites and lakes where sediment cores collected, Fort Worth, Texas.

the control or remediation of each of the listed pollutants.

The report documents the sampling of reservoir-bottom-sediment cores and reservoir-sediment surveys in three lakes and the sampling of stream suspended sediments at 11 streams in the Fort Worth area. Sediment cores were collected in a single sampling trip in May 2001; stream suspended sediments were sampled during selected runoff events during the 16-month period Oct. 2000 to Jan. 2001. The report presents analyses of bottom and suspended sediments that involve a broad range of chemical constituents including all of the elements and organic compounds for which consensus-based sediment-quality guidelines have been developed (MacDonald and others, 2000). Additionally, readily available existing data on legacy pollutants in sediment and fish in the affected water bodies are discussed.

Review of Existing Data

A number of studies of the occurrence of pesticides and PCBs have been conducted in the Trinity River Basin since the 1970s. Ulery and Brown (1995) provide a thorough compilation and assessment of pesticide information available through the early 1990s. Data from numerous Federal, State, and local agencies and universities are presented showing the widespread occurrence of DDT and its breakdown products (DDD and DDE), dieldrin, and chlordane in water, sediment, and fish. Some of these data are from Clear Fork and West Fork Trinity Rivers. To our knowledge, no data on legacy pollutants are available for the three Fort Worth lakes prior to fish samples collected in 1990 by the Texas Department of Health (written commun., 1993).

The only long-term dataset (more than 10 years) for legacy pollutants in sediments in the Trinity River segments in Fort Worth that we are aware of is from the TCEQ surface-water-quality monitoring program (Texas Commission on Environmental Quality, written commun., 2003). Legacy pollutants were sampled 10 times each at West Fork Trinity River at Beach Street and West Fork Trinity River at River Oaks Boulevard (State Highway 183) in Fort Worth. Nine samples were collected at Beach Street between 1980 and 1989, and one more sample was collected in 2000. Chlordane was the most frequently detected legacy pollutant (50 percent of samples), followed by dieldrin (40 percent), and DDE (10 percent). DDT and DDD were not detected. Total PCBs were detected in two of nine samples collected between 1980 and 1989 with a maximum of 280 micrograms per kilogram (μg/kg). PCB Aroclors were not detected in three samples analyzed during 1999–2001. Chlordane concentrations were highly variable, ranged from less than 0.06 to 66.7 μg/kg, and indicated no apparent temporal trend. At River Oaks Boulevard, sampling was conducted from 1977 to 1988. Chlordane was detected in 90 percent of samples and ranged from 1.1 to 196 μg/kg, again indicating no apparent trend. Dieldrin, aldrin, and DDE each were detected in one sample (10 percent), all at relatively low concentrations (5.3 μg/kg or less).

A large-scale sampling of stormwater was conducted by the USGS in the greater Dallas/Fort Worth area (the metroplex) during 1992–94 (Baldys and others, 1997). The study provided data for the National Pollutant Discharge Elimination System permit for the metroplex. Seven storms were sampled at each of 30 sites for a total of 210 samples. Analyses included major and trace elements, volatile organic compounds, base/neutral and acid-extractable semivolatile organic compounds (including PAHs), and chlorinated hydrocarbons including the legacy pollutants. The five sites in Fort Worth that were sampled drain into Clear Fork and West Fork Trinity Rivers. The sites were small, ranging from 25 to 61 hectometers, and were categorized as one of three dominant land uses—residential, commercial, or industrial. Whole-water (unfiltered) samples were analyzed, and except for trace elements, detections of PACs were infrequent. Chlordane was detected in six of the 35 samples at the five sites, four times at a residential site (0.1 to 1.2 micrograms per liter [μg/L]) and twice at a commercial site (0.1 μg/L). PCB Aroclor 1254 was detected four times at the most industrial site (0.1 to 0.8 μg/L), and dieldrin was detected once at a residential site (0.05 μg/L).

Studies of temporal trends of legacy pollutants using age-dated sediment cores from reservoirs in the Dallas/Fort Worth metropolitan area have been conducted by the USGS at White Rock Lake (Van Metre and Callender, 1997), Mountain Creek Lake (Jones and others, 1997), and Lake Worth (P.C. Van Metre, U.S. Geological Survey, written commun., 2002). Concentrations of PCBs, DDE, and DDD peaked in the 1960s in White Rock Lake and declined substantially thereafter, decreasing by about 90 percent by the mid-1990s. Concentrations of chlordane, however, peaked about 1990, suggesting increasing use through the 1980s. These trends are consistent with the regulatory history of these compounds. DDT use peaked in the United States in the early 1960s and was banned in

1972. PCB use was restricted in 1971, then banned in 1979 (National Research Council, 1979). Chlordane use was restricted from agricultural applications in 1974 but remained in urban use until most uses were banned in 1988, with the notable exception of the use of existing stocks by private individuals.

Extensive data on legacy pollutants are available for Mountain Creek Lake, primarily from studies of sediment and fish conducted by the USGS during 1994–96 (Jones and others, 1997; Van Metre and others, 2003) and during 1999–2000 (Wilson, 2000). Because Mountain Creek Lake is one of the lakes in the Dallas/Fort Worth area with a fish consumption ban for legacy pollutants (table 1), findings of the USGS studies of legacy pollutants there are summarized here:

Two rounds of fish sampling were conducted by the USGS at Mountain Creek Lake resulting in one of the more complete fish-tissues datasets available in Texas. All samples were analyzed at the USGS National Water-Quality Laboratory (NWQL). Methods, analytical results, and quality control (QC) results are reported in Jones and others (1997). In the first round of sampling, three composite samples of fillets from five fish each were collected and analyzed for chlorinated hydrocarbons including the legacy pollutants. In the second round of sampling 62 individual fish of three species (channel catfish, common carp, and largemouth bass) were analyzed; sample types included whole-body eviscerated fish, fillets with skin off, and fillets with skin on. PCBs were detected in the three composite samples and in 61 of the 62 individual fish samples. PCBs were quantified as three Aroclors, 1242, 1254, and 1260, with a most frequent laboratory reporting level of 5 µg/kg wet weight, although for many samples the laboratory reporting level was 10 or 15 µg/kg. Concentrations of total PCBs (sum of Aroclors, treating nondetections as zeros) in the individual fish ranged from a single nondetection to 2,630 µg/kg. The median concentration was 131 µg/kg, and the mean was 325 µg/kg. The USGS fish data prompted the issuance of a fish possession ban by the Texas Department of Health in 1996 (Kirk Wiles, Texas Department of Health, written commun., 1996). Technical chlordane and *p,p'*-DDE were the next most frequently detected compounds. Technical chlordane was detected in 56 of 62 fish, and *p,p'*-DDE was detected in 53 of 62 fish.

Historical trends in sediment cores from nine locations in the lake and surface sediment chemistry at more than 50 additional locations indicated decreasing trends since the early 1970s and elevated concentrations of PCBs in some parts of the lake adjacent to the Dallas Naval Air Station and the Naval Weapons Industrial Reserve Plant. The average PCB concentration in surficial bottom sediment (top 3 centimeters [cm]) in the central part of Cottonwood Bay, the most contaminated part of the lake, was 313 µg/kg. PCB concentrations were about 10 times greater in the 1960s and early 1970s than in the 1990s. Several metals were substantially elevated in those same parts of the lake. Those studies are described in Raines and others (1997) and Van Metre and others (2003). Data from the studies are presented in Raines and others (1997), Jones and others (1997), and Wilson (2000).

Various Federal, State, and local agencies have collected aquatic organisms for tissue analysis of legacy pollutants in Fort Worth water bodies. These include the USGS, Texas Department of Health-Seafood Safety Division, Texas Parks and Wildlife Department, Trinity River Authority, and City of Fort Worth. The USGS National Water-Quality Assessment (NAWQA) Program collected Asian clams for chemical analysis in Sycamore Creek and West Fork Trinity River at Beach Street during 1992–93 and detected chlordane, DDE, DDT, dieldrin, and PCBs (Moring, 1997). Available fish-tissue data for chlorinated hydrocarbons in the water bodies investigated by this study (table 1) are summarized in table 2, and complete data are listed in appendix 4. These data are from four agencies: Texas Department of Health, Texas Parks and Wildlife Department, Trinity River Authority, and City of Fort Worth. Sampling dates were from 1990 to 2001, with no regular interval between sampling. Frequency of sampling increased after 1997 to almost an annual rate, although not by any one agency. Neither laboratory methods nor quality assurance data were available, and there is little consistency in the sample types among sampling events. Within each sample set, a wide range of fish species were analyzed, and the tissue samples were prepared for laboratory analysis as whole, fillet, or composite samples. Because of the lack of information on analytical methods and quality assurance and the wide variation of sampling strategies, it is difficult to interpret these data as a single dataset. These limitations, for example, preclude meaningful statistical trend analysis. One thing, however, is clear from these varied data: Legacy pollutants are found in fish in widely varying concentrations and in all of the water bodies sampled.

Table 2. Summary of historical fish-tissue data

[µg/kg, micrograms per kilogram; --, unknown or not available; <, less than; rep, replicate]

Agency/lab: TDH-SSD, Texas Department of Health-Seafood Safety Division; TPWD, Texas Parks and Wildlife Department; CFW, City of Fort Worth; TRA, Trinity River Authority

Species: CC, common carp; LB, largemouth bass; CH, channel catfish; SB, smallmouth buffalo; LG, longnose gar; SG, spotted gar; BB, black bullhead; BG, bluegill; AS, assorted sunfish; WC, white crappie; BC, blue catfish; YB, yellow bullhead; RS, redear sunfish

Date	Agency/ lab	Species	Type of sample	No. of sam- ples	Quality assur- ance data	PCB detec- tions (percent)	PCB median (µg/kg)	PCBs range (µg/kg)	DDE detec- tions (percent)	DDE median (µg/kg)	DDE range (µg/kg)	Dieldrin detec- tions (percent)	Dieldrin median (µg/kg)	Dieldrin range (µg/kg)	Chlor- dane detec- tions (percent)	Chlor- dane median (µg/kg)	Chlor- dane range (µg/kg)
Trinity River downstream of Benbrook Dam																	
06/29/2000	TDH-SSD	CC	--	5	no	0	<40	<40	40	<5	<5–12	40	<6	<6–12	[1]100	111	25–397
Clear Fork Trinity River at Trinity Park																	
07/01/1996	TPWD	CC, LB, CH	Fish muscle	3	no	33	<50	<50–87	100	14	6–26	66	11	<5–15	[2]100	42	33–64
Clear Fork Trinity River at Purcey St. drain																	
07/01/1996	TPWD	CC, SB	Fish muscle	4	rep	100	420	57–3,500	100	18	8–480	50	15	<5–40	[2]100	93	28–360
Trinity River between Beach St. and Riverside Dr. bridge																	
01/03/1998	TDH-SSD	LB, SB, CH, CC, LG	--	10	no	100	240	69–2,700	100	49	8.5–320	30	<6	<6–40	[1]70	125.5	<6–370
06/13/2000	TDH-SSD	CC, SB, LG, SG	--	5	no	100	290	150–3,270	100	21	9–28	40	<6	<6–15	[1]100	258	48–944
Lake Como																	
12/11/1990	TPWD	BB (5 fish)	Whole (composite)	1	no	--	--	--	0	<20	<20	0	<100	<100	[3]0	<40	<40
05/04/1994	CFW	BB, BG, CH	Whole, fillet	18	no	89	67	<16–289	56	30	<8–102	72	35.5	<4–144	[3]83	15	<8–173
09/16/1997	CFW	LB, BB, AS	Whole, fillet	10	no	--	--	--	20	<.4	<.4–10.9	70	19	<5–129	[2]100	682.5	22.8–5,760
05/19/1999	TRA	LB, BB	--	7	no	71	50	<40–80	100	15	1.8–23.7	100	5	2–14	[2]100	4.8	.5–36.1
10/26/2000	CFW	LB	--	5	no	0	<40	<40	0	<5	<5	0	<6	<6	[2]60	17	<10–30
03/06/2001	TDH	LB	--	5	no	0	<40	<40	20	<5	<5–22	20	<6	<6–11	[2]80	37	<10–406
Echo Lake																	
12/13/1990	TPWD	BG (5 fish)	Whole (composite)	1	no	--	--	--	0	<20	<20	0	<100	<100	[3]100	30	30
04/03/1995	TDH	CC, LB, WC, CH, BC	--	8	no	100	104	50–1,400	88	12.7	<5–130	75	8	<6–46	[2]0	<20	<20
09/16/1997	CFW	LB	Fillet, whole	10	no	--	--	--	10	<.4	<.4–50.8	40	58.5	<5–208	[1]90	1,440	358–4,500
05/17/1999	TRA	LB, CH,YB	--	14	no	64	45	<40–210	100	17	4.5–69.1	100	5.5	2–21	[2]100	5.5	1.1–39.3
10/26/2000	TDH-SSD	LB	--	5	no	0	<40	<40	40	<5	<5–8	0	<6	<6	[2]80	21	<10–35
03/16/2001	TDH-SSD	LB, CC	--	5	no	20	<4	<4–431	60	12	<5–116	20	<6	<6–11	[2]100	109	25–499
Fosdic Lake																	
09/16/1997	CFW	LB, WC, BB, AS, RS	Whole, fillet	10	no	--	--	--	60	4.8	<.4–31	70	2.9	<1–37	[1]90	61.3	<1–87.2
05/17/1999	TRA	LB, RS, BB	--	18	no	0	<40	<40	94	3.7	<.4–12.6	61	2	<1–6	[2]94	2.5	<.4–21
10/26/2000	CFW	LB	--	5	no	0	<40	<40	60	5.2	<5–6.2	0	<6	<6	[2]100	41	18–60
03/06/2001	CFW	LB	--	5	no	0	<40	<40	20	<5	<5–8	0	<6	<6	[2]80	62	<10–83

[1] Not specified as technical chlordane or sum of isomers.
[2] Technical chlordane.
[3] Sum of *alpha* and *gamma*.

Acknowledgments

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METHODS

Because of their low water solubility and affinity for sediments, the organochlorine pesticides, PCBs, trace elements, and PAHs that occur in streams primarily are associated with sediments. Numerous researchers have shown the utility of sediment coring for the identification of trends in PACs (Charles and Hites, 1987; Eisenreich and others, 1989; Van Metre and others, 1997). Transport of these compounds and elements can be dominated by movement on suspended sediments (Bradford and Horowitz, 1988); however, the chemistry of suspended sediments rarely is measured (Mahler and Van Metre, 2003). This study used both sediment coring to identify historical trends in concentrations and loads of PACs and suspended-sediment sampling to estimate current (2001) transport in streams. Sampling and analytical methods and quality assurance procedures are described in a quality assurance project plan[1] (QAPP). Methods described here and used by this study are consistent with those described in the QAPP.

Study Design and Watershed Characteristics

Sediment coring was used to evaluate trends in PACs. Bottom-sediment cores were collected, age dated, and analyzed chemically from three sites in each of three small urban lakes: Lake Como, Echo Lake, and Fosdic Lake (figs. 1, 2). Sediment surveys were conducted on each of these lakes to estimate total mass of sediment in storage which, combined with the chemical data from cores, were used to estimate watershed loads and yields of contaminants to the lakes. Chemical analyses included organochlorine pesticides, PCBs, major and trace elements, PAHs, and cesium-137 (^{137}Cs) for sediment age dating.

Suspended sediments were sampled for chemical analysis at 11 sites in greater Fort Worth. Chemical analyses included organochlorine pesticides, PCBs, major and trace elements, and PAHs. Sampling locations were chosen to characterize the occurrence of PACs in the watersheds of each of the impaired water bodies in the Fort Worth area (table 1; Mountain Creek Lake excepted) and to reflect differing land-use patterns in and surrounding Fort Worth (table 3).

Suspended-sediment samples were collected using automated samplers at five sites—the inflows to each of the three lakes and Sycamore Creek and Big Fossil Creek flowing into West Fork Trinity River (fig. 1). Sampling at the three lake inflows was designed to assess occurrence and loads of PACs in current (2001) runoff entering the lakes and to complement sediment coring in the lakes. Sampling on Big Fossil Creek and Sycamore Creek was designed to assess occurrence and loads of PACs in runoff from two larger parts of the watershed to the reach of West Fork Trinity River listed as impaired in the Fort Worth area (table 1). Storm-event-composite samples were collected during four storms at the three lake inflows and at Big Fossil Creek. Sycamore Creek was sampled during three storms; however, the discrete samples were not combined into one sample but instead were analyzed individually or, in some cases, two samples adjacent to one another in time were combined. By this approach, three to five discrete chemical analyses were done during each of three storms.

Suspended-sediment samples were collected using passive samplers at six streams or drainage culverts. Five of these streams flow into Clear Fork Trinity River, and one stream flows into West Fork Trinity River (fig. 1). Passive samplers collect a first-flush sample for chemical analysis of suspended sediments. Two or three storms were sampled at each site.

These sites were selected to (1) represent a substantial percentage of the inflows to these reaches of Clear Fork and West Fork Trinity Rivers, and (2) assess legacy pollutant occurrence in current (2001) runoff from various land-use settings.

To characterize land use, watershed boundaries above the sampling locations were derived from a USGS 30-meter (m) digital elevation model, and land-use data for 2000 (North Central Texas Council of Governments, 2001) were overlain on each watershed. Land-use density, age, and mixture varies from an urban

[1] Source Investigation and Analysis of Status and Trends of Legacy Pollutants in Sediments in the Donna Canal and in Selected Dallas/Fort Worth Area Urban Lakes and Rivers (U.S. Geological Survey, written commun., 2001).

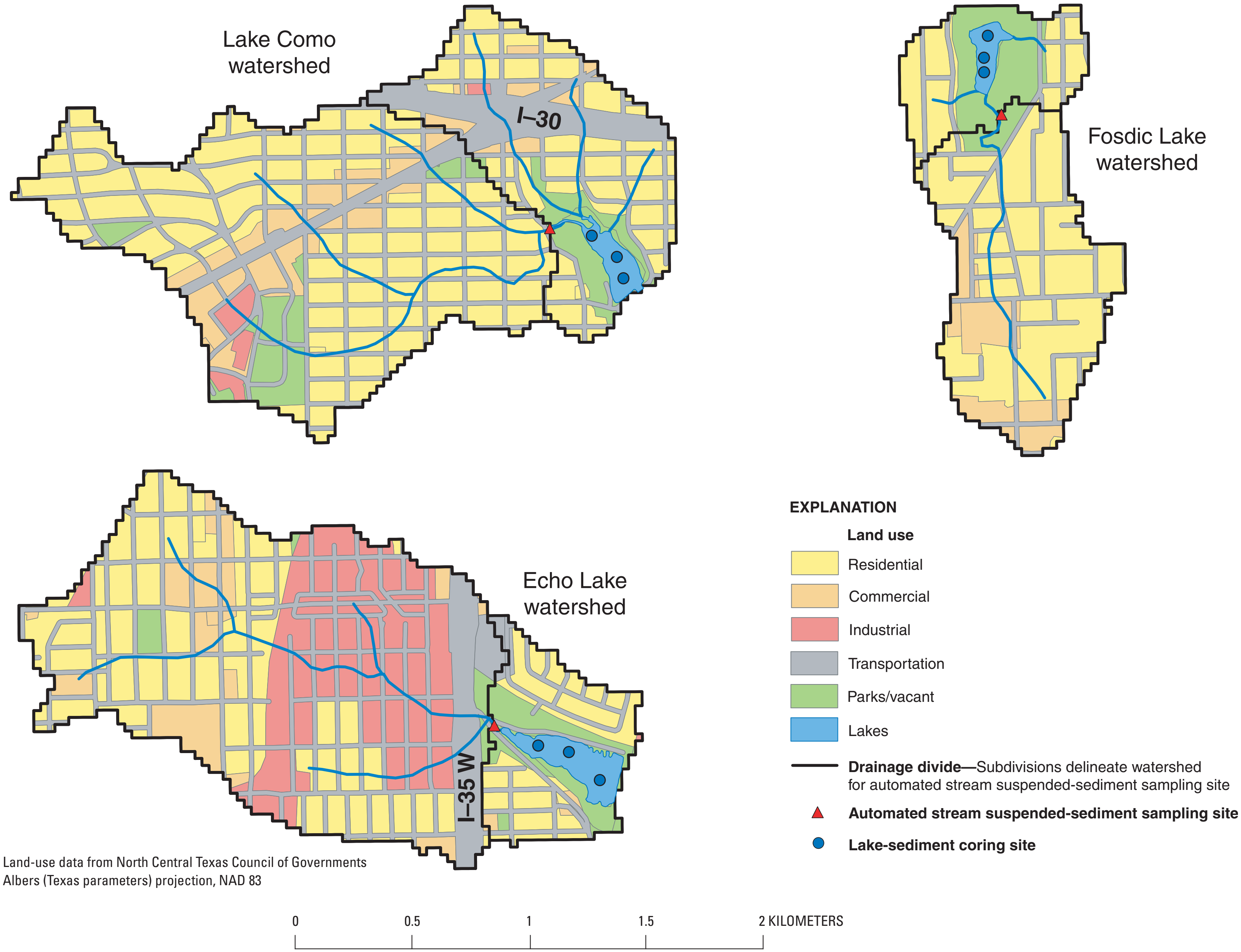

Figure 2. Land use and sampling locations in Lake Como, Echo Lake, and Fosdic Lake watersheds, Fort Worth, Texas.

Table 3. Land use/land cover for study watersheds in 2000

[km^2, square kilometers; --, not applicable]

Watershed	Latitude and longitude of sampling site	Type of large-volume suspended-sediment sampler	Area (km^2)	Urban[1]	Residential	Commercial	Industrial	Transportation
				(percent)				
Benbrook	N 32°40'17" W 97°26'03"	Passive	6.439	37.3	19.2	11.1	0.160	6.83
Big Fossil	N 32°48'26" W 97°14'54"	Automated	136.7	29.5	19.0	2.80	3.43	4.26
Como (inflow)	N 32°43'45" W 97°24'08"	Automated	1.860	93.3	51.7	10.5	2.21	28.9
Lake Como[2]	See table 4	--	2.747	90.4	47.6	8.74	1.67	32.4
Como (outflow)	N 32°43'06" W 97°23'25"	Passive	.8208	63.7	42.3	3.06	.100	18.2
Downtown	N 32°45'16" W 97°20'35"	Passive	2.240	97.7	11.4	26.8	20.0	39.4
Echo (inflow)	N 32°42'03" W 97°19'09"	Automated	2.134	98.3	32.6	9.23	25.4	31.1
Echo Lake[2]	See table 4	--	2.596	92.2	33.5	7.88	20.9	29.9
Fosdic (inflow)	N 32°45'10" W 97°15'27"	Automated	.8379	96.7	61.2	16.1	0	19.4
Fosdic Lake[2]	See table 4	--	1.197	83.7	54.6	11.3	0	17.8
Levee	N 32°41'28" W 97°24'44"	Passive	9.243	65.0	31.9	10.6	4.95	17.6
Little Fossil	N 32°47'26" W 97°15'45"	Passive	42.32	54.4	17.2	4.98	18.0	14.2
Sycamore	N 32°43'55" W 97°17'48"	Automated	77.94	67.0	35.9	8.79	3.95	18.4
Zoo	N 32°43'33" W 97°21'28"	Passive	5.711	92.0	53.4	8.27	4.22	26.1

[1] Includes residential, commercial, industrial, and transportation.

[2] Lake Como, Echo Lake, and Fosdic Lake watersheds include their respective inflow watersheds.

part of the central business district draining to the Downtown site to a mixture of vacant land, rangeland, and new residential and commercial development at the Benbrook site. The most urbanized watersheds include Downtown, Echo Lake, Fosdic Lake, Lake Como, and Zoo. Moderate urbanization characterizes the Como outflow, Levee, Little Fossil, and Sycamore watersheds. Watersheds with the smallest amount of urbanization include Benbrook and Big Fossil Creek; however, these areas also have the greatest percentage of land under construction. The present nonurbanized areas of these watersheds are primarily pasture, cropland, or vacant land.

Collection of Sediment Cores

Sediment cores were collected from three sites in the lower, middle, and upper part of each lake from the pre-reservoir stream channel or the deepest part of the lake in cross section (table 4). One of the three cores, either the lower lake core (Lake Como and Echo Lake) or mid-lake core (Fosdic Lake), was subsampled on a small enough interval (typically 5 cm) to yield about

Table 4. Selected characteristics of sediment cores and core sampling sites

[m, meters; cm, centimeters; >, greater than]

Lake	Sampling date	Site ID	Part of lake	Type of site	Latitude and longitude of site	Depth of water (m)	Total length of core (cm)	Lacustrine sediment thickness (cm)
Lake Como	03/08/2001	CMO.1	Lower lake	Primary	N 32°43'38" W 97°23'56"	7.8	95	>95
		CMO.3	Mid-lake	Secondary	N 32°43'41" W 97°23'57"	5.3	103	>103
		CMO.5	Upper lake	Secondary	N 32°43'44" W 97°24'01"	2.0	63	>63
Echo Lake	03/06/2001	ECO.1	Lower lake	Primary	N 32°41'56" W 97°18'52"	4.6	97	>97
		ECO.4	Mid-lake	Secondary	N 32°42'00" W 97°18'57"	3.0	84	>84
		ECO.3	Upper lake	Secondary	N 32°42'01" W 97°19'02"	1.3	55	>55
Fosdic Lake	03/07/2001	FOS.2	Lower lake	Secondary	N 32°45'20" W 97°15'32"	3.7	121	>121
		FOS.4	Mid-lake	Primary	N 32°45'18" W 97°15'32"	2.4	108	105
		FOS.5	Upper lake	Secondary	N 32°45'16" W 97°15'32"	1.4	99	88

20 samples, of which 10 samples, distributed to evaluate trends during the time represented by the core, were chemically analyzed. This core was designated the primary core. The other two cores, designated the secondary cores, were subsampled on a wider interval, typically 10 cm, and only two or three samples were analyzed representing top, middle, and bottom of the lacustrine sediments in the core. The secondary cores were collected to improve the estimation of the total mass of contaminants in the lake and to evaluate spatial variation in the lake.

The cores were collected using a Benthos gravity corer with a diameter of 6.3 cm, barrel length up to 3.1 m, and polycarbonate core liner. Cores were subsampled on-site by vertical extrusion of the sediment in measured increments using a piston fit into the bottom of the liner. Each subsample was split; samples for analysis of organic compounds were transferred to a baked-glass jar, and samples for analysis of major and trace elements, ^{137}Cs, and grain size were transferred to a polypropylene jar. Sampling tools were washed between each sample using phosphate-free detergent and native water. Samples for analysis of organic compounds were stored on ice until they were shipped chilled overnight for analysis. Samples for analysis of major and trace elements and ^{137}Cs were stored on ice until frozen, freeze-dried, and ground to a fine power prior to submittal to the laboratory for analysis.

Collection of Suspended-Sediment Samples in Streams

To determine if legacy pollutants are currently being transported to the lakes and Clear Fork and West Fork Trinity Rivers, suspended-sediment samples were collected from streams during storm runoff. Sediments were isolated from stormwater by filtration, then chemically analyzed (Mahler and Van Metre, 2003). One of the major difficulties in suspended-sediment sampling is obtaining the mass of sediment required to achieve reasonable laboratory reporting levels. The sample processing methodology presented here is designed to obtain sufficient sediment for analysis of PACs, including organochlorine pesticides, PCBs, major and trace elements, and PAHs. Determining concentrations of individual PAHs and most organochlorine compounds by the USGS NWQL at laboratory reporting levels ranging from about 2 to 20 µg/kg requires 2 to 5 grams (g) of dry sediment. Smaller masses of sediment result in proportionally larger laboratory reporting levels. Analytical interferences, for example from coextracted high-molecular-weight humic substances, can also raise reporting levels. Quantification of major and trace elements requires about 0.5 g of sediment.

Suspended-sediment samples were collected using automated samplers at the inflowing creek to each of the three lakes and at Big Fossil Creek during four storms and at Sycamore Creek during three storms. A water-level sensor and an automatic sampler containing seven 9-liter (L) carboys were installed at each creek just upstream from where the creek flows into the lake. The existing USGS streamflow gage and automated sampler at Sycamore Creek was modified to hold seven 9-L carboys. A new gage was installed at Big Fossil Creek following the same general design as the lake-inflow sampling sites.

Water levels were used to estimate streamflow on the basis of ratings developed using indirect measurements of flow (except Sycamore Creek where an existing rating was available). Developing these ratings necessitated installation of crest-stage gages upstream or downstream from the automated sensor. The crest stage and the maximum stage at the automated sensor were used to determine the slope of the water surface during peak flows, which, in combination with a survey of the channel bottom and estimation of several parameters, were used in theoretical computations to estimate flow. These flows were used to develop stage-discharge ratings for the sites.

The samplers were programmed to begin collecting samples when the water level in the creek reached a predetermined height and to continue to collect samples at predetermined time intervals over the hydrograph. The height and timing of sample collection were designed to capture representative flow for moderate to large storms at the sites on the basis of a review of stage and flow data where available, channel geometry, and professional judgment. Four (one storm) or five (two storms) discrete samples were analyzed from Sycamore Creek. At the other sites, event-based flow-weighted composite samples were analyzed. As many as seven discrete samples were mixed in proportion to the amount of flow associated with each sample time to form the flow-weighted composite sample. Mixing and subsequent sample processing were done using a churn splitter to obtain a representative sample of suspended sediment from each 9-L sample container.

Passive suspended-sediment samplers consisting of a 25-L polyethylene bottle held inside a steel cylinder with an intake line pointed upstream and an air exhaust line were used to collect “first flush” grab samples at six sites (fig. 1).

Samples for analysis of organic compounds were filtered using 0.45-micrometer (µm) polytetrafluoroethylene (PTFE)- or Teflon®-membrane filters held in a 293-millimeter (mm)-diameter stainless steel plate filter holder. The PTFE filter had to be pre-wetted by spraying with methanol before being placed on the filter holder to allow water to pass through the filter. Water was pumped through the filter until the filter clogged. The filter then was placed in a locking plastic bag with a few milliliters of the sampled water and gently massaged until all the sediment on the filter was transferred into a slurry in the bottom of the bag. The filter then was reused for filtration of additional sediment from the same sample. In most cases, three clogged filters were used to obtain a sample. The sediment slurry in the bottom of the bag was placed in a baked-glass vial and chilled for shipment to the laboratory.

Samples for analysis of major and trace elements were filtered using 0.45-µm PTFE-membrane filters held in a 140-mm-diameter acrylic plate filter holder. The PTFE filter had to be pre-wetted by spraying with methanol before being placed on the filter holder to allow water to pass through the filter. Water was pumped through the filter until the filter clogged. The filter then was placed in a locking plastic bag with a few milliliters of the sampled water and gently massaged until all the sediment was transferred into a slurry in the bottom of the bag. Three or more filters were thus clogged and bagged. The slurry from each bag was combined in a small polyethylene jar and chilled or frozen pending freeze-drying.

Analytical Methods

Chemical analyses of suspended sediments were performed using the same methods as used for bottom sediments, and results are reported on a mass-per-mass basis (micrograms per gram for major and trace elements and micrograms per kilogram for organic compounds). This approach was used instead of the more common "whole-water" sampling approaches because the contaminants of interest, particularly the organochlorine compounds, are very hydrophobic and thus occur at many orders of magnitude greater concentrations in sediment than in filtered water. Thus, detection and reliable quantification are better achieved by analyzing the sediment directly.

The USGS sediment laboratory in Iowa City, Iowa, performed the grain size analyses of the sediment core samples using sieve and pipet methods (Guy, 1969). Radiochemical analysis for ^{137}Cs activity was performed by gamma spectroscopy at Severn Trent Laboratories, Inc., in Richland, Wash. (STL Richland), under contract with the USGS NWQL.

Samples for analysis of major and trace elements were freeze-dried and ground to a fine powder. Samples were completely digested using a mixture of hydrochloric-nitric-perchloric-hydrofluoric acids and analyzed for 23 of the major and trace elements (listed in table 5) by inductively-coupled plasma/mass spectrometry at a USGS laboratory in Denver, Colo. (Briggs and Meier, 1999). Mercury was analyzed separately by cold vapor atomic absorption spectrometry (Arbogast, 1996). Total carbon was measured by combustion with an automatic carbon analyzer, inorganic carbon was measured as carbon dioxide by coulometric titration, and organic carbon was computed by difference (Arbogast, 1996). Quality assurance was provided by measuring the elemental concentrations for duplicate samples (split at the laboratory) and a variety of soil, lake, and marine reference samples. One of every eight samples analyzed (about 12 percent) was analyzed in duplicate. Analytical data are presented in appendix 1.5, including duplicate environmental samples, and all laboratory QC data are presented in appendix 2.

Samples for analysis of chlorinated hydrocarbons and PAHs (table 5) were extracted, isolated, and analyzed using a variation of the procedures of Foreman and others (1995) and Furlong and others (1996). Briefly, sediment was extracted overnight with dichloromethane in a Soxhlet apparatus. Two aliquots of the sample extract were injected into a polystyrene-divinylbenzene gel permeation column (GPC) and eluted with dichloromethane to remove sulfur and partially isolate the target analytes from coextracted high-molecular-weight interferences such as humic substances. The first aliquot was analyzed for PAHs and alkyl-PAHs by capillary-column gas chromatography with detection by mass spectrometry. The second aliquot was further split into two fractions by combined alumina/silica adsorption chromatography prior to measuring the concentrations of the organochlorine pesticides and PCBs by dual capillary-column gas chromatography with electron capture detection. DDT, DDD, and DDE reported here are *p,p′*-DDT, *p,p′*-DDD, and *p,p′*-DDE; chlordane is technical chlordane; and total PCBs is the sum of the quantified Aroclors 1242, 1254, and 1260.

Variations on the procedures of Furlong and others (1996) for the analysis of PAHs include the addition of a silica column cleanup step following the GPC step and the use of selected ion monitoring mass spectrometry to reduce chemical interferences and improve laboratory reporting levels. Nineteen parent PAHs, 10 specific alkyl-PAHs, and the homologous series of alkyl-PAHs were identified and measured for this study. Total PAH was computed as the sum of 18 of the 19 parent PAHs (excluding perylene) plus the homologous series. Total "combustion" PAH as used in this report is the sum of 10 of the 4- and 5-ringed parent PAHs (fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[e]pyrene, benzo[a]pyrene, indeno[1,2,3-cd]-pyrene, and benzo[ghi]perylene) that often dominate the PAH mixture in sediments contaminated by combustion of fuels (Prahl and Carpenter, 1983). One indicator of general PAH sources on the basis of the assemblage of PAH was used in this report: the ratio of 2- and 3-ringed compounds plus homologues to total combustion PAH (2+3/COMB). Uncombusted sources (for example, decomposing organic matter, oil seeps, and petroleum spills) contain predominantly 2- and 3-ringed compounds, whereas combustion (for example, vehicle exhaust, domestic heating with coal, and forest fires) results in predominantly 4- and 5-ringed species (Hites and others, 1981; Eganhouse and Gossett, 1991). A decrease in 2+3/COMB indicates a shift from uncombusted to combusted fossil fuels as the PAH source (Van Metre and others, 2000).

Quality assurance was provided by analyzing laboratory duplicate samples (one of every 12 samples in a sample set was split at the laboratory and analyzed in duplicate), a blank, spiked reagent samples, certified reference materials, and monitoring recovery of surrogate compounds. Because sample sets can include samples from other studies, less than one of 12 samples from this study happened to be analyzed in duplicate. Duplicate samples are included with environmental sample data in appendix 1, and all laboratory QC data are presented in appendix 2.

Table 5. Constituents and laboratory reporting levels

[µg/kg, micrograms per kilogram; µg/g, micrograms per gram; pCi/g, picocuries per gram]

Constituent (units)	Laboratory reporting level	Constituent (units)	Laboratory reporting level
Chlorinated hydrocarbons		**Trace elements—Continued**	
Lindane (µg/kg)	0.5	Mercury (µg/g)	0.02
Heptachlor (µg/kg)	.5	Nickel (µg/g)	1
Aldrin (µg/kg)	.5	Scandium (µg/g)	.3
Heptachlor epoxide (µg/kg)	.5	Strontium (µg/g)	.05
Chlordane (µg/kg)	5.0	Vanadium (µg/g)	.4
Endosulfan I (µg/kg)	.5	Zinc (µg/g)	5
Dieldrin (µg/kg)	.5	**Polycyclic aromatic hydrocarbons**	
Endrin (µg/kg)	.5	Naphthalene (µg/kg)	5
p,p'-DDE (µg/kg)	.5	2-Ethylnaphthalene (µg/kg)	5
p,p'-DDD (µg/kg)	.5	2,6-Dimethylnaphthalene (µg/kg)	5
p,p'-DDT (µg/kg)	.5	1,6-Dimethylnaphthalene (µg/kg)	5
Methoxychlor (µg/kg)	2.0	Acenaphthylene (µg/kg)	5
Mirex (µg/kg)	.5	1,2-Dimethylnaphthalene (µg/kg)	5
Toxaphene (µg/kg)	50	Acenaphthene (µg/kg)	5
PCB Aroclor 1242 (µg/kg)	5.0	2,3,6-Trimethylnaphthalene (µg/kg)	5
PCB Aroclor 1254 (µg/kg)	5.0	9H-Fluorene (µg/kg)	5
PCB Aroclor 1260 (µg/kg)	5.0	1-Methyl-9H-fluorene (µg/kg)	5
Major elements		Phenanthrene (µg/kg)	5
Aluminum (µg/g)	8	Anthracene (µg/kg)	5
Calcium (µg/g)	20	2-Methylanthracene (µg/kg)	5
Iron (µg/g)	50	4,5-Methylenephenanthrene (µg/kg)	5
Magnesium (µg/g)	.3	1-Methylphenanthrene (µg/kg)	5
Potassium (µg/g)	8, 20	Fluoranthene (µg/kg)	5
Sodium (µg/g)	6	Pyrene (µg/kg)	5
Titanium (µg/g)	40	1-Methylpyrene (µg/kg)	5
Total carbon (percent)	.01	Benz(a)anthracene (µg/kg)	5
Inorganic carbon (percent)	.01	Chrysene (µg/kg)	5
Organic carbon (percent)	.01	Benzo(b)fluoranthene (µg/kg)	5
Trace elements		Benzo(k)fluoranthene (µg/kg)	5
Arsenic (µg/g)	.1	Benzo(e)pyrene (µg/kg)	5
Barium (µg/g)	.5	Benzo(a)pyrene (µg/kg)	5
Beryllium (µg/g)	.001	Perylene (µg/kg)	5
Cadmium (µg/g)	.003	Benzo(ghi)perylene (µg/kg)	5
Cobalt (µg/g)	.1	Indeno(1,2,3-cd)pyrene (µg/kg)	5
Chromium (µg/g)	.2	Dibenzo(a,h)anthracene (µg/kg)	5
Copper (µg/g)	.5	Coronene (µg/kg)	5
Lead (µg/g)	.2	**Radionuclides**	
Lithium (µg/g)	.2	Cesium-137 (pCi/g)	.20
Manganese (µg/g)	.2		

Age Dating Cores

Cesium-137 was the principal tool used for age dating the cores from each of the three lakes. Nuclear weapons testing released appreciable amounts of ^{137}Cs to the atmosphere beginning in about 1952, and atmospheric concentrations peaked during 1963–64. Because ^{137}Cs sorbs strongly to fine-grained sediments, it is useful for dating sediments exposed to atmospheric fallout, including lake and ocean sediment cores (Durrance, 1986). The peak in ^{137}Cs in the core is assigned a date of 1964.0 (decimal year), consistent with the peak in atmospheric fallout levels. A sharp ^{137}Cs peak and a smooth exponential decrease to the top of the core also can indicate relatively little post-depositional sediment mixing in a core (Van Metre and others, 1997). Two other date markers are available in most reservoir sediment cores, the reservoir construction date matched to the pre-reservoir land surface in the lower part of the core and the sampling date at the top of the core (Van Metre and Callender, 1997).

Ages for samples at depth intervals between known-depth date markers were assigned on the basis of an assumed constant sediment mass accumulation rate (MAR). Using MAR adjusts for sediment compaction whereas linear sedimentation rates do not. MARs were computed by first estimating porosity of each sample by

$$\text{porosity} = (WW - WD)/([WW - WD] + [(WD - WT)/DS]), \qquad (1)$$

where
WW = wet weight, in grams;
WD = dry weight, in grams;
WT = tare weight of container, in grams; and
DS = density of solids, in grams per cubic centimeter.
A DS of 2.5 grams per cubic centimeter (g/cm^3) was assumed.

Porosity then was used to estimate the dry mass per unit area (in grams per square centimeter) contained in each sample interval by

$$\text{DryMass} = (1 - \text{porosity}) * DS * Th, \qquad (2)$$

where
Th = thickness of the sample interval, in centimeters.

Dry mass for each sample interval, plus interpolated dry mass of any intervals that were not analyzed, were summed to yield cumulative mass for the core and for each date-bounded interval. The constant MAR for each date-bounded interval is computed by dividing the cumulative mass (in grams per square centimeter) by the time interval represented (years) to yield MAR (in grams per square centimeter per year).

Once a MAR is computed it can be used to assign dates to intervening samples. If the date-bounded interval ends at the top of the core, the deposition date of sample *i* is computed by

$$\text{Date}_i = \text{SampleDate} - (\text{CM}_i/\text{MAR}), \qquad (3)$$

where
SampleDate = date of core collection, in decimal years, and
CM_i = cumulative mass from the top of core down to the middle of sample *i*.

In many cases MAR changes down a core. A simple case is where different MARs are computed before and after the ^{137}Cs peak, as was the case for Fosdic Lake. Samples above the depth of the ^{137}Cs peak (deposited after 1964) are assigned dates using equation 3. Samples below the depth of the ^{137}Cs peak are assigned dates by

$$\text{Date}_i = \text{DateMarker}_j - ([\text{CM}_i - \text{CM}_j]/\text{MAR}_j), \qquad (4)$$

where
DateMarker_j = date of marker at the top of interval containing sample *i*;
CM_j = cumulative mass to DateMarker_j; and
MAR_j = MAR for interval containing sample *j*.

Contaminant profiles often can be used to corroborate dates assigned to cores using ^{137}Cs or other approaches (Van Metre and others, 2000). Peak concentrations of lead (mid-1970s) (Callender and Van Metre, 1997), total DDT, and PCBs (early and late 1960s, respectively) (Van Metre and others, 1997, 1998) all occur at relatively consistent times and can corroborate or refute dates assigned, especially dates that are not near in time to independent date markers.

Evaluating Trends in Cores

Trends in sediment cores are described graphically and tested statistically. Concentrations of five organochlorine pesticides, total PCBs (the sum of PCB Aroclors 1242, 1254, and 1260), eight trace elements, and nine individual PAHs and total PAH were tested statistically. These elements and compounds were selected because they all have consensus-based sediment-quality guidelines (MacDonald and others, 2000) and were detected in sediment samples during this study. The Kendall's tau correlation test was used to indicate whether there was a statistically significant monotonic relation between concentration and time from 1965 to the top of core. Only the primary core was tested statistically because samples in the other cores were insufficient for meaningful tests. The starting time of 1965 was chosen on the basis of a review of trend graphs in the cores and because 1965 predates the initiation of important environmental legislation or regulatory actions in the United States (for example, the Clean Air Act and the founding of the U.S. Environmental Protection Agency [USEPA] in 1970, the Federal Water Pollution Control Act in 1972, the banning of DDT in 1972, the cessation of production of PCBs in 1976, and the introduction of unleaded gasoline in the early 1970s).

The Kendall's tau test has at least two limitations as applied here. First, the datasets are small, which reduces the power of the test to detect trend; only six samples at Fosdic Lake and eight samples each at Lake Como and Echo Lake. Second, the test is only for monotonic trend. A monotonic relation between two variables is one that changes in only one direction, either increasing or decreasing, during the range of values. It will not identify constituents or sites showing nonmonotonic temporal variations, for example peaks or valleys within the time period tested.

Estimating Contaminant Yields on the Basis of Cores

A mass balance for contaminants in a reservoir can be used to estimate whole-lake contaminant accumulation rates and yields of contaminants per unit area of watershed. Estimates of total mass of sediment in storage in Lake Como, Echo Lake, and Fosdic Lake were made, converted to whole-lake sediment and contaminant MARs, then divided by watershed area to estimate yields. Similar approaches have been applied to natural lakes to estimate rates of atmospheric fallout of mercury (Swain and others, 1992) and to reservoirs in Kansas to estimate phosphorus accumulation rates and yields (Mau and Christensen, 2000).

Mass of sediment in storage was estimated using a sediment penetrometer to measure thickness of lacustrine sediment from a boat at numerous locations in each lake. The penetrometer is a 130-cm-long, 1.4-cm-diameter, threaded steel rod screwed onto the end of an aluminum pole. Additional aluminum poles can be added for a total length of as much as 8 m. The penetrometer was easily pushed through the soft lacustrine sediments but was stopped when the stiffer, drier, pre-reservoir soils were encountered. The thickness of lacustrine mud that coated the threaded rod and aluminum pole handle up to the depth of penetration was measured on the boat after retrieval. Location of each sounding was determined using a global positioning system (Garmin eTrex Vista^{TM}). From 32 to 48 soundings were made in each lake in five or six cross sections. The 8-m pole allowed for soundings in most of all three lakes, except in the center of the lower one-half of Lake Como where water depths exceeded 8 m. Sediment thicknesses of about 3 m were determined.

A geographic information system (GIS) was used to interpolate between point measurements of sediment thickness to estimate sediment thickness and volume of lacustrine sediment over the whole lake. Each lake was subdivided into three areas corresponding to each of the three sediment cores. Porosity and dry bulk density estimates from the cores were used to convert estimated volume of sediment to estimated mass of sediment. Estimated mass of sediment for each area was divided by the time span of sediment deposition to estimate the sediment MAR for the area. The time span of deposition usually was the age of the lake, except for the upper lake area of Lake Como where the core indicated only recent deposition. MARs for the three areas of each lake were summed to estimate the long-term-average whole-lake sediment MAR (MAR_{lake}).

Accumulation rates for selected contaminants were computed by multiplying the MARs for each area of the lake times contaminant concentration at the top of the respective core for the area, then summing these for the whole lake. Whole-lake contaminant MARs then were divided by watershed area to obtain yields. The yield is the estimated mass per unit area per time of a given constituent that is reaching the lake from the watershed and being deposited. Using the top-of-core concentration means these estimates are of recent (2000–2001) contaminant accumulation rates. However, because we don't know annual variations in MAR_{lake} and are using the long-term-average sediment MAR_{lake}, the estimates are interpreted to represent a hypothetical average yield of PACs from the watershed at current (2001) contaminant levels.

Because the estimate of MAR_{lake} is a long-term average, estimates of historical contaminant accumulation rates by this approach would be exactly proportional to contaminant concentrations; thus without knowing time-varying MAR_{lake}, little additional insight is to be gained by computing trends in contaminant yields. They are only different from trends in concentration by a constant, the MAR_{lake}. Undoubtedly, MAR_{lake} varies over time depending on variations in weather and historical changes in land use; however, considering the difficulty and error in any other approaches to making these kinds of estimates, the approach used here is considered useful. In addition to estimates of recent (2000–2001) yields of contaminants, historical yields were estimated for one lake. The cores from Fosdic Lake extend far enough back in time to be assured of predating any appreciable urban development in the watershed, although not necessarily any modern land disturbance, such as farming. Contaminant concentrations for the deepest lacustrine sample, with an estimated deposition date of 1912, were multiplied by MAR_{lake} to estimate pre-urban contaminant yields. These are particularly relevant for trace elements and PAHs that have natural sources. Organochlorine pesticides and PCBs do not have natural sources, and their use began well after 1912; therefore, their yields in 1912 would be expected to be zero.

Several assumptions and limitations are involved in interpreting the estimated contaminant yields as indicative of actual watershed yields. Assumptions include:

1. The measured concentration at the top of each core is representative of average concentration for that area of the lake;

2. The trap efficiency of the reservoir is 100 percent;

3. Contaminants are preserved in bottom sediments; and

4. All of the contaminant yield from the watershed is in the particle phase.

Assumption 1, along with the uncertainly in estimating mass of contaminants in storage and the limitation of using long-term-average MAR, adds uncertainty to the estimates of yield. Any violation of assumptions 2–4 will result in the underestimation of total watershed yield. Depending on the constituent, underestimation because of violations of assumptions 3 and 4 could be relatively large. For example, assuming chemical equilibrium between water and suspended sediment, a median of 35 percent of the total load of organochlorine compounds was transported in the particle phase in a study in Austin, Tex. (Mahler and Van Metre, 2003).

Development of Ratings for Suspended-Sediment Sampling Sites

A rating at a streamflow-gaging station is the relation between water level in the stream, or stage, and flow in the stream, or discharge. Stage-discharge ratings were developed at the five automated sampling sites to enable processing of composite flow-weighted samples after each storm and to estimate contaminant loadings.

Big Fossil Creek

Big Fossil Creek flows into West Fork Trinity River just east of downtown Fort Worth in a northwest-to-southeast direction (fig. 1). As the creek flows under State Highway 183, it changes from a natural channel to a smooth, concrete-lined trapezoidal channel about 75 m wide with 20-degree-from-horizontal side slopes and a channel slope of 0.003.

Given the consistent geometry of the channel and the gradual slope, flow was estimated from recorded stages using the Manning equation under the assumption of uniform flow. The equation is

$$Q = (1.0/n)\ AR^{2/3}S^{1/2}, \qquad (5)$$

where

Q = flow, in cubic meters per second;
n = Manning's n (a coefficient of roughness);
A = wetted area, in square meters;
R = hydraulic radius (ratio of wetted area to wetted perimeter), in meters; and
S = slope of the energy line, in meters per meter.

Manning's equation assumes that the depth, water area, velocity, and discharge are constant in every section of the channel reach and that the energy line, water surface, and channel bottom have equal slopes (Chow, 1959). For this particular channel, a Manning's n of 0.015 was used to account for losses due to friction. Published values of n for a concrete-lined channel like this one range from 0.011 to 0.015, with the larger values accounting for more losses and therefore reduced flow (Chow, 1959).

Sycamore Creek

Sycamore Creek flows in a southwest-to-northeast direction and discharges into West Fork Trinity River just east of downtown Fort Worth, a few kilometers upstream of the inflow from Big Fossil Creek (fig. 1). The channel bottom is rocky and mixed with silt and clay and appears fairly stable. A bridge is located about 61 m downstream from where stage was measured and recorded every minute during a storm. Discharge measurements were made from the bridge, and the relation between stage and discharge was obtained by taking measurements during different flow conditions and fitting a power function to the data. Four measurements were made, with the highest measured stage about 1.22 m. The power function then was used to compute flow for a given stage. Peak stages during the sampled storms ranged from 0.15 to 1.34 m.

Lake Como Inflow

Lake Como is located southwest of downtown Fort Worth and has a part of Interstate-30 crossing its watershed (figs. 1, 2). The passive sampling site Lake Como outflow was on the creek downstream from the lake, which empties into Clear Fork Trinity River. The inflow to Lake Como consists of two parallel culverts, one circular, made from corrugated metal, and one semicircular on top and approximately rectangular on bottom and constructed of concrete. The circular culvert is about 2.44 m in diameter. The semicircular top part of the other culvert has about a 1.22-m radius. The bottom part is about 2.44 m wide and 0.91 m high. Storm samples were collected and stage was measured at the downstream end of the concrete semicircular culvert about 3.35 m upstream of the entrance to the lake.

As with the Big Fossil Creek site, flow was estimated in the concrete culvert from recorded stages using the Manning equation under the assumption of uniform flow. The same Manning's n (0.015) was used. The slope of the reach is 0.01 meter per meter. The Manning equation also was used to estimate flow in the metal culvert ($n = 0.024$). Because stage was not measured in this culvert, it was estimated by assuming that measured stage in the concrete culvert equals stage in the metal culvert. The site was surveyed to determine if this was a reasonable assumption. The two invert elevations are within 0.03 m. Two flows were computed for the storm of Aug. 30, 2001, one by taking the 0.03-m difference into account and the other by assuming equivalent stages. The differences in computed flows were negligible (less than 0.5 percent). Therefore, it was assumed that stage measured in the concrete culvert was representative of stage in the metal culvert.

Echo Lake Inflow

Echo Lake is located in eastern Fort Worth immediately east of Interstate-35W and about midway between Interstate-20 and Interstate-30 (figs. 1, 2). The inflow to the lake consists of two rectangular concrete culverts with cross-sectional areas of 7.6 and 3.8 square meters. The larger culvert transports most of the inflow to the lake because of its larger area and its location—upstream of the culverts is a natural channel that flows directly into the larger culvert. For water to enter the smaller culvert, it must turn 90 degrees in front of the larger culvert and flow about 50 m before making another 90-degree turn and entering the culvert. Stage was measured in the upstream and downstream ends of the larger culvert. The Culvert Analysis Program (CAP) (Fulford, 1998) was used to compute discharge at measured stages. This program solves the one-dimensional steady-state energy and continuity equations to compute an upstream water-surface elevation for a given discharge and downstream water-surface elevation. Because both water-surface elevations were measured and recorded at 5-minute intervals, the known upstream and downstream elevations were used to solve for flow rate. The program of Fulford (1998) is based on a procedure described by Bodhaine (1968).

Flow rates and storm volumes at this site were difficult to estimate because of frequent backwater conditions. Backwater is defined as equivalent upstream and downstream water-surface elevations. The upper end of the lake often was at the downstream end of the culvert, and the lake is small enough that large rainfall causes an appreciable rise in lake level. Backwater conditions were present at the beginning of sampled storms, but as rainfall intensities and runoff amounts increased, the difference between the upstream and downstream water-surface elevations would increase. During non-backwater conditions, the CAP program could be used to compute flow. Only samples collected when backwater conditions were not present were used as representative samples. For these samples, it was possible to estimate total storm volume and compute contaminant loading. During backwater conditions and associated low velocities, sediment transport to the lake probably was negligible.

CAP could not be used to estimate flow in the smaller culvert. The program could not converge on a solution because the smaller culvert is steeper than the larger culvert, and as water traveled through the culvert it passed through critical depth. Engineering judgment was used to estimate total storm volume contributed by the smaller culvert. The cross-sectional area of the larger culvert is twice that of the smaller culvert.

Although flow to the smaller culvert is not as direct as flow to the larger culvert, the slope of the smaller culvert is such that the water travels more efficiently into the lake. Taking these facts into consideration, it was estimated that two-thirds of the total storm volume enters the lake through the larger culvert and one-third through the smaller culvert.

The limitations and uncertainties of computing flow at this site are large, and upstream sites with better conditions for monitoring stream discharge that captured runoff from a large part of the watershed of the lake were not available. Although these uncertainties influence flow and load estimates, they are less important to measurement of contaminant concentrations in suspended sediments. Monitoring, therefore, was performed at this site to meet project objectives to the extent possible.

Fosdic Lake Inflow

Fosdic Lake is located east of downtown Fort Worth and just south of Interstate-30 (figs. 1, 2). The inflow to the lake is a natural channel with a rocky and fairly stable bottom and side slopes. The relation between stage and discharge for this channel was obtained by the slope-area method using the slope-area computation (SAC) program. The method used by SAC is based on the USGS procedure described by Dalrymple and Benson (1967). The method is an indirect measurement of discharge because flow velocities are not actually measured. Instead, high-water marks are measured and used to compute peak discharge after a storm by assuming one-dimensional, gradually varied, steady flow. The method uses the conservation of energy and mass and Manning's equation.

High-water marks were measured after 11 storms of varying peak discharges with crest-stage gages in a reach 34.44 m long. The slope-area method then was used to compute the peak discharge, and a relation between upstream stage and discharge was developed. Stage at the upstream cross section was measured at 5-minute intervals. After a sampled storm, discharge in the channel was computed for each measurement of stage, and a hydrograph was generated to provide data for creation of a composite sample and computation of storm volume. The relation between stage and discharge is linear when the water is contained in the main channel. As the stage rises and flow begins to leave the main channel, smaller increases in stage result in larger increases in flow because of increases in cross-sectional area. This increase in cross-sectional area is true for both the upstream and downstream end of the reach.

Estimating Contaminant Loads in Streams

Loads of sediment and contaminants transported on the sediment can be computed on the basis of the discharge of a stream from a storm and measured suspended-sediment and chemical concentrations. Discharge is obtained from the recorded stream stage and the stage-discharge relation. Stage during a storm, defined as the abrupt rise and fall in water level associated with rainfall, is used to compute instantaneous and total flow. As many as seven 9-L samples for chemical analyses are collected at predetermined time intervals by an automated sampler after the initial rise in stage triggers the sampler to begin operating. The proportion of the total stormflow associated with each discrete sample is determined and used to develop a single event-composite sample. Water from each discrete sample is combined in proportion to total flow. By this approach, measured suspended-sediment and chemical concentrations theoretically are the average concentrations for the storm. Load is therefore the product of these concentrations and total volume of flow. Because the approach here was to analyze sediment chemistry directly and not for whole-water samples, contaminant load was the product of total sediment load and the concentration of the contaminant on the sediment.

At Sycamore Creek, the discrete samples were analyzed individually to evaluate variations in sediment chemistry during a runoff event. Event load was obtained by computing the load represented by each discrete sample and then summing those loads. Halfway in time between each discrete sample commonly was used to define the interval represented by each sample. This approach theoretically yields the same result as given by a flow-weighted event-composite sample times total flow.

Event yield is the mass of contaminant transported by the event per unit area of watershed. Yields were computed by dividing loads by the watershed area. Sediment and contaminant loads and yields are useful because they provide estimates of the amount of contaminant being transported by each storm, which can be used to indicate source strength.

PARTICLE-ASSOCIATED CONTAMINANTS IN CORES AND SUSPENDED SEDIMENTS

Three cores were collected from each of the three lakes (table 4). Suspended-sediment samples were collected from the three inflowing streams to the three lakes, from Sycamore, Big Fossil, and Little Fossil Creeks flowing into West Fork Trinity River, and from five creeks or culverts flowing into Clear Fork Trinity River (fig. 1). Site information is listed in tables 3 and 4, and watershed land-use percentages for the suspended-sediment sites are listed in table 3. Physical and chemical data are presented in appendix 1. Data presented for all sites are organized by chemical or physical characteristic group.

Quality Assurance of Chemical Data

The USGS NWQL analyzes QC samples with each group of environmental samples analyzed for organic compounds and major and trace elements. Laboratory QC data are presented in appendix 2. Environmental duplicates also are presented with the chemical data in appendix 1. A blank, spike, commercially prepared certified reference material (CRM), and environmental-sample duplicate that is split at the laboratory are included with each batch of samples analyzed. Occasionally, duplicate results could not be provided for a batch because little sample material was available for analysis or because the duplicate for the set or batch was from a different study.

The bottom-sediment and suspended-sediment samples were analyzed for organic compounds in 14 groups (appendix 2.1). All organochlorine blank samples were below laboratory reporting levels. The organochlorine spike recoveries were within the statistical control limits defined by the NWQL except for PCB Aroclor 1254 in organochlorine set number 200128405. All organochlorine CRM samples were within an acceptable range as specified by the manufacturer of the CRM. The NWQL used two CRMs, CRM 354 and CRM 362, in the sets of samples analyzed for this study (appendixes 2.2 and 2.4).

The PAH blank samples have five detections of naphthalene and one detection of phenanthrene (appendix 2.4). These PAH detections were at very low concentrations, not exceeding an estimated concentration of 0.3 µg/kg. The NWQL has not defined acceptable spike control limits for PAHs; however, all PAH CRM samples were within an acceptable range as specified by the manufacturer of the CRM. Both CRM 354 and 362 were used in the batches of samples analyzed for PAHs in this study. The CRM was ruined during preparation at the NWQL in batch 8022R01234, and no results are available.

Two duplicate suspended-sediment samples from the Downtown site collected on May 4 and Aug. 16, 2001, were split at the USGS laboratory in Austin, Tex., before filtration. All other duplicate samples were splits of the extracts prepared by the NWQL. The relative percent difference (RPD) is a measure of the variability in the values produced by the analytical method. RPD was computed for each pair of duplicate samples using the equation

$$\mathrm{RPD} = 100 \times \left| \frac{sample1 - sample2}{\left(\frac{sample1 + sample2}{2}\right)} \right| , \qquad (6)$$

where

sample 1 and *sample* 2 = concentrations of individual compounds in duplicate samples.

The NWQL did not report duplicate results for three organochlorine sets and four PAH batches. The duplicate samples analyzed for organochlorine compounds in sets 200122506, 200208407, and 200207706 and those analyzed for PAHs in batches 8022R02192, 8022R01243, 8022R01234, and 8022R01215 were not samples collected by this study; however, they are measures of the variability associated with the analytical method. The overall median RPD for duplicate analyses in the groups of samples analyzed for this study is 8.4 percent for the organochlorine compounds and 6.5 percent for the PAHs. The RPD for each set and batch are listed in appendix 2.1, and details for individual compounds are listed in appendixes 2.3 and 2.5.

Samples to be analyzed for major and trace elements and forms of carbon are sent to the NWQL and then transferred to another analytical laboratory of the USGS. The bottom-sediment and suspended-sediment samples in this study were analyzed for major and trace elements and forms of carbon in 12 batches. Each batch typically consists of as many as 20 environmental samples. Several standard reference materials (SRMs) typically are analyzed with each batch, including National Institute of Standards and Technology Buffalo River Sediment (NIST 2704), USGS Cody Shale (SCO-1), USGS Marine Sediment (MAG-1), and Chinese Quangxi Province stream sediment (GSD-8). One set of

SRMs was analyzed for batches 3209 and 3210 and batches 3342 and 3427. Mercury and forms of carbon are not included in the SRM quality assurance samples. The laboratory compares the results of their analyses of the SRMs with the published concentrations of the SRMs (Xuejing and Mingcai, 1985; Potts and others, 1992). The RPD and percent recovery are computed for the elements of each SRM (appendix 2.7). The percent recovery is a measure of the efficiency of the analytical method. The percent recovery is computed using the equation

$$PercentRecovery = \frac{SRM_{found}}{SRM_{true}} \times 100, \qquad (7)$$

where

SRM_{found} = concentration obtained by the laboratory analysis of the SRM and

SRM_{true} = published concentration.

The median RPD for the 12 batches of QC samples included in this study generally is lowest for the major elements and highest for cadmium, and the mean percent recovery often is lowest for nickel and highest for cadmium and copper. The overall median RPD for the SRMs is 5.1 percent for all batches and elements analyzed in this study, and the mean percent recovery is 102 percent. The RPD and percent recovery of the SRMs for each batch and each major and trace element are listed in appendix 2.7.

Duplicate or triplicate samples split at the laboratory are analyzed with each batch. A triplicate sample includes the analysis of the sample and two splits of the sample. The suspended-sediment sample from the Downtown site collected on Aug. 16, 2001, was split at the USGS laboratory in Austin before filtration. The laboratory analyzed the duplicate split (site 5, Downtown 08/16/01 @ 0846 Dup.) in triplicate. The laboratory split all other samples analyzed in duplicate or triplicate. The duplicate and triplicate samples analyzed for batches 3209, 3210, and 3784 are not samples collected in this study but nonetheless describe the analytical variability of the method. The RPD was computed three times for triplicate samples to compare the concentrations of samples 1 and 2, samples 1 and 3, and samples 2 and 3. The overall median RPD was 2.2 percent for duplicate and triplicate analyses for all batches and elements analyzed in this study. The RPD of duplicate and triplicate sample analyses for individual batches is listed in appendix 2.8.

STL Richland analyzed the core-sediment samples for ^{137}Cs concentrations. A duplicate, blank, and laboratory control sample each is run with each set of samples. The duplicate sample analysis is a single sample preparation counted using two different detectors. The USGS and STL Richland have established contractual required laboratory reporting levels for the environmental and QC samples. However, the contractual required laboratory reporting levels were not met because the sediment available was insufficient for analysis. The minimum laboratory reporting level based on instrument background was achieved for all samples. STL Richland reports overall method uncertainty estimates with their analytical results, which are listed with sample concentrations in appendix 1.1 (Jackie Waddell, Severn Trent Laboratories, Inc., written commun., 2001). The samples from each lake were grouped by lake and analyzed in three separate sets. The QC sample results are summarized in appendix 2.9 with the RPD computed for the duplicate samples and the percent recovery reported for the laboratory control sample.

Not all QC sample results for all constituents were entered into the USGS National Water Information System (NWIS). NWIS is the database used for water-quality and other water-related data. Its contents are periodically compiled and provided to cooperating agencies and are available to the public. The laboratories that analyzed the samples store the QC sample results in their various databases. The QC results presented in this report therefore are available in this report only.

Concentrations reported for suspended sediments are highly variable as are laboratory reporting levels, as indicated by the nondetection and estimated values. The large variability in reporting levels primarily is caused by variable mass of samples, with the highest reporting levels associated with the smallest mass samples (appendix 1.4). A sample mass of only 0.058 g in sample Sycamore Creek #2 on Aug. 16, 2001, for example, resulted in a reporting level of 2,000 µg/kg for chlordane. This sample, admittedly, is not very informative. Following receipt of these results and discussions with laboratory analysts, a decision was made to not analyze samples if the dry mass was less than 0.2 g.

Small sample mass also could affect precision. In the two duplicate samples of suspended sediment analyzed for organochlorine compounds (Downtown site, May 4 and Aug. 16, 2001), mean RPD was 39 and 37 percent. These compare with mean RPD of 7.4 and 15 percent in duplicate bottom-sediment samples from this study and a long-term mean RPD for this analytical method of 18 percent (P.C. Van Metre, U.S. Geological Survey, unpub. data, 2002).

Lake Como

Age Dating and Sedimentation Rates

Lake Como was built in 1889 (Vicki Stokes, City of Fort Worth, oral commun., 2002). Only one of three cores, the upper lake core, CMO.5, penetrated to the pre-reservoir land surface as indicated by an abrupt change in core lithology. The bottom of CMO.1, the primary core from the lower lake site, penetrated a stiff, tan clay at the bottom (95 cm), although no root hairs or sand, common indicators of pre-reservoir soils, were found. The ^{137}Cs activity profile for CMO.1 has a peak at 80 to 85 cm (fig. 3). The peak is sharp and decreases smoothly to the top of the core. The peak to top-of-core ratio of 10, even without decay-correcting the older peak sample, indicates the lack of post-depositional mixing in the core (Van Metre and others, 1997). The presence of ^{137}Cs at the bottom of the core and the location of the peak activity indicate that this core only penetrated to sediments deposited in the late 1950s.

A MAR of 1.54 grams per square centimeter per year (g/cm^2-yr) was computed using the ^{137}Cs peak at 82.5 cm and the sampling date at the top of the core. Age dates were assigned to the entire core using this MAR. Age assignments generally are corroborated by a very large peak in lead that was dated as 1969 and maximum PCB and total DDT concentrations in the bottom sample analyzed dated as 1959. Although these peaks are a few years earlier than generally expected, the excellent ^{137}Cs profile takes precedence over dates suggested by the contaminant profiles.

Only three samples were analyzed from secondary cores CMO.3 (mid-lake) and CMO.5 (upper lake); therefore, detailed ^{137}Cs and contaminant profiles were not obtained. Dates were assigned to these two cores by approximately matching ^{137}Cs activities and lead concentrations to the profiles from CMO.1 (fig. 3).

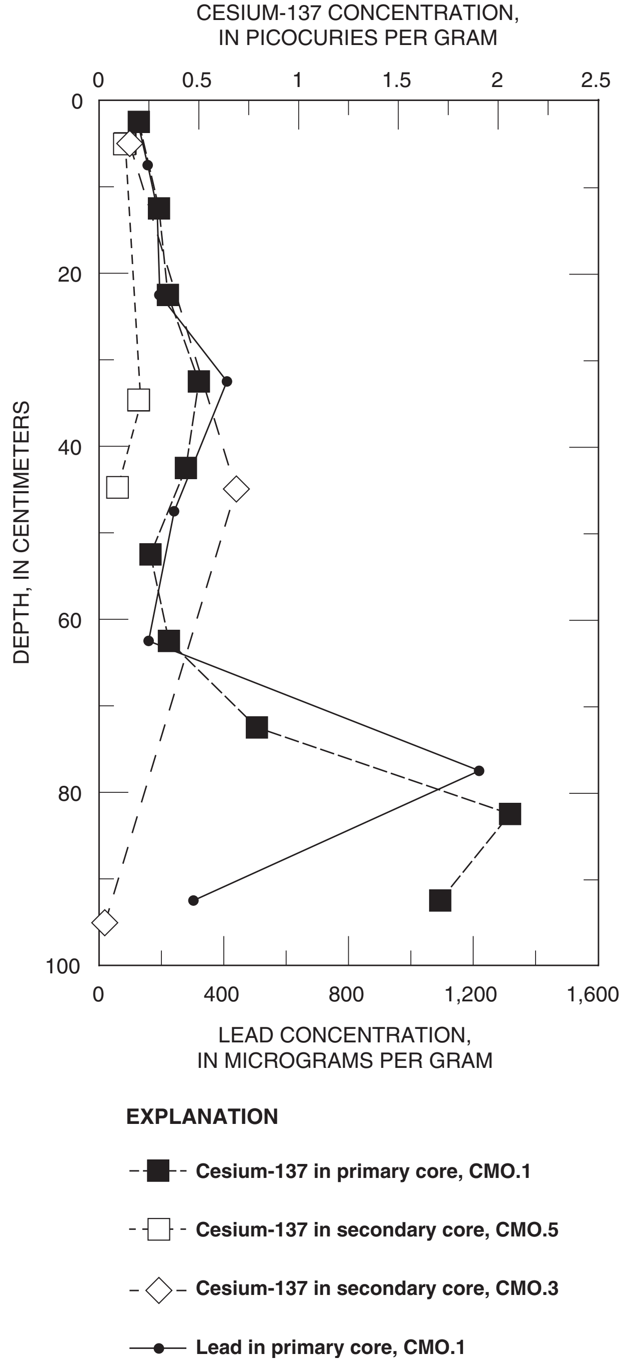

Figure 3. Cesium-137 and lead concentrations in Lake Como core sediment used for age dating samples.

Sediment Properties, Contaminant Trends, and Relations to Inflows

Sediments from CMO.1 are very fine grained with 94 to 100 percent silt and clay size and 43 to 81 percent clay size (fig. 4; appendix 1.2). Sediments are slightly coarser at the mid-lake site, CMO.3, and much coarser at the upper lake site, CMO.5, where sand accounted for 27 percent of sediment at the top of the core and 87 percent at the bottom. Coarser sediments are expected in the upper lake near the stream inflow because the coarsest material settles out of suspension first as the water slows upon entering the lake. A second core for visual description was collected adjacent to

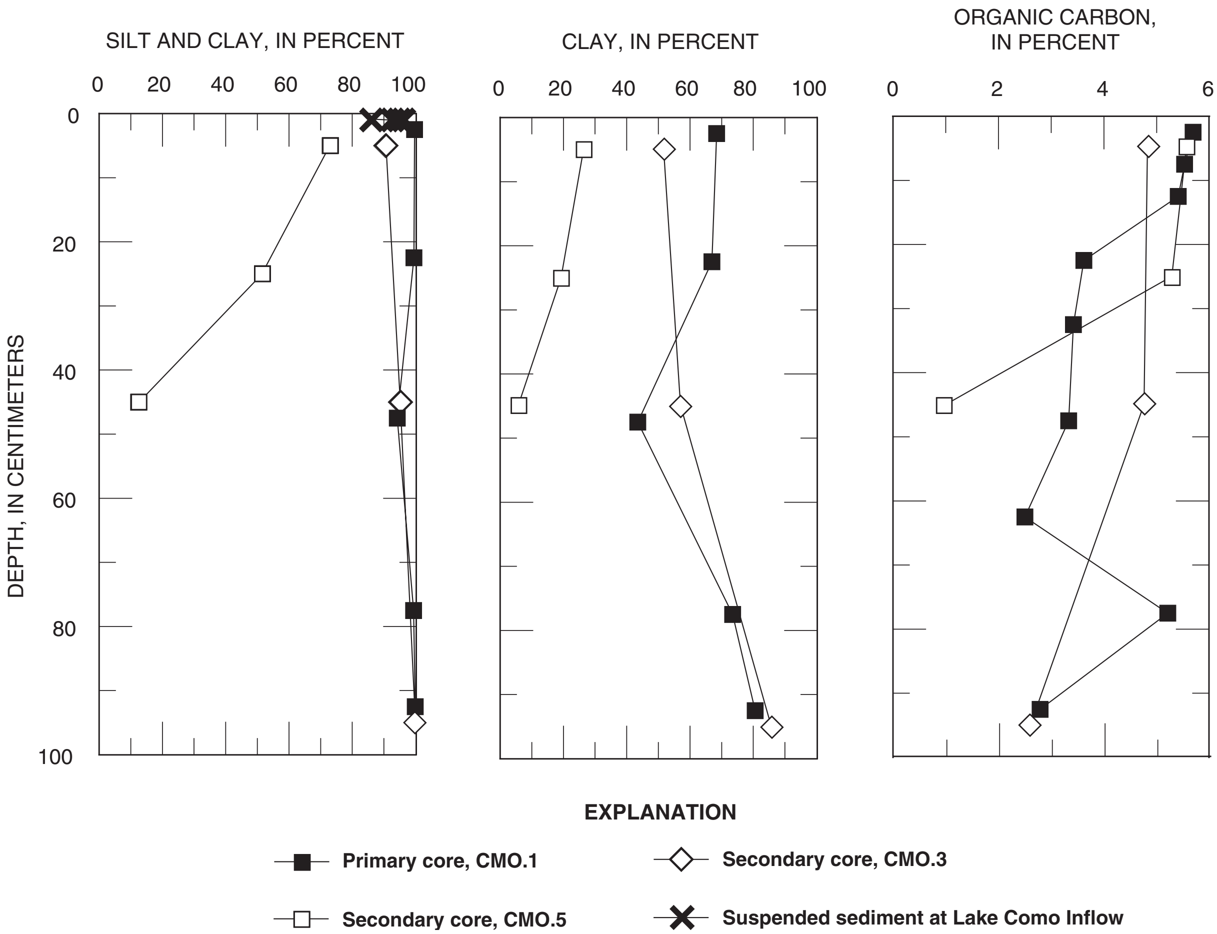

Figure 4. Grain size and organic carbon in Lake Como core sediment and Lake Como inflow suspended-sediment samples.

cores CMO.1 and CMO.3. These cores were designated CMO.2 and CMO.4, respectively. Visual descriptions included observations of color, texture, and odor. Cores CMO.2 and CMO.4 were described as olive-gray soft clay with no visible biota or organic debris such as leaves or sticks.

One factor in comparing trace contaminant concentrations among sediment samples is variation in bulk sediment characteristics, which can affect contaminant concentrations. Two parameters are often assumed to exert a controlling influence on trace contaminants: organic carbon concentrations, especially for nonpolar, hydrophobic organic compounds, and grain size or some other indication of surface area for trace elements (Horowitz and Elrick, 1987; Smith and others, 1988). Aluminum concentrations can be used in predominantly fine-grained sediments as an indicator of clay content and therefore surface area (Van Metre and Callender, 1996).

Aluminum concentrations vary relatively little, as indicated by a coefficient of variation (Cv, the standard deviation divided by the mean) of 0.13 and do not have a significant trend in CMO.1. Organic carbon concentrations, however, increase to the top of the core (fig. 4) and have greater variation among samples as indicated by a Cv of 0.29 (table 6). The largest organic carbon concentrations occur in the top 15 cm, a common pattern in sediment cores that probably is an indication of sedimentary diagenesis. Diagenesis is the chemical alteration of sediments over time; in this case, the oxidation of organic matter while the sediment is still in near contact with the water column and a source of oxygen. Once buried and isolated from the water column, oxidation slows and the chemical characteristics

Table 6. Trend testing results and variability of concentrations from 1965 to 2001 on primary sediment core from each lake

[Test is Kendall's tau correlation test of time versus concentration. Testing of organic compounds in Lake Como samples was also done using normalized values (concentration divided by organic carbon). Statistically significant trends at 95-percent or greater confidence are highlighted. p-values are two-sided. --, not applicable; *ID*, insufficient detections for test]

Constituent	Lake Como (n=8)			Lake Como (organic carbon normalized)		Echo Lake (n=8)			Fosdic Lake (n=6)		
	Cv	Kendall's tau	p-value	Kendall's tau	p-value	Cv	Kendall's tau	p-value	Cv	Kendall's tau	p-value
Organochlorine compounds											
Chlordane	.73	-.33	.26	-.64	.026	.73	.40	.17	.39	.87	.015
Dieldrin	1.34	.59	.040	.29	.32		*ID*		.78	.87	.015
DDE	.60	-.64	.026	-.71	.013	.68	-.50	.083	.56	-.60	.091
DDD	1.28	-.40	.17	-.50	.083	1.61	-.79	.006		*ID*	
DDT		*ID*		*ID*		.61	.43	.14	.93	.28	.44
Total DDT	.95	-.57	.048	-.64	.026	1.06	-.76	.008	.61	-.47	.19
Total PCB	.72	-.64	.026	-.64	.026	.69	-.21	.46	.57	-.47	.19
Major elements											
Aluminum	.13	.21	.46	--	--	.04	-.22	.44	.12	-.33	.35
Organic carbon	0.29	.71	.013	--	--	0.05	-.36	.22	0.07	.33	.35
Trace elements											
Arsenic	.17	-.07	.80	--	--	.12	-.47	.10	.11	-.20	.57
Cadmium	.32	.14	.62	--	--	1.60	-.79	.006	.34	-1.00	.005
Chromium	.21	-.57	.048	--	--	.54	-.79	.006	.11	-.33	.35
Copper	.22	.29	.32	---	--	.11	-.29	.32	.08	-.07	.85
Lead	1.09	-.64	.026	--	--	.70	-.79	.006	.51	-1.00	.005
Mercury	.16	-.52	.072	--	--	.09	-.45	.12	.31	-1.00	.005
Nickel	.08	.29	.32	--	--	.09	-.22	.44	.09	-.33	.35
Zinc	.25	.29	.32	--	--	.22	-.21	.46	.08	.33	.35
PAHs											
Naphthalene	.39	.43	.14	.14	.62	.26	.50	.083	.34	.60	.091
9H-Fluorene	.43	-.29	.32	-.57	.048	.28	.36	.22	.32	.07	.85
Phenanthrene	.44	-.07	.80	-.43	.14	.31	.64	.026	.57	.47	.19
Anthracene	.47	-.36	.22	-.64	.026	.35	.50	.083	.46	.60	.091
Fluoranthene	.45	.07	.80	-.21	.46	.46	.86	.003	.58	.47	.19
Pyrene	.43	.07	.80	-.14	.62	.41	.79	.006	.58	.47	.19
Benz(a)anthracene	.44	.21	.46	.00	1.00	.39	.71	.013	.55	.47	.19
Chrysene	.45	.29	.32	.14	.62	.51	.86	.003	.59	.60	.091
Benzo(a)pyrene	.46	.21	.46	.07	.80	.42	.71	.013	.64	.60	.091
Dibenzo(a,h)anthracene	.52	.36	.22	.14	.62	.64	.71	.013	.65	.60	.091
Coronene	.41	.07	.80	-.43	.14	.48	.57	.048	1.08	.47	.19
Total PAH	.36	.07	.80	-.21	.46	.43	.21	.46	.50	.60	.091
Combustion PAH	.47	.29	.32	.14	.62	.46	.79	.006	.59	.60	.091

of the sediments are better preserved (Callender, 2000). Because organic carbon has relatively large variation and a significant trend, trends in organic compounds were tested using both measured concentrations and concentrations normalized to (divided by) organic carbon concentrations.

Suspended sediment in the four sampled storms at Lake Como inflow also is fine grained, with about 85 to 97 percent silt and clay size (fig. 4; appendix 1.3). The relative distribution of grain sizes at the inflow is consistent with those observed in the lake and with preferential settling of the coarser fractions in the upper lake. Material obtained in each of these samples was insufficient for analysis of organic carbon concentration.

Organochlorine Pesticides and Polychlorinated Biphenyls

Seventeen chlorinated hydrocarbon compounds or mixtures of compounds, consisting of 14 organochlorine pesticides and three PCB Aroclors, were analyzed for suspended and bottom sediments (table 5). Of the 14 pesticides, five were detected in one or more samples from Lake Como and Lake Como inflow (chlordane, DDD, DDE, DDT, and dieldrin), and all three PCB Aroclors were detected (appendix 1.4). The fish possession ban in effect at Lake Como is based on elevated levels of chlordane, DDE, dieldrin, and PCBs (table 1). Also listed in appendix 1.4 are the consensus-based sediment-quality guidelines (MacDonald and others, 2000). These guidelines are a numerical consensus of as many as six published sets of guidelines developed using similar methods. The methods use measured chemical concentrations in sediments and observed toxicity or some other adverse response of biota exposed to the sediments. They were shown to be reliable predictors of observed toxicity and lack of toxicity in sediments from a variety of settings in North America. MacDonald and others (2000) determined threshold effect concentrations (TECs) and probable effect concentrations (PECs) for eight elements, nine individual PAHs, total PAH, total PCBs, eight individual organochlorine pesticides, and total DDT.

Concentrations of chlordane in Lake Como are large in comparison to published sediment-quality guidelines (appendix 1.4). Only one chlordane concentration, from the bottom of core CMO.3, did not exceed the PEC, and most samples were about an order of magnitude or more greater than the PEC. Concentrations of DDD (four samples, one of which is a duplicate) and total PCBs (one sample) also exceeded the PEC.

Pronounced temporal trends in many chlorinated hydrocarbons are indicated by concentration profiles in the sediment cores and statistical tests of trend (fig. 5; table 6). Concentrations are graphed versus time on the basis of age assignments to the three cores and the sampling dates for suspended-sediment samples. Trend results for all three lakes are included in table 6 to facilitate comparison and discussion of results among the lakes. Concentrations of total DDT and DDE, the dominant metabolite in these cores, peaked in the 1960s at about 10 times higher than at present (tops of cores). Decreases in total DDT and DDE are statistically significant for measured concentrations and organic carbon normalized concentrations, as is the decrease in PCBs. Temporal trends in PCBs are very similar to total DDT trends with maximum values at the bottoms of the cores in the late 1950s or 1960s and an approximate 10-fold decrease to the tops of the cores. Similar trends are found in many U.S. lakes and reservoirs (Van Metre and others, 1998). Concentrations of total DDT and PCBs on suspended sediments from the Lake Como inflow are generally equal to or greater than concentrations at the tops of the cores. The presence of these long-banned compounds in current (2001) runoff probably can be attributed to erosion of historically contaminated soils.

Trends in chlordane are similar to trends in total DDT, although the peak in about 1970 is defined by a single sample. The chlordane trend in CMO.1 is not significant, but the organic carbon normalized trend significantly decreases (fig. 5; table 6). Except for the 1970 sample and the nondetection at the bottom of CMO.3, chlordane concentrations are relatively high and uniform in the three cores, ranging from 120 to 330 μg/kg with a median of 150 μg/kg. Chlordane concentrations in recently deposited sediment at the top of the three cores (150, 140, and 150 μg/kg) are uniform. The core profiles and the similarity between concentrations in the tops of cores and the median concentration of all core samples indicate that chlordane remains at high concentrations 13 years after use was restricted in 1988. At that time, commercial sales and use of chlordane were cancelled; however, use of existing stocks by homeowners was permitted (U.S. Environmental Protection Agency, 1997; Mattina and others, 1999). The high concentrations in suspended sediments are a direct confirmation that chlordane continues to enter the lake in runoff.

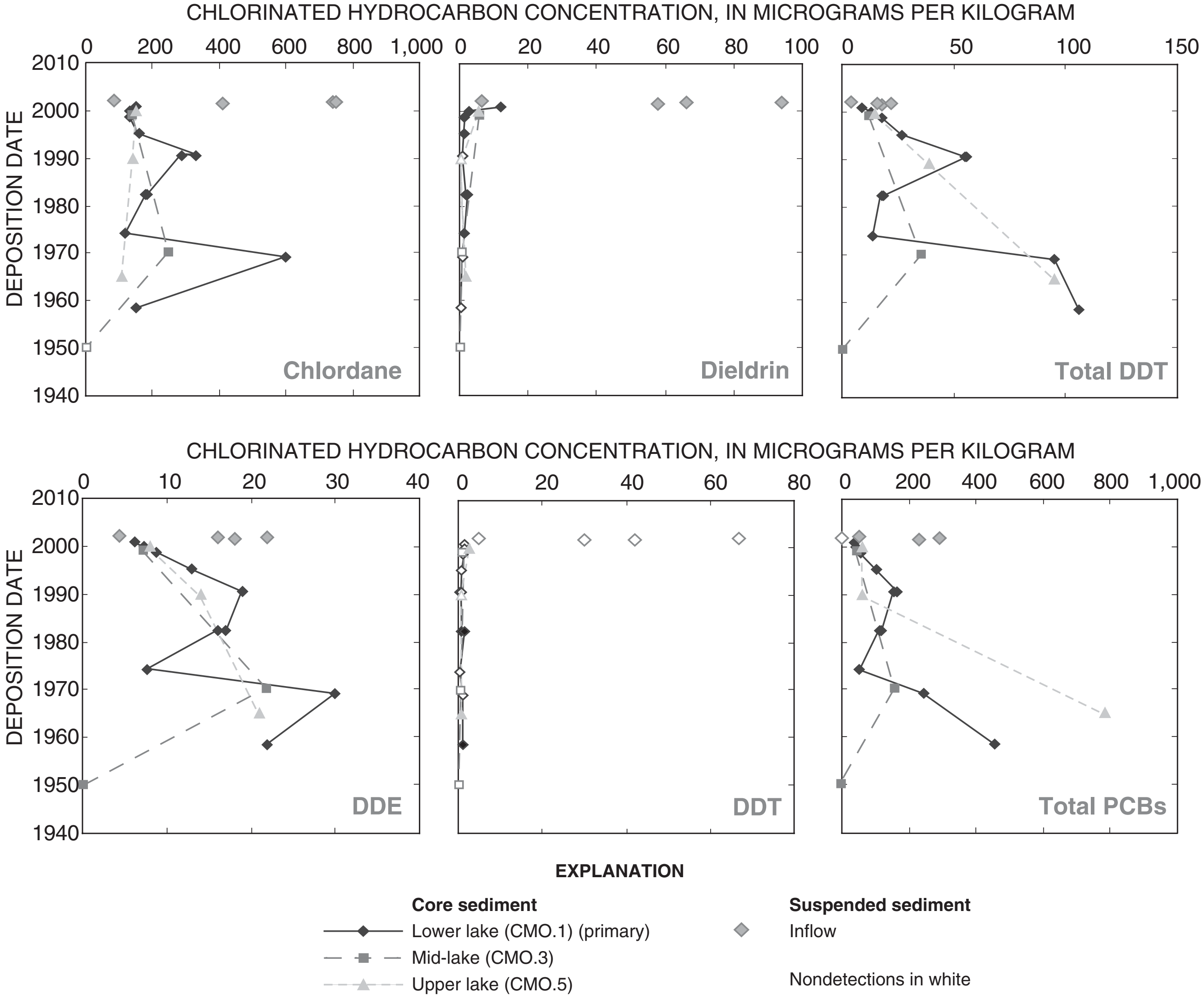

Figure 5. Trends of chlorinated hydrocarbons in Lake Como core sediment and Lake Como inflow suspended sediment. Kendall's tau rank correlation test was used to indicate whether there was a statistically significant relation between concentration and time from 1965 to top of the core. (See table 6.)

Dieldrin concentrations increase at the top of the core; (parent) DDT was not detected in the top six samples in the core or in the suspended sediment samples. Dieldrin is at considerably higher concentrations in suspended sediments entering the lake than at the tops of the cores. Rather than indicating a recent increase in loading to the lake, these data in combination with historical use suggest that dieldrin is not well preserved in older sediments in the core. Even if it is not preserved in the bottom sediments on decadal time scales, suspended and top-of-core sediments are an indication of current loading and potential bioavailability to fish.

Trace Elements

Major and trace elements measured in the Lake Como cores and Lake Como inflow suspended-sediment samples are presented in appendix 1.5. Eight trace elements have consensus-based sediment-quality guidelines, and of those, only lead and zinc in Lake Como sediments exceeded the PEC. Lead concentrations exceeded the PEC in 11 of 15 core samples and in three of four suspended-sediment samples. In one sample from CMO.1, deposited about 1970, the lead concentration was 1,220 micrograms per gram (µg/g), about 10 times the PEC. Zinc concentrations exceeded the PEC in three of four suspended-sediment samples but in none of the core samples.

Two of the eight trace elements that have sediment-quality guidelines have significant trends, chromium and lead, and both are decreasing since 1965 (fig. 6; table 6). Lead increased from about 300 µg/g in the late 1950s to a peak of more than 1,200 µg/g in about 1970 and, with the introduction of unleaded gasoline in the early 1970s, has decreased to 124 µg/g in the most recent sample at CMO.1 (fig. 6). Pronounced trends in lead have been reported for many urban lakes and have been attributed to the use and then removal of lead in gasoline (Callender and Van Metre, 1997). Chromium decreased by about one-half from 120 µg/g in the 1950s and 1960s to 68 µg/g in the most recent sample.

Although significant monotonic trends are not indicated for the other elements, pronounced temporal variations occur for many, as indicated by the core profiles. Arsenic, cadmium, mercury, and zinc all had relatively high concentrations in the late 1960s sample and a smaller concentration peak near the top of the core. All four also had the lowest concentrations in core CMO.1 in the 1970s or early 1980s.

Concentrations of trace elements in suspended sediments at the inflow are similar to concentrations at the tops of the sediment cores except for cadmium, copper, and zinc (fig. 6). Concentrations of these three elements generally are more variable between storms than other elements and are considerably larger than top-of-core concentrations for most storms sampled.

Polycyclic Aromatic Hydrocarbons

Concentrations of selected individual PAHs, total PAH, total combustion PAH, and the 2+3/COMB source indicator ratio are listed in appendix 1.6. Several individual PAHs, total PAH, and 2+3/COMB are shown in figure 7, and trend test results for total PAH, total combustion PAH, and 11 individual PAHs (nine of which have consensus-based PECs) are listed in table 6. PAH concentrations were largest in the Lake Como inflow samples and in the upper lake core (CMO.5), with many exceeding the PEC. One sample near the top-of-core CMO.1 also exceeded the PEC for many PAHs. Elevated concentrations of PAHs commonly are found in urban aquatic sediments and attributed to the numerous urban sources (Takada and others, 1991; Lopes and others, 1997; Van Metre and others, 2000). Those sources include vehicle, power plant, and industrial emissions; leaking and spilled motor oil; and tire and road wear.

Individual and total PAH concentrations appear to have increased in the three Lake Como cores from the 1950s to the 1960s, then to have been highly variable but without trend since (fig. 7). For example, total PAH concentrations in CMO.1 were 5,700 µg/kg in the oldest sample (1959), increased to 19,400 µg/kg in the next sample analyzed (1969), and ranged from 9,080 to 24,600 µg/kg with no distinct pattern in the remaining samples. This impression is supported by trend analysis with no significant trends since 1965 using raw concentrations and none for most of the organic carbon normalized PAHs including total PAH and total combustion PAH (table 6). Decreasing trends occur for two lower-molecular-weight organic carbon normalized PAHs, 9H-fluorene and anthracene.

PAH concentrations on suspended sediments at Lake Como inflow (appendix 1.6) are large, with total PAH concentrations ranging from 45,800 to 94,800 µg/kg, indicating appreciable loading of PAHs to the lake during storm runoff. These samples all have a strong combustion source signature with 2+3/COMB source indicator ratios ranging from 0.14 to 0.22. In comparison, the top sample from the upper lake core has a concentration of 30,200 µg/kg and a 2+3/COMB of 0.19. Total PAH concentrations decrease and source indicator ratios increase in the top-of-core samples moving down the lake, changing to 10,800 µg/kg and 0.42 in the lower lake surficial sample. This change in PAH concentrations and 2+3/COMB is unexpected in this small lake and suggests dilution of sediments from the inflow by cleaner sediments (with a noncombustion PAH signature), perhaps eroded from the lake shore and surrounding parkland.

Contaminant Yields Based on Cores

Estimates of yields of selected contaminants from the Lake Como watershed were made by multiplying contaminant concentrations in cores by the estimated long-term-average whole-lake sediment mass accumulation rate, MAR_{lake}. The MAR_{lake} for Lake Como was estimated on the basis of 32 soundings of sediment thickness in five cross sections (fig. 8), unit dry mass of sediment in the cores, and age of the reservoir or age of sediments at the pre-reservoir surface in each core. Sediment thickness ranged from near zero to more than 200 cm in the middle of the lake. Sediment thickness in the deepest part of the lake could not be measured with

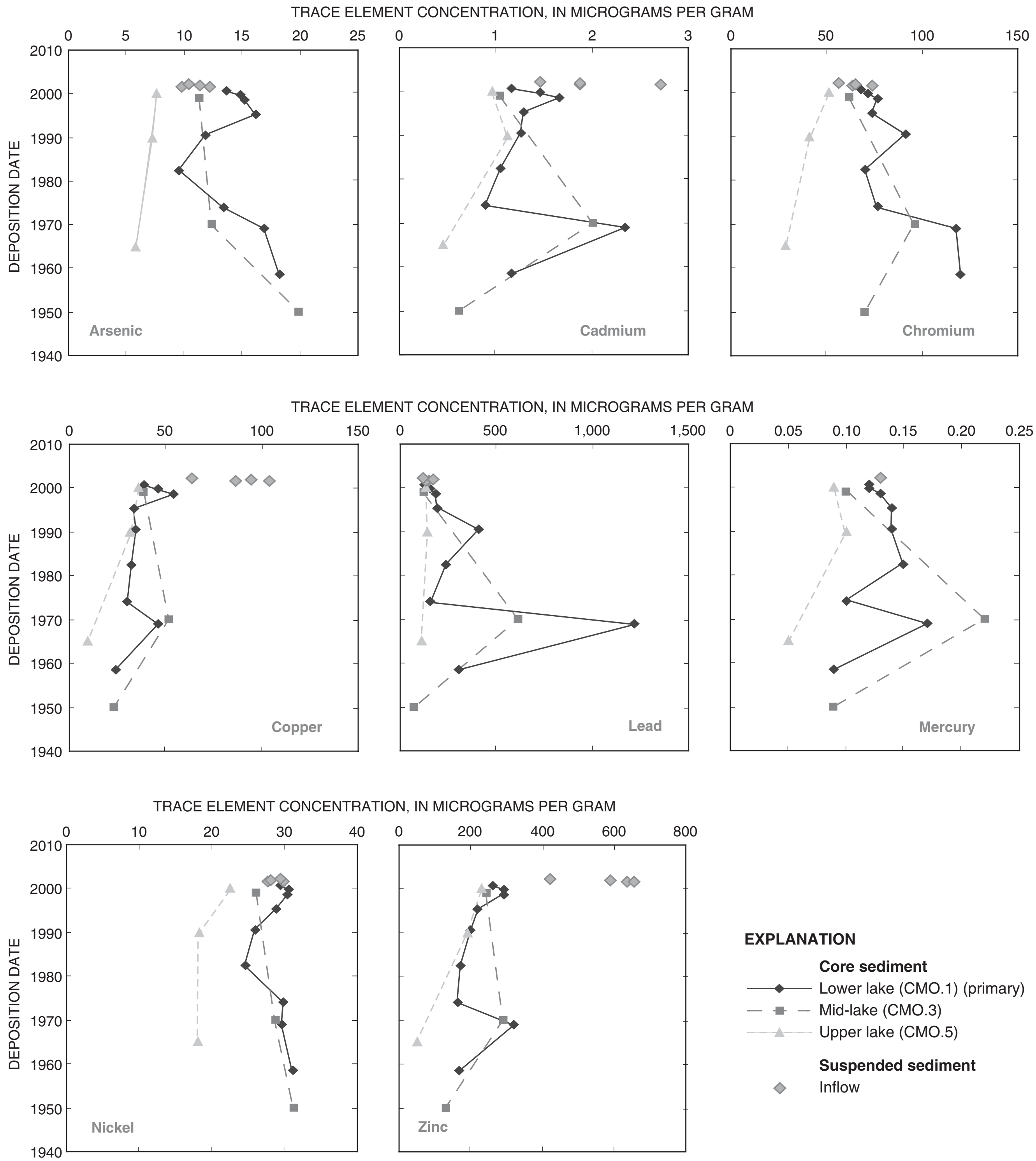

Figure 6. Trends of trace elements in Lake Como core sediment and Lake Como inflow suspended sediment. Kendall's tau rank correlation test was used to indicate whether there was a statistically significant relation between concentration and time from 1965 to top of the core. (See table 6.)

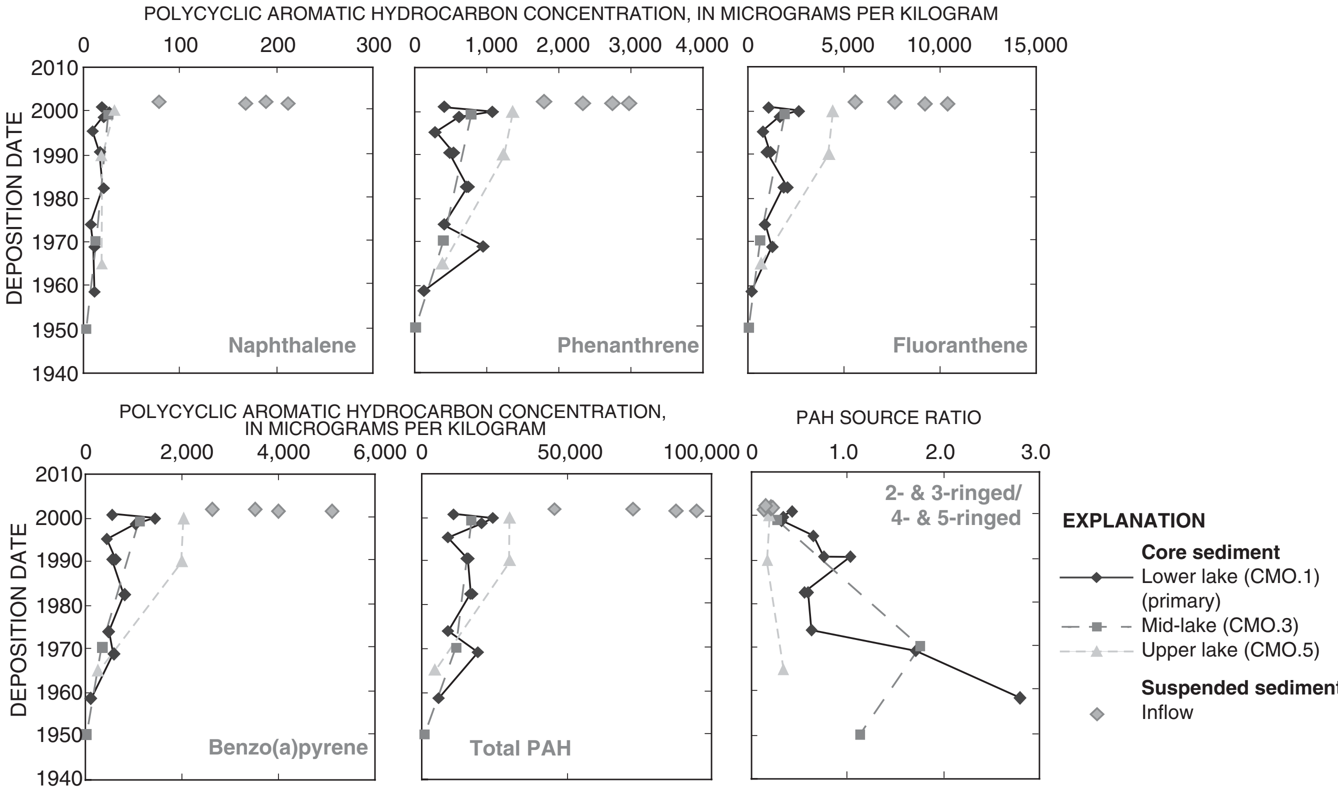

Figure 7. Trends of polycyclic aromatic hydrocarbons (PAHs) in Lake Como core sediment and Lake Como inflow suspended sediment. Kendall's tau rank correlation test was used to indicate whether there was a statistically significant relation between concentration and time from 1965 to top of the core. (See table 6.)

the tool used; thickness there was estimated on the basis of trends in thickness from the sides of each cross section. The sediment thicknesses were used to estimate total volume of sediment in a contouring and surface estimation program in a GIS and then divided into three areas of the lake corresponding to the three sediment-coring locations. Estimated total volume of lacustrine sediment for Lake Como is 41,700 cubic meters (m^3) (table 7).

Measured wet and dry weights of core samples were used to estimate porosity and unit dry mass (mass of solids per wet volume, in grams per cubic centimeter). These estimates define two general layers in the sediments: a rapidly compacting upper layer, the upper 35 cm in the primary core (CMO.1), and a more stable, compacted deeper (lower) layer (table 7). The mean unit dry mass of each layer was multiplied by the proportion of each lake area it was assumed to represent, and the results were summed to estimate total mass of sediment in the area. The total mass for each area was divided by the number of years sediment was assumed to have accumulated to compute a MAR for the area. These values were summed to yield the MAR_{lake}. On the basis of age dating of the cores and total sediment thickness, sediment accumulation for the mid-lake and lower lake areas was assumed to have occurred since reservoir construction in 1889. In the upper lake area, the core (CMO.5) encountered pre-reservoir material at a shallow depth and, on the basis of ^{137}Cs results, lacustrine sediment was estimated to date back only to the 1960s. Erosion of sediment was assumed to have occurred here, perhaps during historically low water levels in the 1950s, so a date of 1965 was used to compute the area MAR. The resulting time-averaged MAR_{lake} is 433,000 kilograms per year (kg/yr) or, when divided by the area of the lake, 0.77 g/cm^2-yr. This value compares with the MARs determined independently for the three cores: 0.91, 0.96, and 1.54 g/cm^2-yr in the upper, mid-, and lower lake cores, respectively (table 7). Considering that the cores were collected in the center of the lake where sediment deposition is greatest, the average rate of 0.77 g/cm^2-yr seems reasonable.

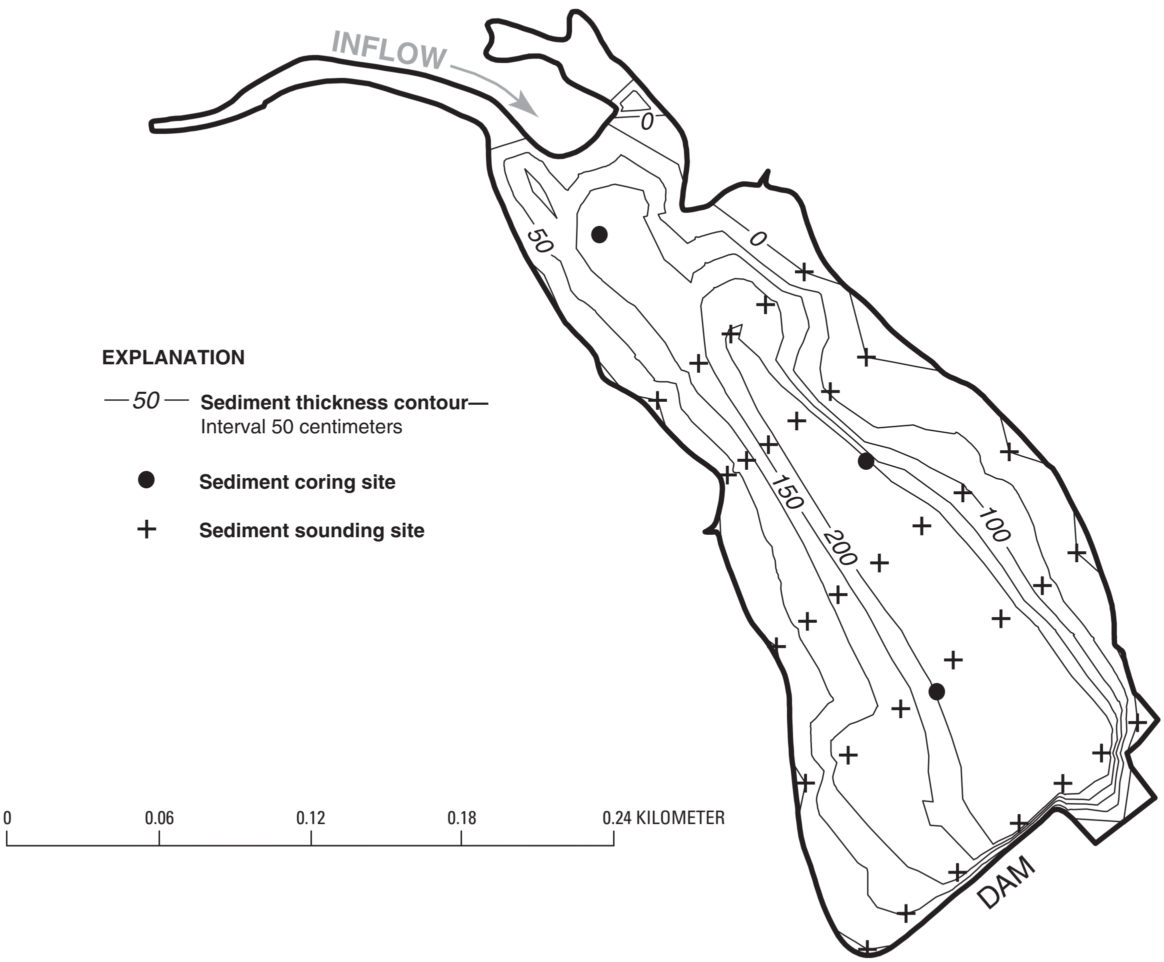

Figure 8. Sediment thickness and sampling sites in Lake Como.

Accumulation rates of selected contaminants were computed by multiplying the MAR for each area of the lake times contaminant concentrations at the top of the respective core for the area, then summing these for the whole lake. Whole-lake contaminant MARs were divided by watershed area to compute yields (table 8). Viewed alone, these numbers are not particularly informative; therefore, contaminant yields are discussed in the section "Source Strength: Contaminant Yields to Reservoirs."

Echo Lake

Age Dating and Sedimentation Rates

Echo Lake was built in 1919 (Vicki Stokes, City of Fort Worth, oral commun., 2002). The cores collected during this study did not penetrate to the pre-reservoir land surface. The primary core from the lower lake site, ECO.1, was 97 cm long, compared with 84 cm in the mid-lake site (core ECO.4) and 55 cm from the upper lake site (core ECO.3). The ^{137}Cs activity profile for ECO.1 contains a very pronounced peak at 70 to 75 cm (fig. 9). The peak is sharp and decreases smoothly to the top of the core, indicating continuous sediment deposition at the site. The peak to top-of-core ratio of about 20, even without decay-correcting the samples, indicates no significant post-depositional mixing in this core (Van Metre and others, 1997). The presence of ^{137}Cs at the bottom of the core and the location of the peak activity indicate that this core only penetrated to sediments deposited in the early 1950s. A MAR of 0.91 g/cm^2-yr was computed using the ^{137}Cs peak at 72.5 cm and the sampling date at the top of the core. Age dates were assigned to the entire core

Table 7. Sediment mass accumulation rates (MAR) in lakes

[m^3, cubic meters; g/cm^3, grams per cubic centimeter; kg, kilograms; kg/yr, kilograms per year; g/cm^2-yr, grams per square centimeter per year; kg/m^2-yr, kilograms per square meter per year; pCi/cm^2, picocuries per square centimeter; --, not applicable]

Lake	Part of lake	Vertical layer within area	Volume of wet sediment (m^3)	Vertical layer (fraction of total)	Volume of wet sediment (m^3)	Unit dry mass (g/cm^3)	Mass of sediment (kg)	Time interval of sediment accumulation (years)	MAR_{lake} (kg/yr)	MAR per unit area of lake (g/cm^2-yr)	MAR core (g/cm^2-yr)	Sediment yield (kg/m^2-yr)	Cesium-137 burden, 1952–2001 (pCi/cm^2)	Water-shed to lake area ratio	Whole-lake cesium focusing factor[1]
Lake Como	Upper lake	Upper layer	11,000	0.2	2,190	0.47	1,030,000	--	--	--	--	--	--	--	--
		Lower layer	--	.8	8,760	.68	5,960,000	--	--	--	--	--	--	--	--
		Total	--	--	--	--	6,990,000	1970–2001	233,000	--	0.91	--	--	--	--
	Mid-lake	Upper layer	13,600	.2	2,730	.40	1,090,000	--	--	--	--	--	--	--	--
		Lower layer	--	.8	10,900	.70	7,640,000	--	--	--	--	--	--	--	--
		Total	--	--	--	--	8,730,000	1890–2001	78,700	--	.96	--	--	--	--
	Lower lake	Upper layer	17,100	.14	2,400	.52	1,250,000	--	--	--	--	--	--	--	--
		Lower layer	--	.86	14,700	.83	12,200,000	--	--	--	--	--	--	--	--
		Total	--	--	--	--	13,500,000	1890–2001	121,000	--	1.54	--	35.0	--	--
	Whole lake		41,700	--	--	--	29,200,000	--	433,000	0.77	--	0.11	35.0	71	6.9
Echo Lake	Upper lake		7,080	1	7,080	.47	3,330,000	1920–2001	41,100	--	.87	--	--	--	--
	Mid-lake		23,500	1	23,500	.40	9,400,000	1920–2001	116,000	--	.70	--	--	--	--
	Lower lake		47,600	1	47,600	.52	24,800,000	1920–2001	306,000	--	.91	--	--	--	--
	Whole lake		78,200	--	--	--	37,500,000	--	463,000	.40	--	.18	32.9	22	6.5
Fosdic Lake	Upper lake	Upper layer	4,170	.3	1,250	.26	325,000	--	--	--	--	--	--	--	--
		Lower layer	--	.7	2,920	.86	2,510,000	--	--	--	--	--	--	--	--
		Total	--	--	--	--	2,840,000	1911–2001	31,500	--	.51	--	--	--	--
	Mid-lake	Upper layer	8,620	.29	2,500	.30	739,000	--	--	--	--	--	--	--	--
		Lower layer	--	.71	6,120	.66	4,060,000	--	--	--	--	--	--	--	--
		Total	--	--	--	--	4,800,000	1911–2001	53,300	--	.69	--	--	--	--
	Lower lake	Upper layer	12,800	.3	3,840	.20	768,000	--	--	--	--	--	--	--	--
		Lower layer	--	.7	8,960	.63	5,640,000	--	--	--	--	--	--	--	--
		Total	--	--	--	--	6,410,000	1911–2001	71,300	--	.71	--	--	--	--
	Whole lake		25,600	--	--	--	14,000,000	--	156,000	.47	--	.13	22.6	36	4.4
White Rock Lake[2]			--	--	--	--	--	--	79,000,000	1.8	.74	.31	10.7	60	2.3

[1] Focusing factor computed by dividing cesium burden by estimated historical fallout of 5.1 pCi/cm^2 (Van Metre and others, 1997).

[2] Van Metre and Callender (1997) and Van Metre (unpub. data). MAR_{lake} estimated using sedimentation surveys and core data.

using this MAR (appendix 1.1). Age assignments are corroborated by peaks in lead and total DDT that are dated as 1972. The deepest sample was assigned an estimated deposition date of 1951.

Three samples were analyzed from secondary cores ECO.4 (mid-lake) and ECO.3 (upper lake). Dates were assigned to these two cores by approximately matching pronounced lead and DDE peaks to the profile from ECO.1 (figs. 9, 10; appendix 1.1).

Sediment Properties, Contaminant Trends, and Relations to Inflows

Sediments from ECO.1 are very fine grained with greater than 99 percent silt and clay size and 69 to 77 percent clay size (appendix 1.2). Sediments are slightly coarser at the mid-lake site, ECO.4, and considerably coarser at the upper lake site, ECO.3, where silt size particles dominate. A second core for visual description was collected adjacent to core ECO.1. Sediment in this core was described as a soft, sticky, olive-gray to black clay.

Neither organic carbon nor aluminum had significant trends in ECO.1, the primary core at Echo Lake (table 6). Lack of trend in these constituents and small relative variation (Cv = 0.05 and 0.04 for organic carbon and aluminum, respectively) indicate the sediments are relatively homogeneous in the core. Homogeneous sediment in terms of bulk properties allows for interpretation without normalizing data and strengthens conclusions obtained from comparisons among samples.

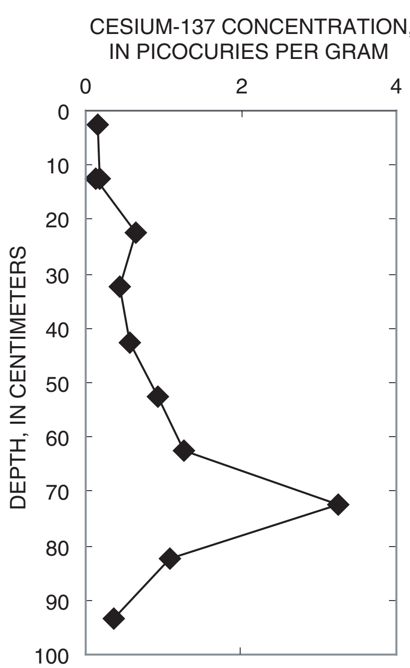

Figure 9. Cesium-137 concentrations in Echo Lake core sediment used for age dating samples.

Suspended sediment in the four sampled storms at Echo Lake inflow generally are fine grained, with 62 to 95 percent silt and clay size (appendix 1.3). The relative distribution of grain sizes at the inflow is consistent with those observed in the lake, assuming the sand settles out quickly, probably before flow reaches the upper lake coring site.

Organochlorine Pesticides and Polychlorinated Biphenyls

Of the 14 organochlorine pesticides measured (table 5), five were detected in one or more samples from Echo Lake and Echo Lake inflow (chlordane, DDD, DDE, DDT, and dieldrin), and all three PCB Aroclors were detected (appendix 1.4). These are the same eight compounds or groups of compounds detected in Lake Como. The fish possession ban in effect at Echo Lake is based only on PCBs (table 1), although dieldrin, DDE, and chlordane were detected in fish collected from Echo Lake in 1999, and median concentrations exceeded those in fish from Lake Como and Fosdic Lake (table 2).

Concentrations of some chlorinated hydrocarbons in Echo Lake are relatively large in comparison to published sediment-quality guidelines (MacDonald and others, 2000), particularly chlordane (appendix 1.4). Seventy-five percent of chlordane samples including all samples deposited since about 1970 in all three cores had concentrations greater than the PEC, and 19 percent were an order of magnitude or more greater than the PEC. Concentrations of DDE (37 percent of samples), DDD (19 percent), and PCBs (6 percent) exceeded the PEC.

Large temporal variations in many chlorinated hydrocarbons are indicated by concentration profiles in the sediment cores (fig. 10; appendix 1.4), however, only DDD and total DDT test significantly for monotonic trend (table 6). Total DDT, DDD, and DDE peak in the early 1970s at about four to 20 times higher concentrations than at present (tops of cores). Temporal trends in PCBs are very similar to trends in total DDT except for a single high concentration near the top of the core in a sample dated as 1996. Excluding this sample, the maximum values are in the early 1970s at levels

Table 8. Watershed yields of selected constituents estimated using a mass-balance approach in reservoirs

[Yields are in micrograms per square meter per year and are computed by multiplying sediment core concentrations by long-term-average sediment mass accumulation rates; --, not computed]

Organochlorine compounds:

Reservoir	Year estimates represent	Technical chlordane	Dieldrin	DDE	DDD	DDT	Total DDT	Total PCB
Lake Como	2001	16	0.8	0.8	0.4	0.2	1.4	5.5
Echo Lake	2001	22	.6	3.7	1.2	.7	5.5	27
Fosdic Lake	2001	20	.9	2.6	.9	.2	2.8	14
Fosdic Lake, pre-urban	1912	0	0	0	0	0	0	0
White Rock Lake[1]	1996	7.3	.3	1.3	1.0	.1	2.3	3.3
White Rock Lake, pre-urban	1916	0	0	0	0	0	0	0

Major and trace elements:

Reservoir	Year estimates represent	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
Lake Como	2001	1,080	113	6,290	4,040	13,900	11	2,720	26,200
Echo Lake	2001	2,650	570	12,300	8,050	23,01	19	5,400	54,000
Fosdic Lake	2001	1,800	241	10,400	5,030	14,500	31	3,340	29,500
Fosdic Lake, pre-urban	1912	2,760	28	8,450	2,090	3,540	5.3	3,270	9,240
White Rock Lake[1]	1996	2,030	38	15,300	2,900	5,200	14	7,650	26,000
White Rock Lake, pre-urban	1916	2,230	35	15,500	2,780	2,650	11	9,000	29,500

Polycyclic aromatic hydrocarbons:

Reservoir	Year estimates represent	Naphthalene	9H-Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)-anthracene	Chrysene	Benzo-(a)-pyrene	Dibenzo-(a,h)-anthracene	Coronene	Total PAH	Combustion PAH
Lake Como	2001	3.1	8.1	108	17	333	200	131	206	158	31	23	2,440	1,800
Echo Lake	2001	5.0	8.6	75	28	244	194	104	213	124	36	20	3,450	1,610
Fosdic Lake	2001	3.8	8.2	102	24	328	255	98	171	157	36	13	3,100	1,830
Fosdic Lake, pre-urban	1912	.6	1.4	2.2	.7	5.2	4.1	1.6	2.0	2.0	.6	.5	75.5	24.6
White Rock Lake[1]	1996	.8	1.3	16	5.5	66	55	22	49	39	11	--	699	426
White Rock Lake, pre-urban	1916	.5	1.7	2.0	.4	3.3	2.6	.7	1.4	1.2	.3	.3	44.9	15.0

[1] Van Metre and Callender (1997) and P.C. Van Metre (U.S. Geological Survey, unpub. data, 1996). MAR_{lake} estimated using sedimentation surveys and core data.

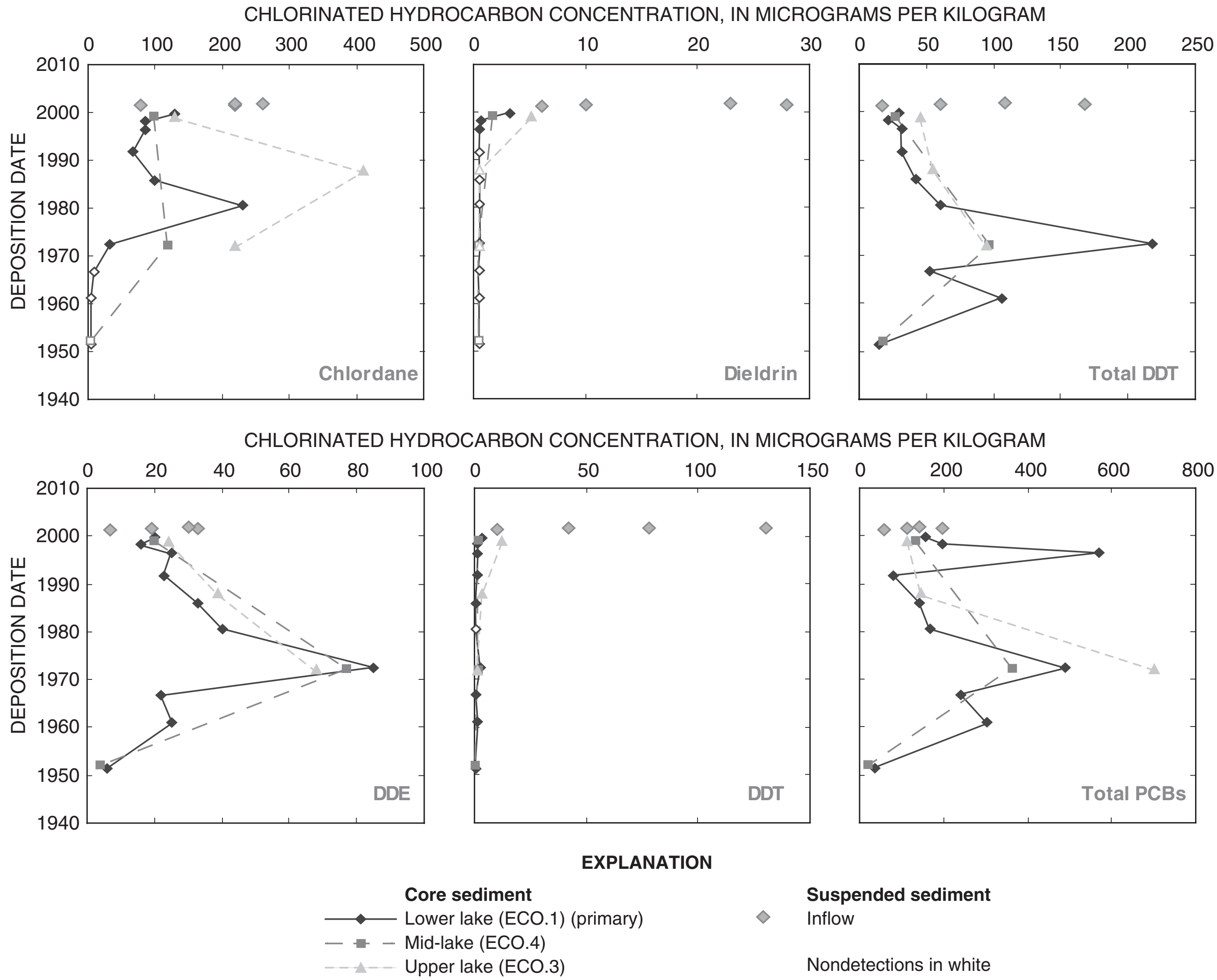

Figure 10. Trends of chlorinated hydrocarbons in Echo Lake core sediment and Echo Lake inflow suspended sediment. Kendall's tau rank correlation test was used to indicate whether there was a statistically significant relation between concentration and time from 1965 to top of the core. (See table 6.)

about three to five times concentrations at the tops of the cores. Concentrations of total DDT and PCBs on suspended sediments from the Echo Lake inflow generally are similar to or greater than concentrations at the tops of the cores.

Trends in chlordane are similar to trends in total DDT, although with more recent peak concentrations occurring in the 1980s instead of the 1970s. Although some decrease is indicated since the 1980s, especially at the upper lake site, concentrations at the tops of the cores remain large, with a median of 130 µg/kg. As would be expected, this trend does not test as a significant monotonic trend (table 6). Chlordane concentrations in suspended sediments are variable and high and confirm that chlordane, like DDT and PCBs, continues to enter the lake in runoff.

Dieldrin concentrations increase sharply at the top of the core, and DDT concentrations occur at low levels throughout the core. Both occur at much higher levels in suspended sediments at the inflow (appendix 1.6). These patterns, repeated in all three lakes, suggest that dieldrin and DDT are not well preserved in bottom sediments. High concentrations in suspended sediments entering the lake are an indication of current loading and potential bioavailability to fish.

Trace Elements

Among the eight trace elements with sediment-quality guidelines, the PEC was exceeded in 12 of 16 lead samples, seven of 16 cadmium samples, and one of 16 zinc samples (appendix 1.5). Cadmium concentrations in Echo Lake sediments are extremely large in some samples with a peak concentration in the mid-1960s of 182 µg/g and a second, smaller peak in the mid-1980s at 54.7 µg/g. These concentrations are more than an order of magnitude greater than the PEC of 4.98 µg/g. The higher concentration exceeds all cadmium concentrations measured nationally in streambed sediments by the USGS NAWQA Program during 1992–98 (Land and others, 1998; Kalkhoff and others, 2000). Although not exceeding the PEC, chromium and nickel concentrations, and to a lesser extent copper and zinc concentrations, have temporal trends similar to those for cadmium with peaks in the mid-1960s and mid-1980s (fig. 11). All these metals are associated with industrial uses, and cadmium, chromium, and nickel are associated with metal plating industries. Numerous small metal shops and automobile repair shops are located in the watershed of Echo Lake.

One USEPA National Priorities List (Superfund) site and one State Superfund site in central and south Fort Worth, respectively, might have contributed historical metal contamination to Echo and Fosdic Lake cores. During 1978–81, the Pesses Chemical Company operated a cadmium reclamation plant about six blocks north of the watershed boundary of Echo Lake (fig. 1). The site became a Superfund site, was remediated, and removed from the USEPA list in 1995 (Texas Commission on Environmental Quality, 2003a). Cadmium and other heavy metals from the Pesses site might have contributed to the smaller metal peaks in about 1980. The other State Superfund site in the Fort Worth area that might have contributed to metal contamination in the Echo and Fosdic Lake cores is the Tricon America, Inc., aluminum and zinc smelting and casting facility. This site is located south of Fort Worth (fig. 1) and operated from 1978 to 1984 (Texas Commission on Environmental Quality, 2003b). Smelting releases heavy metals to the atmosphere, and the primary area of concern following closure of the facility was an ash pile contaminated with heavy metals.

Kendall's tau correlation coefficients for all eight elements tested are negative, indicating decreasing concentrations with time (since 1965), and decreasing trends of cadmium, chromium, and lead are statistically significant at a greater-than-99-percent confidence level (table 6). Trends in lead concentrations are very pronounced (fig. 11) and typical of urban areas, but concentrations are higher than those in many urban lakes. Although smaller than the lead peak of 1,220 µg/g in Lake Como, lead peaks in the Echo Lake cores of 700 to 750 µg/g are much larger than peak lead concentrations reported for urban lakes in Dallas, Tex., Atlanta, Ga., and Reston, Va., which ranged from 90 to 160 µg/g (Callender and Van Metre, 1997).

Concentrations of trace elements in suspended sediments generally compare well with concentrations at the tops of the sediment cores except for zinc (fig. 11). This similarity suggests that lake-bottom sediments are representative of the chemistry of sediments transported by the influent stream and that, with the possible exception of zinc, trace element concentrations undergo relatively little chemical alteration (diagenesis) after sediment is deposited in the lake.

Polycyclic Aromatic Hydrocarbons

Concentrations of selected individual PAHs, total PAH, total combustion PAH, and 2+3/COMB are shown in figure 12 and listed in appendix 1.6. PAH concentrations generally are of similar magnitude to concentrations in Lake Como. In a pattern similar to Lake Como, PAH concentrations were largest in the Echo Lake inflow samples and in the upper lake core (ECO.3). Among the nine individual PAHs and total PAH with PECs, nine of 30 ECO.3 core-sediment sample concentrations and 22 of 40 suspended-sediment sample concentrations exceeded the PECs, including all four inflow samples for total PAH.

Individual and total PAH concentrations increased from the bottoms of the three Echo Lake cores (dated 1950s and 1960s) to the middle and upper parts of the cores (dated 1970s to the present). Total PAH concentrations peaked in about 1980, decreased for a time, and then increased in the late 1990s to levels similar to the 1980 peak. Statistically significant increases since 1965 occur for most individual PAHs and total combustion PAH but not for total PAH (table 6). The peak in total PAH in 1980 was caused by very large concentrations of alkyl-PAH in this sample compared with other samples. The source indicator ratio has a pronounced peak in about 1980, increasing from about

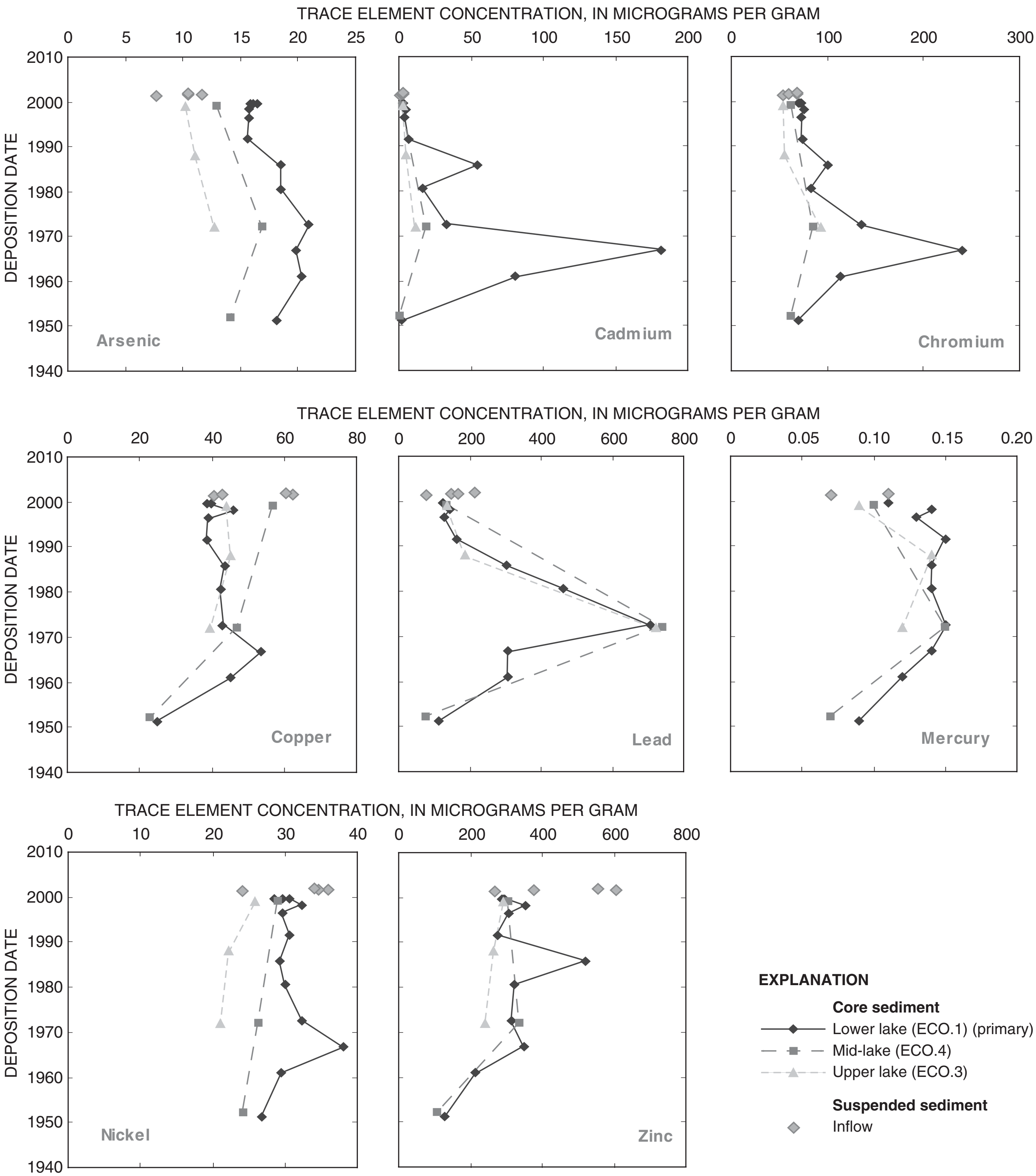

Figure 11. Trends of trace elements in Echo Lake core sediment and Echo Lake inflow suspended sediment. Kendall's tau rank correlation test was used to indicate whether there was a statistically significant relation between concentration and time from 1965 to top of the core. (See table 6.)

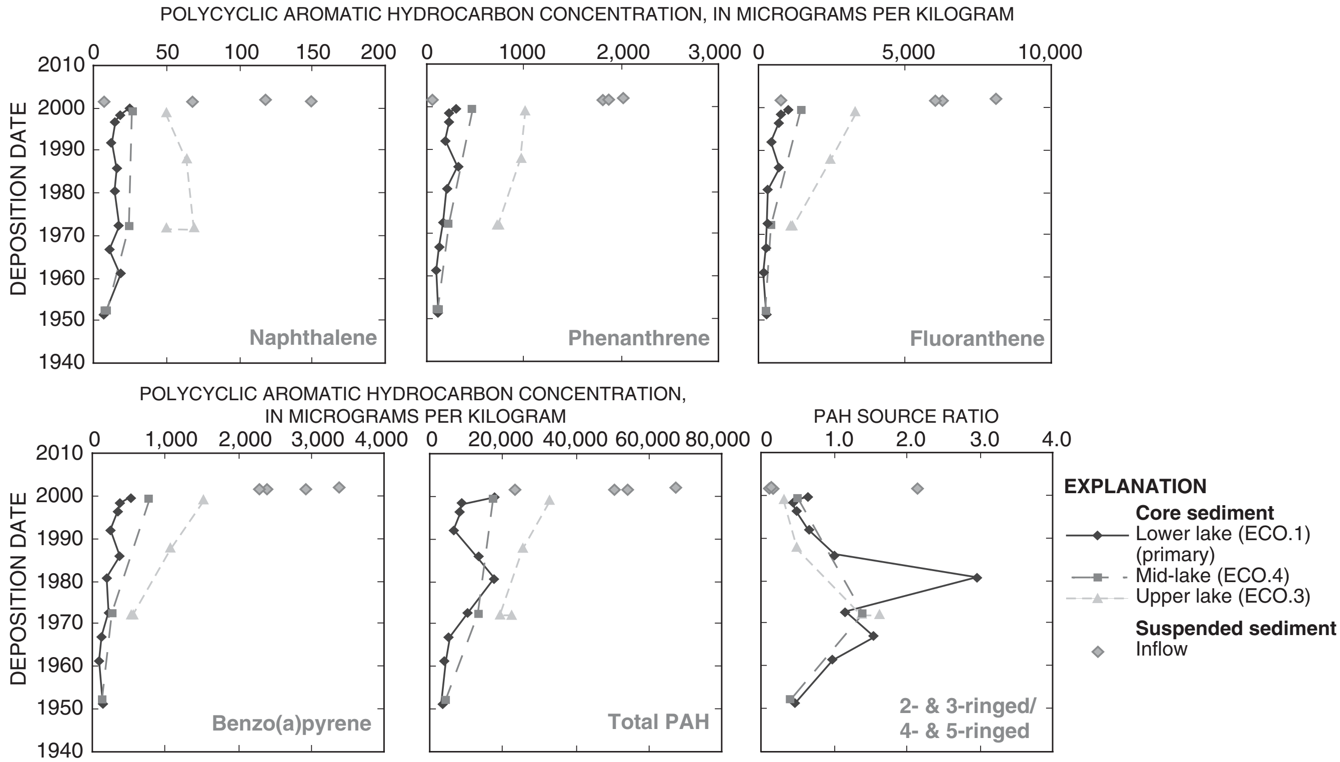

Figure 12. Trends of polycyclic aromatic hydrocarbons (PAHs) in Echo Lake core sediment and Echo Lake inflow suspended sediment. Kendall's tau rank correlation test was used to indicate whether there was a statistically significant relation between concentration and time from 1965 to top of the core. (See table 6.)

1.0 to 1.5 prior to 1980, to about 3.0 at the 1980 peak, then decreasing to less than 1.0 in recent years (fig. 12).

The highest PAH concentrations in Echo Lake were on suspended sediments at the inflow, with total PAH concentrations ranging from 23,500 to 67,700 µg/kg, indicating substantial loading of PAH to the lake during runoff events (appendix 1.6). In comparison, the concentration in the top sample from the upper lake core was 33,200 µg/kg. The three suspended-sediment samples with the highest concentrations have a strong combustion source signature with source indicator ratios ranging from 0.14 to 0.18, although the sample with the lowest total PAH concentration has a strong fuel signature (ratio = 2.16). Total and combustion PAH concentrations decrease and source indicator ratios increase in the top-of-core samples moving down lake in a pattern similar to Lake Como. As hypothesized for Lake Como, these changes suggest dilution of sediments from the inflow by cleaner sediments (with a non-combustion PAH signature), perhaps eroded from the lake shore and surrounding parkland.

Contaminant Yields Based on Cores

The MAR_{lake} for Echo Lake was estimated on the basis of 42 soundings of sediment thickness in six cross sections (fig. 13), unit dry mass of sediment in the cores, and age of the reservoir. Sediment thickness ranged from near zero to more than 300 cm in the center of the lake near the dam. Estimated total volume of lacustrine sediment for Echo Lake is 78,200 m^3 (table 7).

Unlike the Lake Como cores, there was no clear definition of an upper, compacting layer and a lower, more stable layer; therefore, the average unit dry mass for each core was used to estimate total mass of sediment in each of the three coring areas. The total mass of each area was divided by the number of years sediment was assumed to have accumulated, an estimated 81 years, to compute a MAR for each area. These values were summed to yield the time-averaged MAR_{lake} of 463,000 kg/yr or, when divided by the area of the lake, 0.40 g/cm^2-yr. This value seems reasonable compared with the MARs obtained independently for the cores:

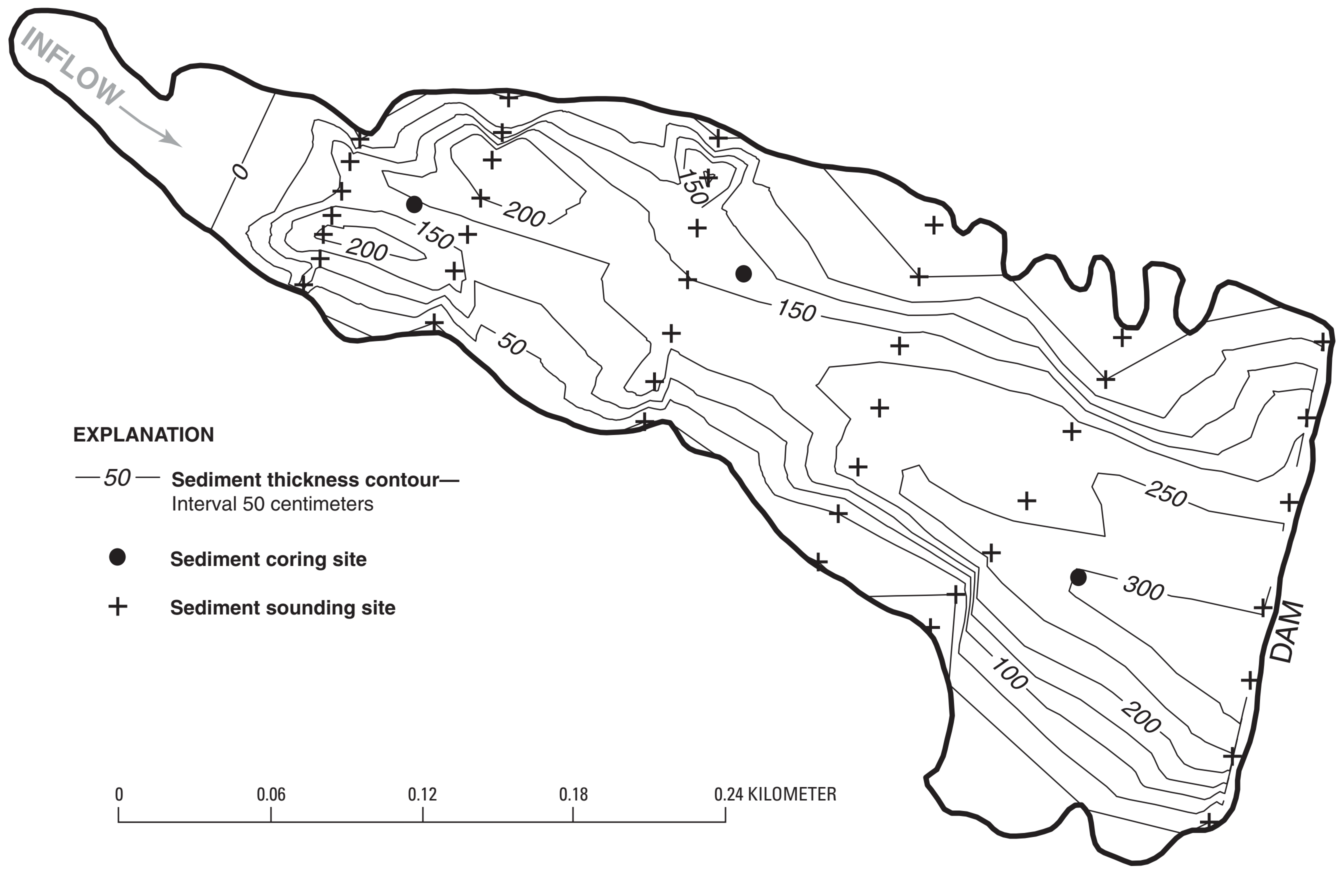

Figure 13. Sediment thickness and sampling sites in Echo Lake.

0.87, 0.70, and 0.91 g/cm^2-yr for the upper, mid-, and lower lake cores, respectively.

Accumulation rates of selected contaminants were computed by multiplying the MAR for each of the three coring areas times contaminant concentrations at the top of the respective core for the area, then summing these for the whole lake. Whole-lake contaminant MARs were divided by watershed area to compute yields (table 8). Contaminant yields are discussed in the section "Source Strength: Contaminant Yields to Reservoirs."

Fosdic Lake

Age Dating and Sedimentation Rates

Fosdic Lake was built between 1909 and 1912 (Vicki Stokes, City of Fort Worth, oral commun., 2002); a construction date of 1910 was used in age dating the cores. The primary core (FOS.4) was from the mid-lake site and penetrated the pre-reservoir land surface at 105 cm. The ^{137}Cs activity profile has a pronounced peak at 50 to 55 cm and supports the assumption that the sediments represent the whole period from 1910 to 2001 (fig. 14). Using as date markers the ^{137}Cs activity peak (1964), the pre-reservoir land surface (1910), and the sampling date at the top of the core (2001), MARs of 0.69 and 0.57 g/cm^2-yr were computed for 1910–64 and 1964–2001, respectively. Age dates were assigned to the core using these MARs. Age assignments generally are corroborated by a very large peak in lead that was dated as 1969, maximum PCB and total DDT concentrations in 1969, and first occurrence of organochlorine compounds in the mid-1940s.

Only three samples were analyzed from secondary cores FOS.2 (lower lake) and FOS.5 (upper lake). Core FOS.2 was 121 cm long and, on the basis of visual inspection, did not reach pre-reservoir soil; however, the bottom 11 cm of the core was described in the field as very stiff, and ^{137}Cs was not detected in the 100- to 110-cm interval. Core FOS.5 penetrated pre-reservoir

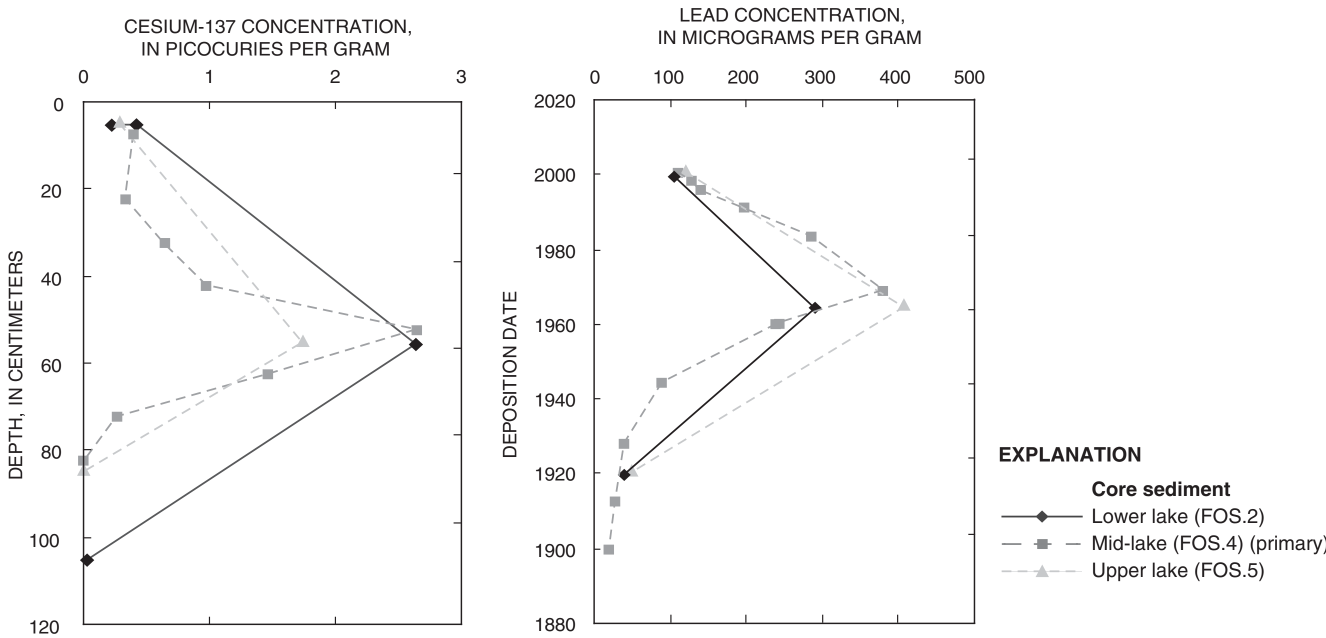

Figure 14. Cesium-137 and lead concentrations in Fosdic Lake core sediment used for age dating samples.

soil at 88 cm. Dates were assigned to these two cores by approximately matching ^{137}Cs activities to the profile from FOS.4, taking into account lead concentrations which have very pronounced peaks in these cores, and the pre-reservoir surface in FOS.5 (fig. 14).

Sediment Properties, Contaminant Trends, and Relations to Inflows

Sediments from FOS.2, the lower lake core, are very fine grained with 97 to 100 percent silt and clay size and 68 to 75 percent clay size (fig. 15; appendix 1.2). Sediments are slightly coarser at the mid-lake site (FOS.4) and more variable with some much coarser sediment at the upper lake site (FOS.5); the top sample from core FOS.5 is 22-percent sand. The pattern of progressively coarser sediments toward the stream inflow is the same for each of the three lakes. A second core for visual description was collected adjacent to core FOS.4. This core was described as a grayish-black to olive-gray silty clay containing small leaf and plant bits.

Neither organic carbon nor aluminum had significant trends in FOS.4, the primary core (table 6). Lack of trend in these constituents and small relative variation (Cv = 0.07 and 0.12 for organic carbon and aluminum, respectively) indicate the sediments are relatively homogeneous in the core. Trends were evaluated without normalizing data. Although organic carbon concentrations were fairly uniform in FOS.4 (1.91 to 2.97 percent; appendix 1.5), located in the middle of Fosdic Lake, they were much higher at the tops of the other two cores (6.84 and 8.27 percent). The reason for this spatial variability is not known, although productivity of the lake appears to be very large and an aeration fountain is maintained in the lower part of the lake to improve dissolved oxygen levels.

Suspended sediment in the four sampled storms at Fosdic Lake inflow also are fine grained, with 95 to 99 percent silt and clay size in three of the storms and about 70 percent in the fourth (appendix 1.3). The relative distribution of grain sizes at the inflow is consistent with those observed in the upper lake core (FOS.5). Organic carbon concentrations in suspended sediments in the two samples with sufficient material for the analysis were 4.81 and 8.25 percent, bracketing the 6.84 percent at the top of the upper lake core, FOS.5 (appendix 1.5).

Organochlorine Pesticides and Polychlorinated Biphenyls

Of the 17 organochlorine pesticides analyzed for, six were detected in one or more samples from Fosdic Lake and Fosdic Lake inflow (chlordane, DDD, DDE,

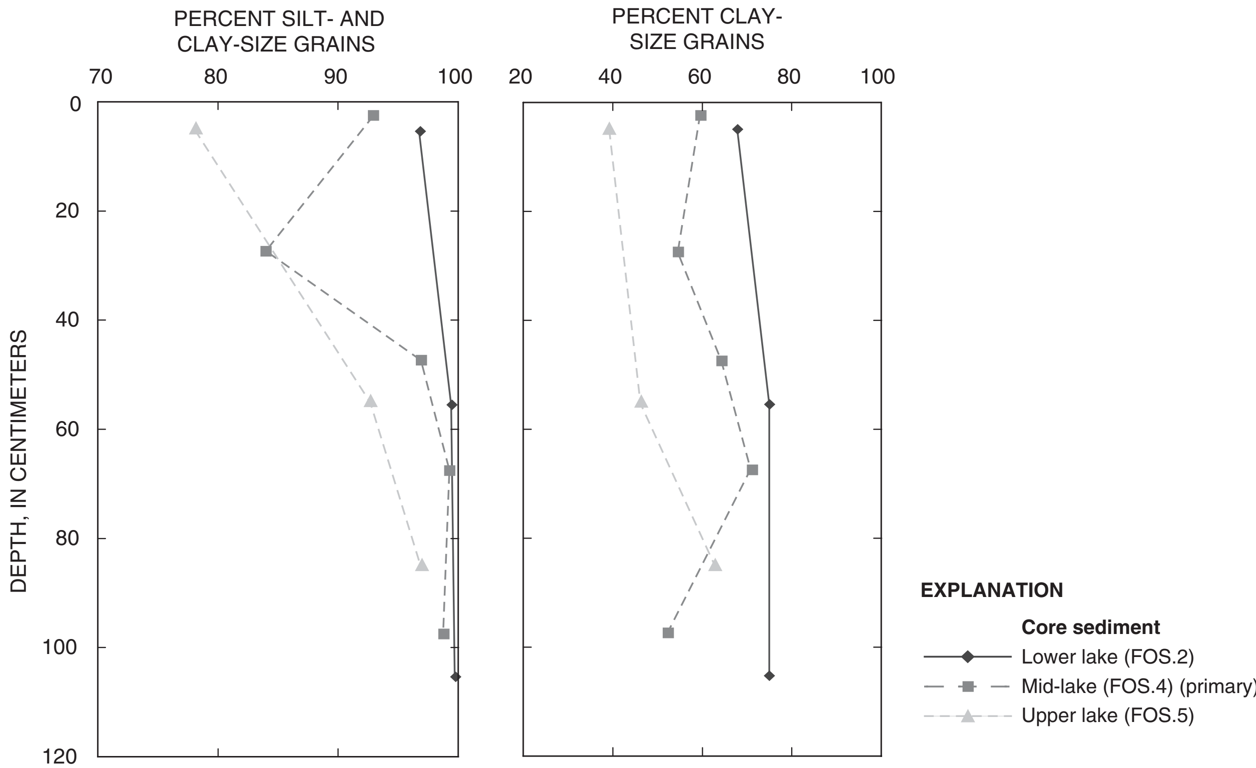

Figure 15. Grain-size variations in Fosdic Lake core sediment.

DDT, dieldrin, and toxaphene), and two of the three PCB Aroclors were detected (appendix 1.4). The fish possession ban in effect at Fosdic Lake is based on elevated levels of chlordane, DDE, dieldrin, and PCBs (table 1), all of which were detected in bottom and suspended sediments. The Oct. 10, 2001, sample from Fosdic Lake inflow contained 13,000 µg/kg of DDT and an estimated 12,000 µg/kg of toxaphene, the only detection of toxaphene in this study. These concentrations were verified by the laboratory and are extremely high in comparison to sediment-quality guidelines (for DDT; none available for toxaphene), other Fort Worth area sediments (this study), and urban reservoir (Van Metre and others, 1998) and streambed sediments nationally (Nowell and others, 1999). The DDT concentration, for example, is more that 10 times greater than the largest total DDT concentration in streambed sediment nationally reported by the USGS NAWQA Program for sampling during 1992–95 (Land and others, 1998) and 1996–98 (Kalkhoff and others, 2000).

Chlordane concentrations and the extremely high DDT concentration on Oct. 10, 2001, are large in comparison to published sediment-quality guidelines (MacDonald and others, 2000) (appendix 1.4). Only four of 15 samples did not exceed the PEC for chlordane, and all of these were from the lower parts of cores and were dated as deposited in the 1950s. Chlordane was detected in three of four suspended-sediment samples at even higher concentrations, ranging from 300 to 450 µg/kg, and the one nondetection was at a very high laboratory reporting level of <1,100 µg/kg. Reporting levels for this sample were too high for it to be a useful environmental sample because of very small sample mass, 0.107 g, and no chlorinated hydrocarbons were detected.

Pronounced temporal trends in many chlorinated hydrocarbons are indicated by concentration profiles in the sediment cores (fig. 16). Total DDT and DDE peak in about 1969 at about three times the concentrations at the top of the core. Temporal trends in PCBs are very similar to trends in total DDT with nondetections prior to about 1940, a peak in about 1969, and a three-fold decrease to the top of the core; however, none of the DDTs and PCBs has a statistically significant decreasing trend (table 6). Lack of statistical significance even though the trends appear to be large could be

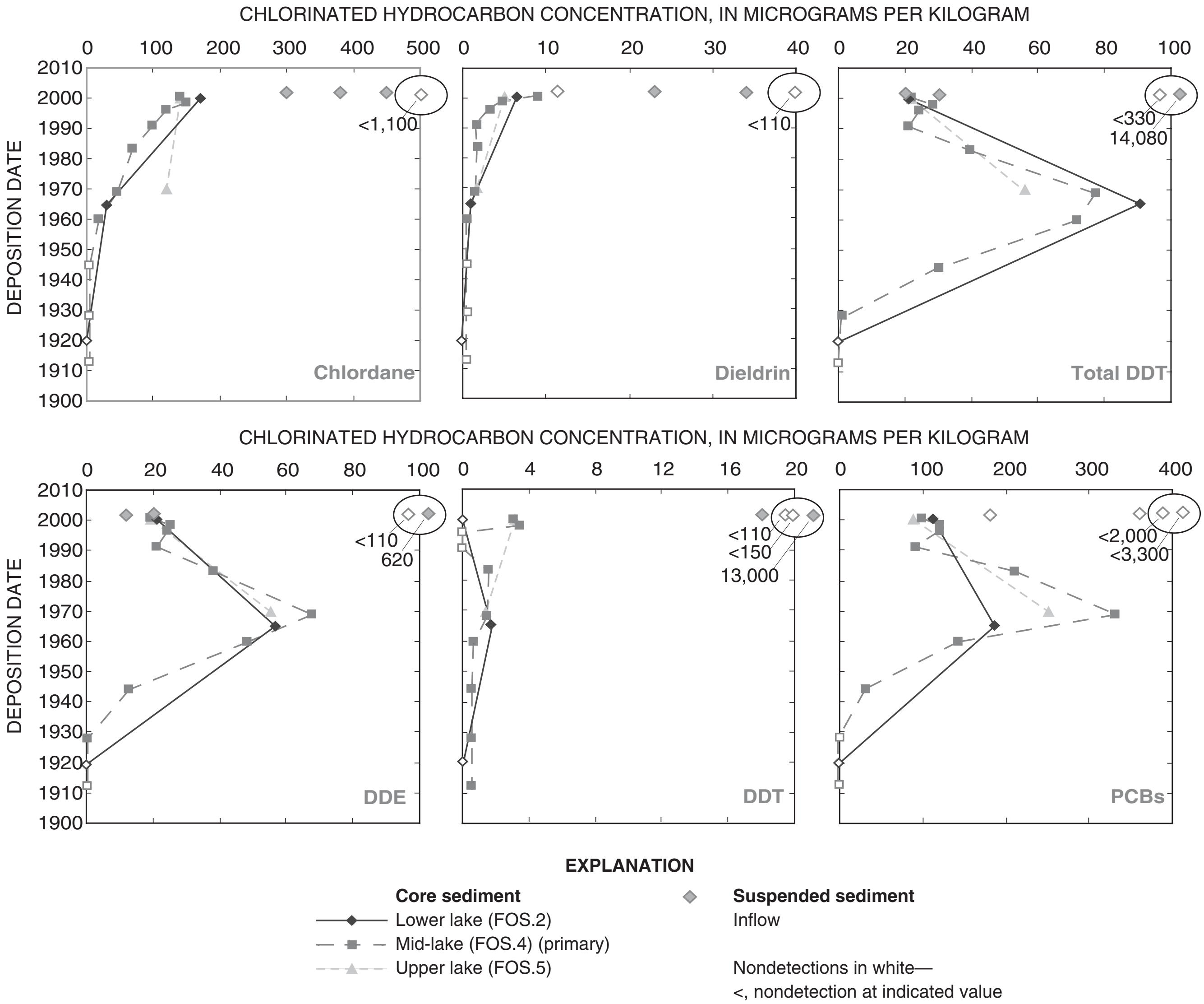

Figure 16. Trends of chlorinated hydrocarbons in Fosdic Lake core sediment and Fosdic Lake inflow suspended sediment. Kendall's tau rank correlation test was used to indicate whether there was a statistically significant relation between concentration and time from 1965 to top of the core. (See table 6.)

the result of the small sample size (six) and the use of a nonparametric test. A parametric correlation of these same constituents results in significant decreasing trends ($r \geqq .93$; p-values <.1) for DDE, total DDT, and PCBs.

Trends in chlordane, dieldrin, and parent DDT all appear to be increasing in Fosdic Lake (fig. 16). Chlordane was first detected in about 1960 and has increased steadily ever since. The trend is statistically significant using both nonparametric (table 6) and parametric tests ($r = .95$; p-value = .004). This pattern, combined with higher concentrations on suspended sediments at the inflow, indicates chlordane loading to Fosdic Lake has yet to decrease appreciably since chlordane use was restricted in 1988 (U.S. Environmental Protection Agency, 1997; Mattina and others, 1999). Although concentration profiles in the core suggest dieldrin and DDT also are increasing, both profiles instead probably indicate continuing transport to the lake followed by chemical breakdown in bottom sediments over years to decades. The different interpretation of chlordane trends compared with dieldrin and DDT is based largely on what was observed in the other two lake cores. In both of those cores, much larger historical concentrations of chlordane indicate that chlordane generally is preserved in bottom sediments. The virtual disappearance of dieldrin and DDT below about 10 cm in all three cores, on the other hand, supports the conclusion that they are not well preserved in bottom sediments.

Concentrations of chlordane, dieldrin, DDTs, and PCBs on suspended sediments from Fosdic Lake inflow are similar to or greater than concentrations at the tops of the cores, indicating inputs of these contaminants continue to occur. The presence of these long-restricted compounds in current runoff can be attributed to erosion of historically contaminated soils and possibly, with the exception of PCBs, to continuing use or release. One sample, from Oct. 10, 2001, contained extremely high DDT and toxaphene concentrations that cannot be attributed to historically contaminated soils. These levels are much too high compared with those of other samples for that explanation, which suggests unregulated use or disposal.

Trace Elements

Major and trace element concentrations measured in the Fosdic Lake cores and Fosdic Lake inflow samples are presented in appendix 1.5. Of the eight trace elements with sediment-quality guidelines, arsenic exceeded the PEC in one sample and lead in eight of 16 samples. The sample with the single high arsenic concentration of 220 µg/g appears anomalous; however, the sample was analyzed in triplicate with similar results each time. It is at 55 to 60 cm deep in FOS.4 and dated as 1960. The maximum lead concentration of 410 µg/g, although lower than maximum lead concentrations in the other two lakes, is still large compared with lead concentrations in lake sediments nationally (Callender and Van Metre, 1997).

Pronounced trends in cadmium, mercury, and lead are indicated by the (primary) core profiles (fig. 17), and all three have significant decreasing trends since 1965 (table 6). Lead increased from a pre-urban background level of about 20 µg/g in about 1912 to a peak of 379 µg/g in 1969 and, with the introduction of unleaded gasoline in the early 1970s, has decreased to 108 µg/g in the most recently deposited sample (fig. 17). Cadmium and mercury and to a lesser extent chromium had trends similar to lead. All three peaked in the 1969 sample at about double their current (2001) levels.

An increasing trend in zinc is suggested by fig. 17; however, the trend does not test as statistically significant (table 6), probably because concentrations have decreased since 1991. The longer term increase in zinc, from 53 µg/g in 1900 to between 206 and 248 µg/g since 1969, probably reflects urban inputs. An increase in zinc in a sediment core from White Rock Lake in Dallas was reported by Van Metre and Callender (1997) coincident with urban development, and anthropogenic increases in zinc in stream and reservoir sediments were reported by Callender and Rice (2000). Concentrations of trace elements in suspended sediments generally compare well with concentrations at the tops of the sediment cores except for nickel and zinc, both of which are generally larger in suspended sediments (fig. 17).

Polycyclic Aromatic Hydrocarbons

Individual PAHs and total PAH increase from the bottoms of the three Fosdic Lake cores, dating back to the early 1900s, to an apparent peak in the mid-1990s, just below the top of the sediments (fig. 18). None of the trends are significant at the 95-percent confidence level; however, seven of the 15 PAHs tested, including total PAH and total combustion PAH, have significant trends at the 90-percent confidence level (table 6). The Fosdic Lake cores are the only ones of the three lakes that extend back in time to well before urban development began in any of the three watersheds. The two oldest samples from FOS.2, dated as 1912 and 1928, had total PAH concentrations of 570 and 880 µg/kg, respectively, similar to background (pre-urban) levels of PAHs in lake and reservoir sediment cores reported nationally (Van Metre and others, 2000). These background levels reflect the natural occurrence of PAHs in organic matter. Concentrations at the tops of the three Fosdic Lake cores, in contrast, are from 16,000 to 27,500 µg/kg, about 20 to 50 times larger than pre-urban levels. Similar concentrations occur at the tops of the cores from the other two lakes. The trend in 2+3/COMB indicates a progressive shift from noncombustion to combustion sources as concentrations have increased over the past century (fig. 18). Source ratios ranged from about 1.0 to 2.0 prior to about 1960 and are between 0.33 and 0.64 at the tops of the cores (appendix 1.6).

Unlike the other two lakes, where PAH concentrations on suspended sediments at the inflow were considerably larger than top-of-core concentrations, suspended-sediment and top-of-core concentrations at Fosdic Lake are similar (fig. 18; appendix 1.6). Total

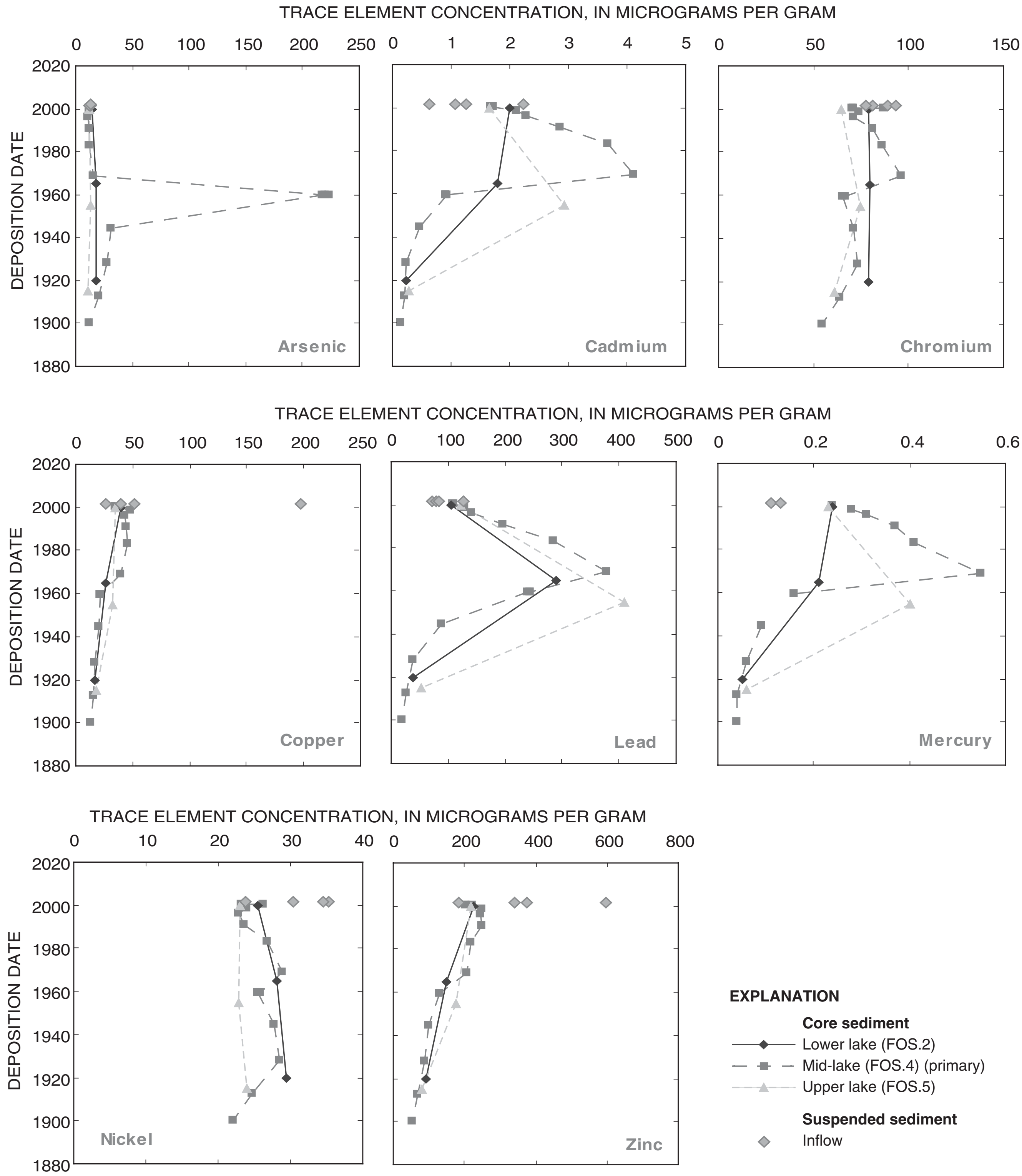

Figure 17. Trends of trace elements in Fosdic Lake core sediment and Fosdic Lake inflow suspended sediment. Kendall's tau rank correlation test was used to indicate whether there was a statistically significant relation between concentration and time from 1965 to top of the core. (See table 6.)

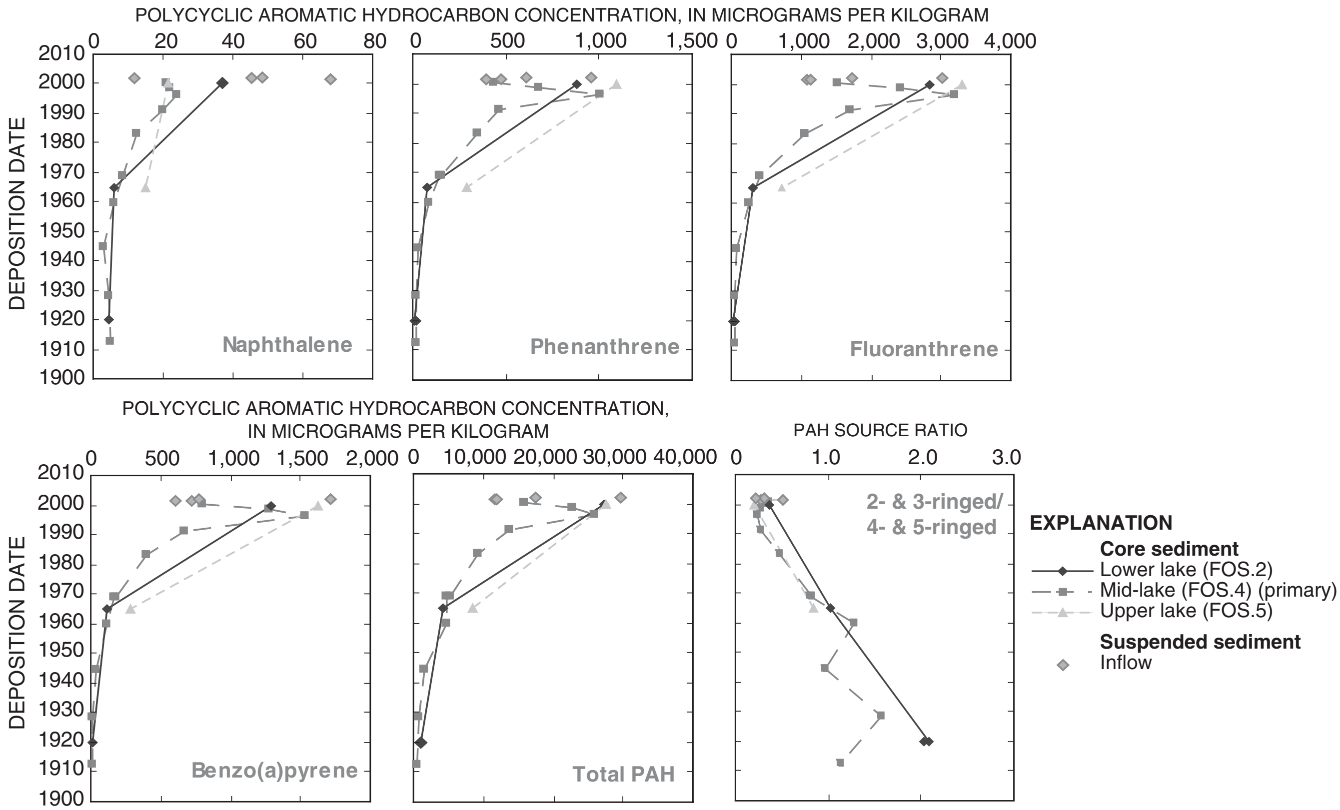

Figure 18. Trends of polycyclic aromatic hydrocarbons (PAHs) in Fosdic Lake core sediment and Fosdic Lake inflow suspended sediment. Kendall's tau rank correlation test was used to indicate whether there was a statistically significant relation between concentration and time from 1965 to top of the core. (See table 6.)

PAH concentrations in the four suspended-sediment samples ranged from 11,800 to 29,600 µg/kg, similar to the range in sediments from the tops of cores. With one exception, these samples also have similar source indicator ratios, indicating the strong combustion signature commonly found in urban settings (Van Metre and others, 2000).

Contaminant Yields Based on Cores

The MAR_{lake} for Fosdic Lake was estimated on the basis of soundings of sediment thickness (fig. 19), unit dry mass in the cores, and age of the reservoir. Sediment thickness ranged from near zero to about 250 cm. Estimated total volume of lacustrine sediment for Fosdic Lake is 25,600 m^3 (table 7).

As was the case for Lake Como, an upper, compacting layer and a lower, more stable layer, were clearly identifiable in terms of porosity and unit dry mass; therefore, upper and lower layers with different unit dry mass values were used to estimate total mass of sediment in each of three areas of the lake. The total mass of each area then was divided by the number of years sediment was assumed to have accumulated, 90 years, to compute a MAR for each area. These were summed to yield the MAR_{lake}. The resulting time-averaged MAR_{lake} is 156,000 kg/yr or, when divided by the area of the lake, 0.47 g/cm^2-yr. This rate compares with the MARs determined independently for the cores: 0.51, 0.69, and 0.71 g/cm^2-yr for the upper, mid-, and lower lake cores, respectively.

Accumulation rates of selected contaminants were computed by multiplying the MAR_{area} times the contaminant concentration at the top of the core from the area, then summing these for the whole lake. Whole-lake contaminant MARs then were divided by watershed area to compute yields (table 8). Contaminant yields are discussed in the section "Source Strength: Contaminant Yields to Reservoirs."

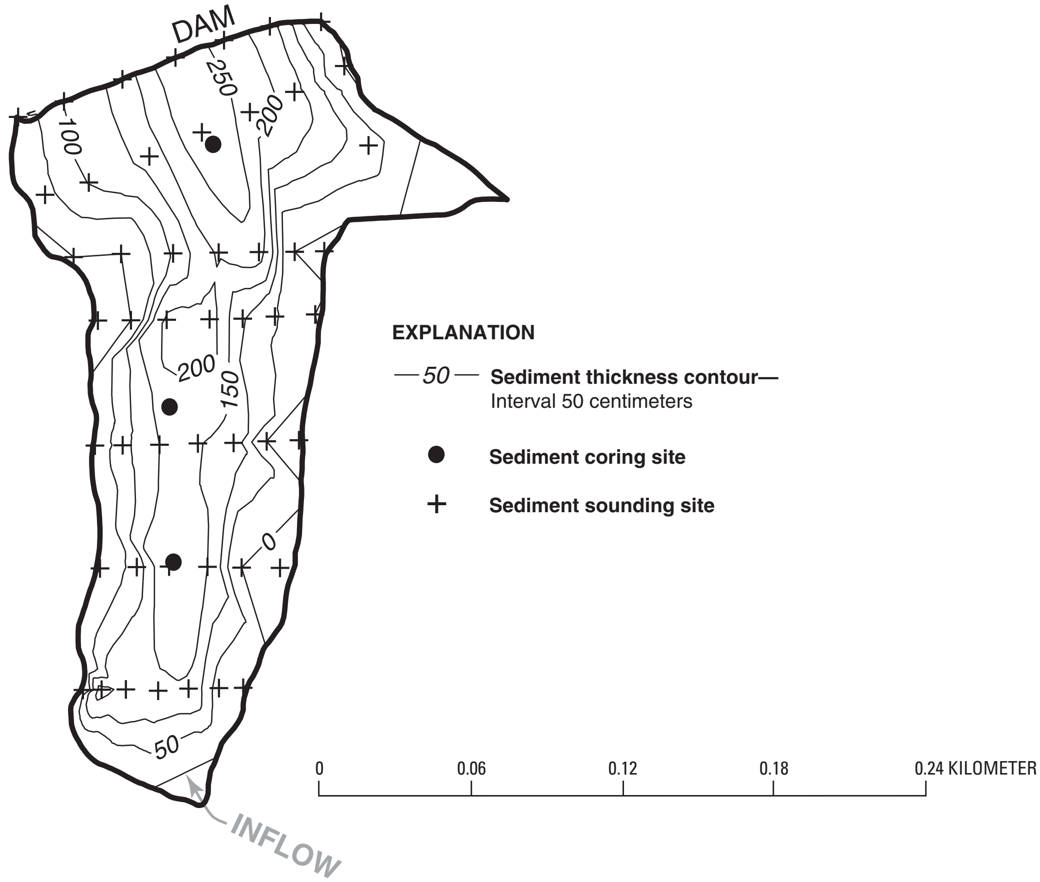

Figure 19. Sediment thickness and sampling sites in Fosdic Lake.

Inflows to Clear Fork and West Fork Trinity River

Eight sites were instrumented (six passive and two automated samplers) to monitor discharge to Clear Fork and West Fork Trinity Rivers (fig. 1). Suspended-sediment concentrations and grain-size distribution of sampled storms are presented in appendix 1.3. Chemical data are presented in appendixes 1.4 through 1.6. Suspended-sediment concentrations varied widely within and between sampling sites, ranging from a low of 40 mg/L in a discrete sample from Sycamore Creek to a high of 4,460 mg/L in a sample from the Zoo site (appendix 1.3). Because the passive samples are point-grab samples in the early part of the storm, it is not known how representative they are of average concentrations in the stream cross section at the time of collection or of event-mean concentrations. Generally, similar suspended-sediment concentrations were obtained at the automated sampling sites, including the three lake inflow sites. Suspended sediments at all 11 sites monitored generally were fine grained with less than 20-percent sand and frequently less than 5-percent sand (appendix 1.3). Concentrations of organic carbon in these sites generally were similar to concentrations in the three lake inflow sites and larger than the concentrations in the lake cores (appendix 1.5).

Organochlorine Pesticides and Polychlorinated Biphenyls

The same organochlorine compounds detected in inflows to and bottom sediments of the three lakes and responsible for the fish consumption bans were detected in one or more suspended-sediment samples. Detected compounds include chlordane, dieldrin, DDT, DDD, DDE, and PCB Aroclors 1242, 1254, and 1260 (appendix 1.4). Concentrations and rates of detection varied among compounds and sites, with the highest concentrations at the more-urban sites and nondetections of all of these compounds except DDE at the less-urban

Benbrook site. Chlordane was detected in 70 percent of suspended-sediment samples from these eight sites, and among the 30 percent of samples with nondetections, the laboratory reporting level frequently was high because of low sample mass (ranging from 15 to 2,000 µg/kg with a median of 370 µg/kg). Rates of detection among the other compounds ranged from a low of 6 percent for DDD to a high of 91 percent for DDE. Rates of detection exceeded 50 percent for dieldrin (55 percent), PCB Aroclor 1254 (52 percent), and PCB Aroclor 1260 (58 percent). Overall rates of detection of these compounds at the eight sites are similar to rates of detection at the three lake inflow sites. The only organochlorine compounds that exceeded the PEC are chlordane and PCBs. Chlordane exceeded the PEC in 67 percent of samples, often by an order of magnitude, whereas PCBs exceeded the PEC in two of 33 samples (6 percent) (appendix 1.4).

Trace Elements and Polycyclic Aromatic Hydrocarbons

Trace element concentrations among these sites are largest for the Downtown site where copper (one of three samples), lead (two of three samples), and zinc (three of three samples) exceeded the PEC (appendix 1.5). The highest copper and zinc concentrations measured in this study were 281 and 1,600 µg/g, respectively, in a sample from the Downtown site. Concentrations of legacy pollutants at these sites in relation to other sites and land use are discussed below.

Concentrations of selected individual PAHs, total PAH, total combustion PAH, and the 2+3/COMB ratio in suspended sediments are listed in appendix 1.6. Very high concentrations of PAHs occurred at the Downtown site and at Little Fossil Creek (total PAH of ±100,000 µg/kg) and high concentrations occurred at the Levee site (total PAH of ±30,000 µg/kg). PAH concentrations and trends have been shown to correlate with urban land use (Lopes and others, 1997) and traffic (Van Metre and others, 2000), so high concentrations at the Downtown site are expected. Relations between PAHs and land use are discussed further below.

Event Loads and Yields in Streams

Data collected using automated samplers at five stream sites allowed for computation of event loads of monitored constituents. The five sites are on the streams flowing into each of the three lakes and on Big Fossil and Sycamore Creeks flowing into West Fork Trinity River (fig. 1). Each had a continuous stage record, a stage-discharge relation, and event-composite sediment chemistry samples. At Sycamore Creek, sediment-chemistry samples over the storm hydrograph were analyzed separately. Four storms were sampled at the three lake inflows and Big Fossil Creek; three storms were sampled at Sycamore Creek.

The product of the storm volume and suspended-sediment concentration is the sediment load transported by a storm. The sediment loads were highest at Big Fossil and Sycamore Creeks (which have the two largest watershed areas) because the storm volumes were the largest at these two locations, not because they had appreciably higher suspended-sediment concentrations (table 9). Sediment loads were lowest at the Lake Como and Fosdic Lake inflows, which have the two smallest watershed areas. The sediment loads for two of the storms at the Echo Lake inflow are much larger than those at the two other inflows although the watershed areas are of similar size. The higher sediment loads at the Echo Lake inflow were caused by larger storm volumes and higher suspended-sediment concentrations. Contaminant loads, the product of sediment loads and contaminant concentrations, are listed in appendix 3. Nondetections were treated as zeros in the computations.

Yields, the load per unit area of watershed, also are listed in appendix 3. Yields, like loads, are highly variable and largely a function of the size of the storm (fig. 20). At Sycamore Creek, for example, two relatively large storms and one very small storm were sampled. Loads and contaminant yields for the large storms were between two and three orders of magnitude larger than the small storm. This variability illustrates an important point when evaluating transport of PACs in streams: Most of the transport occurs on the largest storms. This probably is the main reason that long-term annual yields computed using the reservoir mass-balance approach are so much larger (table 8) than event yields computed at the three lake inflow sites (appendix 3). If the storms sampled are modest, they can account for only a small percentage of total long-term loading. For example, three suspended-sediment samples were collected at Lake Como inflow during 2001. The rainfall recorded at Dallas-Fort Worth (DFW) Airport during these three storms is 2.7 percent of the rainfall recorded for 2001. Likewise, only 3.5 and 7.5 percent of the annual rainfall occurred during the four storms sampled at Fosdic and Echo Lakes, respectively.

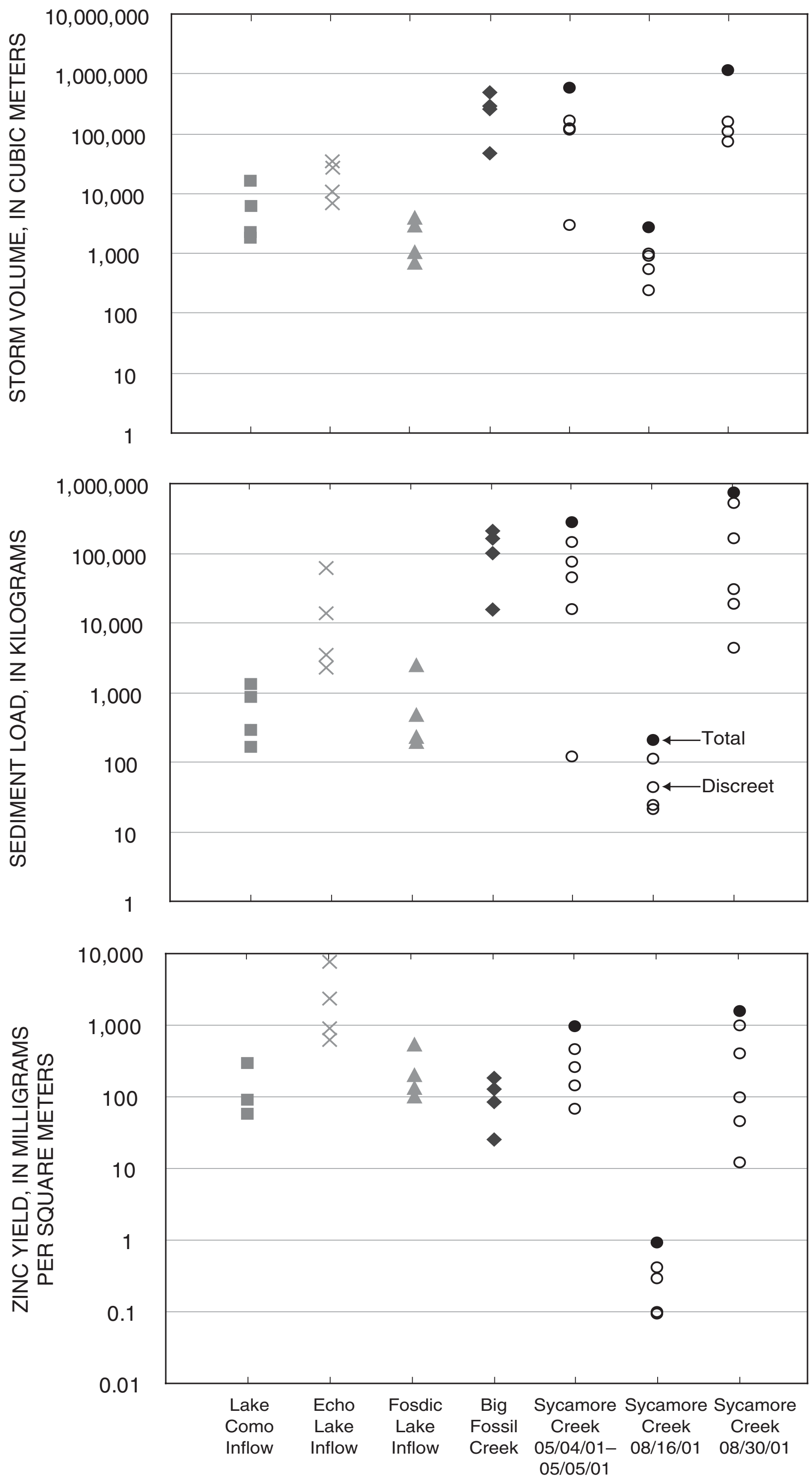

Figure 20. Storm volume, sediment load, and zinc yield for storms at the three lake inflows and Big Fossil and Sycamore Creeks.

Table 9. Storm volumes and sediment loads used to compute contaminant loads and yields

[km^2, square kilometers; m^3, cubic meters; ft, feet; ft^3/s, cubic feet per second; hr, hours; mg/L, milligrams per liter; kg, kilograms; --, not applicable; US, upstream stage]

Site	Date	Water-shed area (km^2)	Storm volume (m^3)	Highest recorded stage (ft)	Highest calculated flow (ft^3)	Storm duration (hr)	Suspended-sediment concentration (mg/L)	Sedi-ment load (kg)
Lake Como inflow	08/30/2001	1.86	15,400	8.51	47	9.08	55	850
	09/20/2001		1,770	8.15	14	2.67	92	162
	11/09/2001		2,210	8.32	35	1.83	133	293
	01/23/2002		6,250	8.66	56	15.1	212	1,330
Echo Lake inflow	05/28/2001	2.13	27,000	4.90 (US)	248	.48	2,200	59,400
	08/17/2001		34,000	4.95 (US)	255	1.08	389	13,200
	09/20/2001		11,200	3.79 (US)	130	1.25	200	2,240
	10/11/2001		6,770	4.29 (US)	178	.38	501	3,390
Fosdic Lake inflow	08/11/2001	.84	940	2.18	11	2.42	188	177
	09/18/2001		2,650	4.01	83	1.08	844	2,240
	10/10/2001		695	2.30	13	1.00	323	225
	12/06/2001		3,630	2.84	26	3.33	125	454
Big Fossil Creek	05/04/2001	136	478,000	3.73	1,060	21.8	445	213,000
	08/11/2001		47,600	3.03	304	6.75	308	14,600
	09/18/2001		292,000	3.86	1,210	16.8	561	164,000
	10/11/2001		254,000	3.39	687	21.5	380	96,500
Sycamore Creek # 1	05/04/2001	77.9	3,000	--	--	--	40	120
Sycamore Creek # 2	05/04/2001		122,000	--	--	--	1,130	138,000
Sycamore Creek # 3	05/04/2001		120,000	--	--	--	381	45,500
Sycamore Creek # 4&5	05/05/2001		161,000	--	--	--	463	74,700
Sycamore Creek # 6&7	05/05/2001		162,000	--	--	--	95	15,400
TOTAL			568,000	--	1,760	11.7	--	274,000
Sycamore Creek # 1	08/16/2001	77.9	887	--	--	--	48	43
Sycamore Creek # 2	08/16/2001		546	--	--	--	37.5	20
Sycamore Creek # 3	08/16/2001		1,010	--	--	--	112	114
Sycamore Creek # 4	08/16/2001		240	--	--	--	98.5	24
TOTAL			2,680	--	18	9.13	--	200
Sycamore Creek # 1	08/30/2001	77.9	74,900	--	--	--	410	30,700
Sycamore Creek # 2	08/30/2001		193,000	--	--	--	846	163,000
Sycamore Creek # 3	08/30/2001		580,000	--	--	--	911	528,000
Sycamore Creek # 4	08/30/2001		153,000	--	--	--	123	18,800
Sycamore Creek # 5	08/30/2001		103,000	--	--	--	41	4,200
TOTAL			1,100,000	--	2,790	21.2	--	745,000

INTERPRETATIONS AND IMPLICATIONS OF CONTAMINANT OCCURRENCE, TRENDS, AND SOURCES

The data presented here for numerous PACs can be used to describe their occurrence in streams and lakes, trends, sources, and the relation between transport in streams and fate in the receiving water bodies. Each of these topics is discussed below. Occurrence is indicated by concentrations in suspended sediments and in the cores. Trends are indicated by concentration profiles in age-dated sediment cores for those contaminants that are chemically stable over many years. Source areas are evaluated on the basis of occurrence and loads in sampled watersheds in relation to land use. The relation between transport and fate is indicated by comparing contaminant concentrations in cores with concentrations in suspended sediments in the influent streams. Finally, concentrations in sediments are compared with recent and historical fish-tissue data to assess the long-term prospects for the quality of fish in the streams and lakes studied.

Contaminant Occurrence

The occurrence of legacy pollutants in Fort Worth area water bodies remains widespread 13 to 30 years after their use was restricted. All four of the legacy pollutants responsible for the fish consumption advisories in the Fort Worth area, chlordane, dieldrin, DDE, and PCBs, were frequently detected in lake-bottom sediments and stream suspended sediments. DDD and DDT also were detected frequently (appendix 1.4). Chlordane is the legacy pollutant with the highest overall concentrations in comparison to sediment-quality guidelines, followed by PCBs. Chlordane exceeded the PEC in 69 percent of samples, and 22 percent of those exceeded it by more than an order of magnitude (appendix 1.4). Of 93 samples, the PEC was exceeded by dieldrin in two, DDE in 12, DDD in nine, DDT in two, and total PCB in four.

The Oct. 10, 2001, suspended-sediment sample from Fosdic Lake inflow warrants discussion. This sample contained 13,000 μg/kg of (parent) DDT and an estimated 12,000 μg/kg of toxaphene, the only detection of toxaphene in this study. These concentrations are extremely high compared with sediment-quality guidelines and sediment concentrations reported nationally. Erosion of historically contaminated soils cannot explain these numbers, especially considering that the only other detection of DDT in the four storms sampled was at a concentration of 18 μg/kg, and toxaphene was not detected in any other samples. Furthermore, this DDT concentration is about 20 times larger than the DDD and DDE concentrations in this sample, 460 and 620 μg/kg, respectively, accounting for 92 percent of total DDT, the least weathered DDT sampled collected by this study. These results suggest a spill or unregulated use or disposal of DDT and toxaphene occurred during or prior to this storm runoff sampling. This storm occurred after the sediment cores were collected from Fosdic Lake, so it is not known what effect the storm had on sediment quality in the lake.

In some cases, concentrations of trace elements are at levels of concern for aquatic life as indicated by comparison with sediment-quality guidelines. Lead concentrations exceeded the PEC in 43 of 93 samples, the most frequently of any trace element (appendix 1.5). There are many sources of lead in the urban environment, most prominently the historical use of lead in gasoline. Other elements with one or more concentrations that exceeded the PEC are arsenic, cadmium, chromium, copper, and zinc. Cadmium concentrations exceeded the PEC by more than an order of magnitude in three samples from the Echo Lake core, the only trace element to do so.

PAHs represent the largest class of suspected carcinogens (Björseth and Ramdahl, 1985) and can present a threat to aquatic life (MacDonald and others, 2000). PAH concentrations in lake-bottom and suspended sediments frequently exceeded the PEC values for individual PAHs and total PAH (appendix 1.6). The highest concentrations were in suspended sediments from the Downtown site, the inflows to Lake Como and Echo Lake, and Little Fossil Creek. PECs also were exceeded frequently in the upper parts of cores (recent sediments) at the upper lake coring site in the three lakes. This finding emphasizes the link between inputs of contaminated sediment from the streams and contamination in bottom sediments of the lakes.

Trends

Organochlorine Pesticides and Polychlorinated Biphenyls

Trends in organochlorine compounds are not all decreasing, despite the restrictions or bans on their use 13 to 30 years before this study. Chlordane trends are variable with moderate decreases since historical highs in the 1970s for Lake Como and Echo Lake, but with an increasing trend to the present in Fosdic Lake. The increase in chlordane concentrations in Fosdic Lake since 1965 is statistically significant and the decreases in the other two lakes are not, although the organic carbon normalized trend in Lake Como is significantly decreasing (table 6). Similar variability in chlordane trends has been observed in other urban and nonurban U.S. lakes (Van Metre and others, 1997). Chlordane has been used as an agricultural and urban insecticide since 1948. Agricultural use was canceled in 1974, but use continued in U.S. urban areas for control of ants and termites. In 1983, the USEPA banned most uses of chlordane and in 1988 banned all uses except for fire ant control in power transformers and for depletion of existing stocks by homeowners (U.S. Environmental Protection Agency, 1997; Mattina and others, 1999). Thus, it is possible that some chlordane use continues to the present (2001) in residential applications in Fort Worth.

DDE, total DDT, and PCB trends all have negative correlation coefficients indicating decreases, however, not all are statistically significant (table 6). All three are significant for concentrations and organic carbon normalized concentrations in Lake Como. In Echo and Fosdic Lakes, decreasing trends in these three contaminants are significant only for total DDT in Echo. Van Metre and others (1998) reported similar findings among 11 reservoirs in the eastern and central United States, with a majority of decreasing trends in PCBs and total DDT. Although concentrations generally are decreasing for PCBs and DDT, their occurrence at the tops of the cores and in suspended sediments indicates that transport of these legacy pollutants into streams and lakes continues.

Van Metre and others (1998) modeled rates of decrease of total DDT and PCB concentrations in age-dated sediment cores from 11 reservoirs across the eastern and central United States and found that rates of decrease averaged about one-half every 10 years. The 10-year half-lives do not reflect any specific chemical process but rather are an approximation of the rate of decrease in concentrations since the 1970s. A similar approach using first-order rate models was applied to the three Fort Worth lakes to evaluate rates of decrease in legacy pollutants since about 1970. For Lake Como, half-lives were 18.8, 15.5, and 15.1 years for organic carbon normalized chlordane, total DDT, and PCBs, respectively. The slopes of the regression equations were all significant at a 94-percent confidence level or greater and coefficients of determination (R^2) were .56, .42, and .48, for the three constituents, respectively. The half-life for total DDT at Echo Lake is 10.0 years, and the R^2 is .85. Using a nonparametric test, none of the legacy pollutants had significant decreasing trends at Fosdic Lake (table 6); however, parametric linear regression models of logarithmic PCB and total DDT concentrations were both significant (>0.98 percent confidence) with half-lives of 18.2 and 18.1 years, respectively, and R^2 of .83 and .84, respectively. These models suggest that rates of decrease of legacy pollutants might be slower for the Fort Worth area than observed elsewhere. There are at least several possible reasons this could be the case, beyond data and model uncertainty: One is differences in erosion and transport processes in these watersheds compared with those modeled by Van Metre and others (1998), and another is continuing new releases of legacy pollutants in Fort Worth. It is this second possibility that the Oct. 10, 2001, sample of DDT and toxaphene at Fosdic Lake inflow suggests.

Trace Elements

There are similarities in trends in heavy metals in the three Fort Worth lakes (figs. 6, 11, and 17). One is the striking trend in lead, with large peaks in the 1970s. Similar lead trends have been reported in urban lakes and reservoirs across the Nation, with large increases up to the 1970s, then large decreases following the introduction of unleaded gasoline. Such trends have been attributed primarily to gasoline use of lead (Callender and Van Metre, 1997). Trends in concentrations of many of the other trace elements, whether statistically significant monotonic trends or not (table 6), tend to be similar among these lakes. Many of them, including cadmium, chromium, copper, mercury, nickel, and, to a lesser extent, zinc, peak about 1970 (figs. 6, 11, and 17). Some have a secondary peak in the 1980s, especially in Echo Lake, and a few have a peak in the late 1990s, near the top of the core. This similarity suggests some commonality of sources, which in turn suggests atmospheric sources.

Similarity in trends among some trace elements is even stronger within each lake. In Echo Lake, cadmium, chromium, copper, nickel, and to some extent zinc follow similar temporal patterns (fig. 11). These metals are associated with metal industries and automobiles, and numerous small metal shops and automobile repair shops are in the watershed of Echo Lake. In Fosdic Lake, cadmium, lead, and mercury are very similar with a large, bulging peak in about 1970 (fig. 17).

Chromium, copper, and nickel each have a similar but much less pronounced peak. In Lake Como, all eight trace elements shown in figure 6 have somewhat similar temporal patterns, with a high in 1970 and either one or two relative highs in the early and (or) late 1990s. These similarities suggest that when trace elements are released to the urban environment, they often are in combination.

Polycyclic Aromatic Hydrocarbons

Trends in PAHs in lake and reservoir cores reflect the land-use history of the watershed of the lake. Because there are many urban sources of PAHs, as watersheds are developed, concentrations increase. In some older urban watersheds, the highest historical levels occurred in the 1940s and 1950s, when environmental regulations were almost nonexistent. In newer, recently urbanizing watersheds, trends are increasing as urban density and traffic increase (Van Metre and others, 2000). Both of these trend patterns are indicated in the Fort Worth lakes. Fosdic Lake, the most recently and the least heavily urbanized in terms of commercial, industrial, and highway areas, has a steady increasing trend to the mid-1990s then a small drop to the present (fig. 18). Concentrations began to increase in the 1950s, consistent with initial development of this part of Fort Worth. It is unclear if the drop in concentrations in the top 10 cm of the core indicates the beginning of a long-term improving trend or reflects short-term variation.

In contrast to the systematic increasing trends in PAHs in Fosdic Lake, Lake Como and Echo Lake have more variable temporal patterns. Individual PAHs and total PAH appear to have increased in the three Lake Como cores from the 1950s to the 1960s, then to have been highly variable but without trend since (fig. 7; table 6). The watershed of Lake Como was developed mostly in the 1950s and 1960s, with no appreciable change in urban land-use density in recent decades. Thus, the PAH concentrations are consistent with urban sources and the land-use history of the watershed.

Individual PAHs and total PAH increased from the bottoms of the three Echo Lake cores (dated in the 1950s and 1960s) to the middle and upper parts of the cores (fig. 12). Total PAH concentrations peaked about 1980, decreased for a time, and then increased in the late 1990s to levels similar to the 1980 peak. Statistically significant increases since 1965 occur for most individual PAHs and total combustion PAH but not for total PAH (table 6). The lack of a trend for total PAH is not a statistical anomaly but rather a consequence of different trends in many of the other individual PAHs not shown here. Profiles of the major combustion PAHs, fluoranthene and benzo(a)pyrene, for example, do not show peaks in 1980 and have smoother increasing trends from the 1960s to the present. The peak in total PAH in 1980 was caused by very large concentrations of alkyl-PAH in this sample compared with other samples. The source indicator ratio illustrates these differences, increasing from about 1.0 to 1.5 prior to 1980, to about 3.0 at the 1980 peak, then decreasing to less than 1.0 in recent years (fig. 12). The watershed of Echo Lake developed mostly in the 1950s and 1960s. Traffic on Interstate-35W, however, presumably has increased greatly during the past several decades, which provides a logical explanation for increases in combustion PAH. The relatively high total PAH and strong fuel-source indicator ratio in 1980 suggest there might have been a fuel spill.

Sources and Transport: Relations Between Land Use and Contaminants

One way to identify possible contaminant sources is to compare the distribution of possible sources with a contaminant response. There are numerous and varied urban point and nonpoint sources of contaminants, and a complete inventory of urban sources does not exist; therefore, general measures of land use were used as surrogates for urban sources. Land-use data are for 2000 and include percentage of urban land use and percentages of four major subcategories of urban—residential, industrial, transportation, and commercial (table 3). The contaminant response evaluated here is concentrations in suspended and bottom sediment in streams and lakes. Land use was compared with two groups of sediment samples. The first group, referred to as “all samples,” is all samples dated as post-1990, which includes the upper parts of all of the sediment cores and all of the suspended-sediment samples. To use relatively comparable data from each stream site, the discrete samples from Sycamore Creek were numerically combined to form a single event-composite sample for each of the three storms. The second group of samples comprises only the suspended-sediment samples. Nine contaminants, which represent all three major contaminant groups and include all four of the legacy pollutants responsible for the fish bans, were tested. These nine contaminants were chosen because they are believed to be of the most concern to human health (chlordane, dieldrin, DDE, total DDT, and PCBs) and aquatic life (the legacy pollutants plus cadmium, lead, zinc, and combustion PAH) and to be useful indicators of the effect of urbanization on water quality (all nine and especially lead and combustion PAH).

The contaminant data are highly variable and non-normally distributed; therefore, the nonparametric Spearman's rank correlation test (Helsel and Hirsch, 1992) was used to indicate whether there were statistically significant correlations in contaminant concentrations with land use. Nondetections were handled in two ways. Because there were numerous nondetections among the chlorinated hydrocarbons (the combustion PAH and metals were detected in all samples) and because laboratory reporting levels were highly variable and sometimes very large, using the reporting level in the correlation could produce misleading results. In most cases, nondetections were replaced with the laboratory reporting level, resulting in a low rank for the sample. In a few samples, very low mass of suspended sediment resulted in very large nondetections for chlorinated hydrocarbons (appendix 1.4). Nondetections greater than 1,000 µg/kg were deleted from these tests on the basis of the assertion that they were not providing useful information on concentrations in the stream. Data also were log-transformed, resulting in more normal distributions, and compared graphically with percent urban land use. A least-squares regression line fit to the log of concentrations is shown on each graph (figs. 21, 22).

All nine contaminants tested are strongly correlated with percent urban land use and with the sum of commercial, industrial, and transportation land uses for all samples and suspended-sediment samples (table 10). All p-values are less than .010 (99-percent or greater confidence level). These relations are strong evidence of the likelihood of urban sources for these contaminants. All nine correlation coefficients (Spearman's rho) are consistently larger for suspended sediments than for all sediments, although this probably is not surprising because the "all samples" group mixes samples of different types, which introduces variation. The strongest correlations, with correlation coefficients greater than .7 and p-values of zero (at 3 significant figures), are for the three metals tested.

There are variations in correlations among specific land-use types that are indicative of possible source areas in the urban area. Correlations for both sample groups with percent residential are significant for the four organochlorine pesticides but not for PCBs, PAHs, or metals (table 10). These relations suggest that residential areas are relatively important sources of pesticides but are less important sources of the other contaminants. Conversely, the only significant pesticide correlation with commercial or industrial land use was chlordane with commercial land use. PCBs, metals, and PAHs might be expected to come from commercial and industrial areas, and many are significantly correlated with these land uses. The only contaminant showing a significant correlation with percent industrial land use for both sample groups is PCBs, which are known to have many industrial sources. All contaminants from both groups, except dieldrin in "all samples," correlate with percent transportation. This might be expected for metals and PAHs, which have many road and vehicle-related sources, but is unexpected for the legacy pollutants. It's possible that this particular land use affects transport of the contaminant, for example increasing contaminant movement to streams because it functions as connected impervious cover, in addition to being a source area for some contaminants.

The highest overall correlations are with (total) percent urban land use; therefore, it was chosen for graphical comparisons and regression analysis with selected contaminants. Water-quality and sediment-chemistry data often are log-normally distributed (Helsel and Hirsch, 1992). The sediment-chemistry data analyzed here are no exception—therefore, they are graphed on a logarithmic scale and were log-transformed prior to fitting the regression lines shown in figures 21 and 22. The regression equations are not meant to be widely applicable predictive equations but rather to aid the reader in visualizing the relations shown in these figures. They also are used to evaluate the relative magnitude of contaminant enrichment indicated by these data for Fort Worth streams and lakes. Note also that statistical significance of the nonparametric test (table 10) does not guarantee significance for the slope of the regression equation, a parametric test (figs. 21, 22).

The regression equations and graphs of figures 21 and 22 can provide an indication of the relative magnitude of "cultural enrichment" of contaminants in response to urbanization. The ratio of a human-affected contaminant level to a reference or background level has been termed the cultural enrichment factor (CEF) (Heit and others, 1981). The regression equations are used to compute expected CEFs, and the 30- and 100-percent land-use values were chosen as background and human-affected levels, respectively, because the equations are calibrated approximately over this range. As used here and shown in table 11, the CEF is a general indicator of

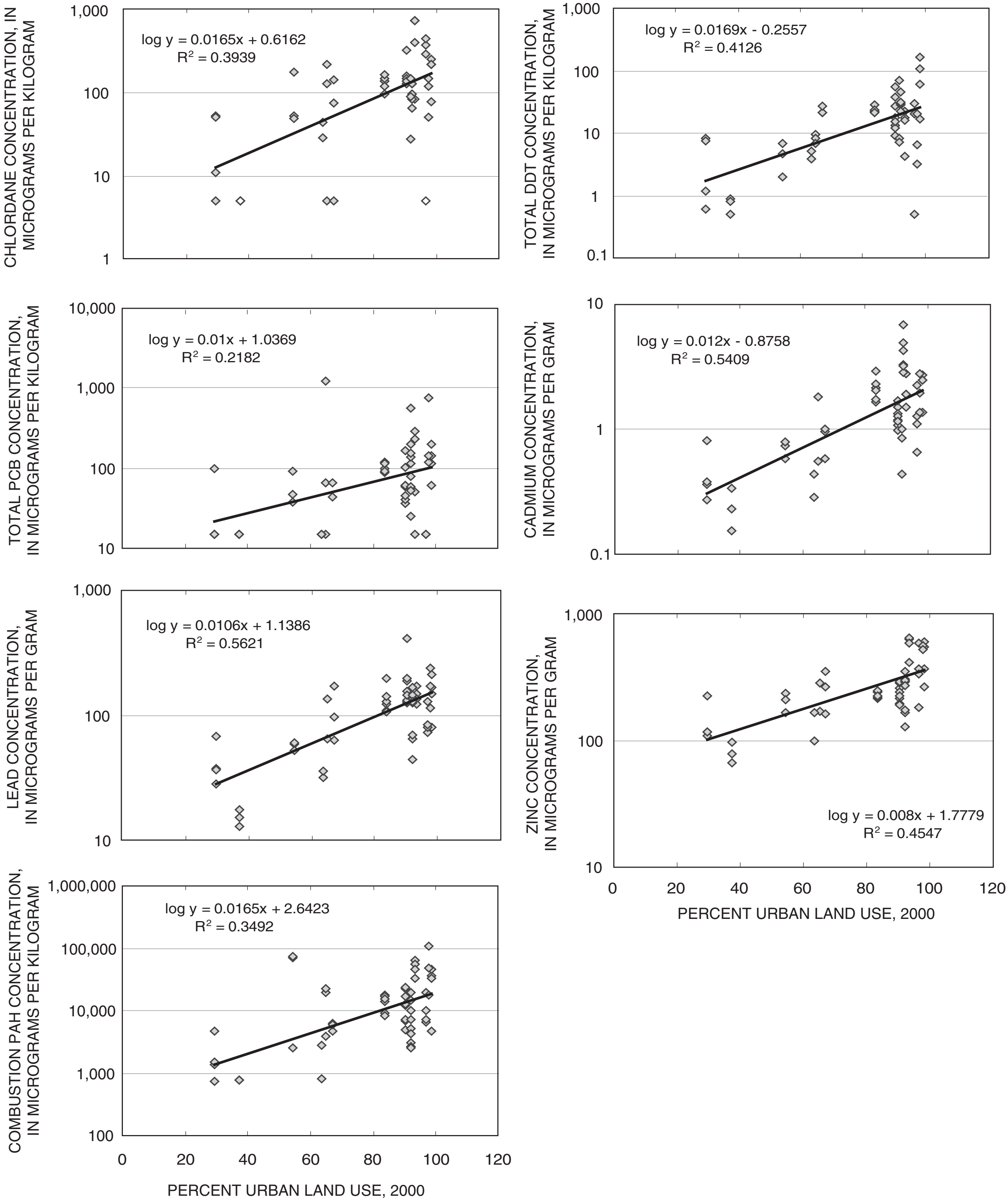

Figure 21. Relations between selected contaminant concentrations in sediment and percent urban land use for all suspended-sediment samples and all core samples dated 1990 or later.

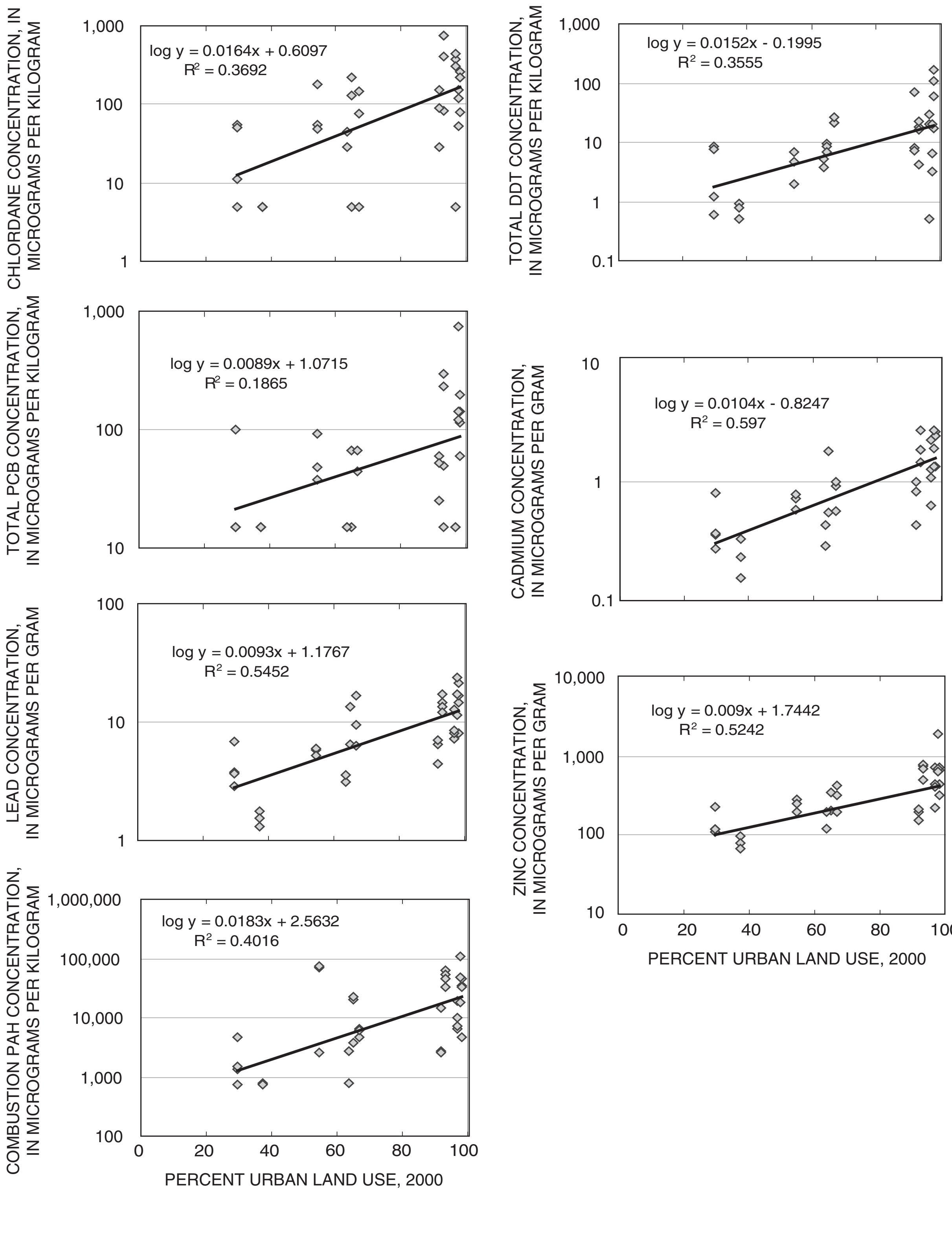

Figure 22. Relations between selected contaminant concentrations in suspended sediment and percent urban land use for all suspended-sediment samples.

Table 10. Spearman's rank order correlations between selected organochlorine compounds or trace elements in sediment and land use

[p-values are two-sided. Statistically significant correlations at 95-percent or greater confidence are highlighted; <, less than]

Organochlorine compound or trace element	Suspended-sediment samples			Suspended-sediment and core samples		
	No. of samples	Spearman's rho	2-sided p-value	No. of samples	Spearman's rho	2-sided p-value
Correlation with percent urban						
Chlordane	36	.58	<.001	56	.50	<.001
Dieldrin	36	.51	.002	56	.40	.002
DDE	36	.62	<.001	56	.48	<.001
Total DDT	36	.58	<.001	56	.50	<.001
Total PCB	33	.53	.001	53	.47	<.001
Cadmium	35	.81	<.001	55	.65	<.001
Lead	35	.78	<.001	55	.57	<.001
Zinc	35	.76	<.001	55	.76	<.001
Combustion PAH	36	.59	<.001	56	.50	<.001
Correlation with percent commercial, industrial, and transportation						
Chlordane	36	.57	<.001	56	.38	.004
Dieldrin	36	.54	.001	56	.25	.062
DDE	36	.49	.003	56	.35	.009
Total DDT	36	.40	.015	56	.43	.001
Total PCB	33	.65	<.001	53	.54	<.001
Cadmium	35	.79	<.001	55	.62	<.001
Lead	35	.72	<.001	55	.64	<.001
Zinc	35	.75	<.001	55	.65	<.001
Combustion PAH	36	.72	<.001	56	.49	<.001
Correlation with percent residential						
Chlordane	36	.34	.045	56	.40	.002
Dieldrin	36	.36	.030	56	.28	.034
DDE	36	.45	.006	56	.45	.001
Total DDT	36	.41	.012	56	.38	.004
Total PCB	33	-.15	.390	53	-.01	.920
Cadmium	35	.16	.351	55	.20	.138
Lead	35	.15	.378	55	.18	.176
Zinc	35	.15	.383	55	.10	.470
Combustion PAH	36	.01	.948	56	.10	.470
Correlation with percent industrial						
Chlordane	36	.12	.470	56	-.06	.646
Dieldrin	36	.18	.305	56	.08	.559
DDE	36	.20	.245	56	.07	.617
Total DDT	36	.23	.168	56	.16	.248
Total PCB	33	.63	<.001	53	.39	.004
Cadmium	35	.38	.026	55	.28	.037
Lead	35	.36	.033	55	.18	.192
Zinc	35	.27	.117	55	.31	.021

Table 10. Spearman's rank order correlations between selected organochlorine compounds or trace elements in sediment and land use—Continued

Organochlorine compound or trace element	Suspended-sediment samples			Suspended-sediment and core samples		
	No. of samples	Spearman's rho	2-sided p-value	No. of samples	Spearman's rho	2-sided p-value
Combustion PAH	36	.38	.024	56	.15	.255
Correlation with percent transportation						
Chlordane	36	.55	.001	56	.42	.001
Dieldrin	36	.53	.001	56	.22	.108
DDE	36	.57	<.001	56	.33	.014
Total DDT	36	.51	.002	56	.44	.001
Total PCB	33	.58	<.001	53	.42	.002
Cadmium	35	.80	<.001	55	.52	<.001
Lead	35	.77	<.001	55	.69	<.001
Zinc	35	.76	<.001	55	.58	<.001
Combustion PAH	36	.61	<.001	56	.42	.001
Correlation with percent commercial						
Chlordane	36	.24	.150	56	.29	.029
Dieldrin	36	.12	.485	56	.23	.086
DDE	36	.18	.289	56	.21	.119
Total DDT	36	.09	.586	56	.08	.546
Total PCB	33	.21	.232	53	.19	.165
Cadmium	35	.44	.009	55	.25	.063
Lead	35	.45	.007	55	.26	.055
Zinc	35	.46	.005	55	.37	.006
Combustion PAH	36	.32	.055	56	.35	.008

Table 11. Selected contaminant concentrations and cultural enrichment factors (CEF) estimated using regression equations presented in figures 21 and 22

[µg/kg, micrograms per kilogram; µg/g, micrograms per gram]

Contaminant (units)	Predicted concentration		CEF	Fosdic Lake core sediment concentration	
	30-percent urban	100-percent urban		About 1912 (no urban)	About 2001 (84-percent urban)
Chlordane (µg/kg)	12.9	185	14	0	140
Total DDT (µg/kg)	1.8	27.2	15	0	22.0
Total PCB (µg/kg)	21.7	109	5.0	0	99.0
Cadmium (µg/g)	.3	2.1	6.9	.2	1.7
Lead (µg/g)	28.6	158	5.5	26.8	108
Zinc (µg/g)	104	378	3.6	70.0	220
Combustion PAH (µg/kg)	1,365	19,498	14	186	9,100

expected enrichment in contaminant levels coinciding with an increase in urban land use from 30 to 100 percent. For a spatial-relations versus temporal-trends comparison, the pre-urban (about 1912) and recent (about 2001) sediment concentrations from the Fosdic Lake core also are listed in table 11.

Predicted CEFs are large, ranging from 3.6 for zinc to 15 for total DDT (table 11). Chlordane, total DDT, and combustion PAH all are expected to increase by a factor of about 15 with this change in land use. PCBs, cadmium, lead, and zinc are expected to increase proportionally less, but still by factors from 3.6 to 6.9. The predicted concentrations and CEFs indicate that much higher contaminant concentrations result from urbanization in Fort Worth. The modeled concentrations are consistent with concentrations in the Fosdic Lake core. As expected, none of the manufactured legacy pollutants were detected at the bottom of the core in the 1912 sample. Concentrations of all seven contaminants from the top of the core, the 2001 sample, seem logical in relation to predicted concentrations and are smaller than the 100-percent urban concentrations. Somewhat smaller concentrations are expected because the Fosdic Lake watershed is 84-percent urban, has largely residential land use, and suspended-sediment samples in many cases have higher concentrations than top-of-core samples.

Many of the broad statistical relations are supported by occurrence or lack of it at specific sites. Chlordane, for example, was detected at all sampling locations except the Benbrook passive-sampler site. The only legacy pollutant detected at that site was DDE and only at low levels. The site was the second least-urbanized site sampled, 7.8 percent in 1990 increasing to 37 percent in 2000; thus, the site was predominantly undeveloped rangeland during permitted use of all of the legacy pollutants. Therefore, even though urban development in the 1990s could be contributing to mobilizing sediment during runoff, as suggested by the relatively large suspended-sediment concentrations at the Benbrook site (appendix 1.3), those sediments are relatively free of legacy pollutants because of the lack of historical use in the watershed. In contrast, sediment mobilized during runoff from the older urban watersheds contains a mixture of legacy pollutants.

Although the number of detections is small relative to the number of samples, the results of Baldys and others (1998) for stormwater are consistent with the correlations with land use presented here. Among the 30 Dallas/Fort Worth area sites documented in Baldys and others (1998), organochlorine pesticides were most frequently detected at residential sites followed by commercial and industrial sites, which suggests residential areas are more important sources of these pesticides. Detection frequencies of PAHs were the opposite, most frequent in industrial sites followed by commercial then residential sites. Site-specific results in Fort Worth are similar (Baldys and others, 1997). Chlordane, for example, was detected at two of the five Fort Worth sites. The most detections (four of seven samples) and highest concentration measured (1.2 µg/L) were at the site with the greatest percentage of residential land use (site 08048700). PCB Aroclor 1254, the only Aroclor detected, was detected in four of seven samples from the most industrialized site (site 08048545). Metals followed a similar pattern. Mean concentrations of cadmium, lead, and zinc at the industrial site were 1.6, 104, and 623 µg/L, respectively, compared with no detections of cadmium at a reporting level of 1.0 µg/L and means of 36 and 93 µg/L for lead and zinc, respectively, at the residential site.

Anthropogenic sources of PAHs include vehicle, power plant, home heating, and waste incineration emissions; wear of tires and asphalt roads; and spills and leaks of motor oil. Van Metre and others (2000) showed positive relations between PAH trends in urban lake sediment cores and temporal changes in traffic in urban areas. The highest PAH concentrations are in suspended sediments from the Downtown site, the inflows to Lake Como and Echo Lake, and Little Fossil Creek. Three of these sites have interstate highways crossing their watersheds, and the fourth, the Downtown site, has the density of roads and traffic expected in a major city center. Downtown, Little Fossil Creek, and Echo Lake inflow have the highest percentage of industrial land use in the study, also a possible source for PAHs.

Source Strength: Contaminant Yields to Reservoirs

Another way to evaluate relations between sources, transport, and fate of these contaminants is to evaluate the magnitude of yields for the watersheds studied. Watershed yields of selected contaminants estimated using a reservoir mass-balance approach are listed in table 8. These estimates provide a relatively rare look into urban yields of particle-associated legacy pollutants. Yields of these contaminants from the White Rock Lake watershed in Dallas estimated on the basis of 1994 cores (Van Metre and Callender, 1997) and 1996 cores (P.C. Van Metre, U.S. Geological Survey, unpub. data, 1996) and using a similar mass-balance approach are included. Pre-urban land-use yields for Fosdic Lake and White Rock Lake also are included in table 8 because both of these lake cores extended far enough back in time to represent pre-urban conditions. Land use in these watersheds in the early 1900s probably was a mixture of agriculture and rangeland. The older estimates of yields were made by multiplying sediment concentrations from the lower parts of the core or cores by the long-term-average sediment yield (table 7).

Yields of legacy pollutants consistently follow several patterns. Yields of organochlorine pesticides are similar among the Fort Worth lakes and are large compared with those of White Rock Lake; for example, chlordane yields to Fort Worth lakes range from 16 to 22 micrograms per square meter per year ($\mu g/m^2$-yr) compared with 7.3 $\mu g/m^2$-yr to White Rock Lake. Yields of PCBs are largest to Echo Lake, two to three times larger than to other lakes. Echo Lake has the highest percentage of industrial land use of these lakes (table 3; Van Metre and Callender, 1997).

Yields of cadmium, copper, lead, and zinc are much greater to the Fort Worth lakes than to White Rock Lake; however, yields of chromium and nickel to White Rock Lake, even under pre-urban conditions, are larger. These large pre-urban yields likely represent natural sources and reflect sediment yields to White Rock Lake that are about double sediment yields to the Fort Worth Lakes (table 8). Yields of cadmium, copper, mercury, lead, and zinc increase with urbanization in Fosdic Lake by factors ranging from about 2 to 8. Arsenic yields to Fosdic Lake and White Rock Lake decrease with time. It is not known if this decrease results from some historical anthropogenic loading of arsenic that has decreased, for example use of arsenic-based pesticides, or is just a result of natural variations in arsenic concentrations or an artifact of sedimentary diagenesis. In the case of White Rock Lake, the decrease in yield is caused by a relatively small change in the concentration of arsenic, 10.1 µg/g in the 1916 sample versus 8.1 µg/g at the top of the core, suggesting natural variations. In Fosdic Lake, however, the 1912 sample was 20.9 µg/g, increasing to a peak of 220 µg/g in about 1960, then decreasing to 13.0 µg/g at the top of the core. These variations suggest some relatively large anthropogenic sources in the watershed in the first one-half of the 20th century. A similar trend in arsenic concentrations was found in a sediment core from Lorence Creek Lake on the north side of San Antonio, Tex. (Ging and others, 1999).

Yields of cadmium, chromium, copper, lead, nickel, and zinc are larger to Echo Lake than to the other two Fort Worth lakes. These larger yields probably reflect the inputs from industrial sources such as the numerous small metal and automobile repair shops in the Echo Lake watershed. Mercury yields are greatest in the Fosdic Lake watershed. Anthropogenic releases of mercury are assumed to come mostly from coal-fired power plants and waste incinerators, both regional sources; thus, local variations of a factor of two or three are not expected. The causes of larger mercury yields in the Fosdic Lake watershed are not known. One hypothesis is that asphalt shingles could be a source of mercury and the Fosdic Lake watershed is more densely covered with single-family homes with asphalt-shingle roofs than the other watersheds. In a recent study of PACs washed from metal and asphalt-shingle roofs in Austin, Tex., Van Metre and Mahler (2003) found significantly larger mercury and lead concentrations in particles washed from asphalt-shingle roofs than from comparable metal roofs.

In some ways, yields of PAHs present the clearest picture of anthropogenic effects related to urbanization. Yields of PAHs are very similar for the three Fort Worth lakes with, for example, total combustion PAH ranging from 1,610 to 1,830 $\mu g/m^2$-yr (table 8). Considering that all three lakes are located in fully urbanized small watersheds, this similarity seems logical. These yields are about four times greater than yields to White Rock Lake. White Rock Lake is about 76-percent urban land use, is much larger (surface area 4.4 square kilometers [km^2] and watershed area 259 km^2) and has appreciable parklands and greenbelt along the upper end of the lake and along White Rock Creek (Van Metre and Callender, 1997). These characteristics all could act to reduce loading of PAHs to the lake. The change in PAH yields from pre-urban to urban is particularly striking. Loading under pre-urban conditions is small and similar, 25 and 15 $\mu g/m^2$-yr for Fosdic and White Rock Lakes, respectively. These yields increased by between one and two orders of magnitude with urbanization.

Table 7 lists ^{137}Cs burdens in cores and cesium focusing factors (FF). The ^{137}Cs is the product of the ^{137}Cs concentration profile and dry mass in the core and, in this case, was computed from the peak concentration to the top of the core. Cesium FF provides an estimate of the degree of focusing of PACs from both the watershed and in the reservoir. Cesium FF ranging from 2.3 to 7.1 were estimated for six reservoirs in the central and southeastern United States by Van Metre and others (1997). Cesium FF ranges from 4.4 in Fosdic Lake to 6.9 in Lake Como (table 7), which indicates a relatively high degree of focusing. The relatively even sediment thickness on the bottoms of these lakes and the large watershed-to-lake-area ratios suggest that much of the focusing is material transported from the watershed.

Transport and Fate: Relations Between Suspended Sediments and Sediment Cores

Age-dated sediment cores often are used to indicate trends in PACs in the environment (Charles and Hites, 1987). In some cases, for example reservoirs, an assumption is that the trends recorded in the sediment core are indicative of trends in the influent stream (Van Metre and others, 2001). Although this assumption might seem logical, considering most of the sediment deposited in a small reservoir with relatively stable banks is the sediment transported to it by the stream, it has not been demonstrated, to our knowledge. The data collected by this study provide at least a partial opportunity to test this assumption.

Concentrations of selected organic contaminants and trace elements were compared between suspended sediments and top-of-core sediments (fig. 23). Figure 23 shows the ratio of the median concentration in sediment at the tops of the three cores from each lake to the median concentration in the four suspended-sediment samples from the lake inflows, expressed as a percentage. Concentrations of most trace elements at the tops of cores were somewhat similar to those of influent suspended sediments. Concentrations of most trace elements were much less variable in suspended sediments than were those of organic compounds. The similarity between suspended-sediment concentrations and reservoir-bottom sediment concentrations and the low variability between storms for trace elements could be partly a consequence of the natural occurrence of trace elements, as proportionally larger background levels translate to relatively less variability in total concentrations. The similarity between trace element concentrations in sediments from the tops of the cores and suspended sediments suggests that trace element trends preserved in cores reflect historical concentrations in influent streams. Lead, for example, shows pronounced trends in the cores (figs. 6, 11, and 17), mirroring the historical use, then removal, of lead from gasoline and other reductions in releases of lead brought about by environmental regulations (Callender and Van Metre, 1997). The agreement between lead concentrations at the tops of the cores and in suspended sediments suggests that the cores not only record trends but also could be reasonable predictors of historical concentrations on suspended sediments in the influent streams. The similarity between suspended sediment and sediment cores occurs for other trace elements as well (fig. 23). One exception was zinc—concentrations of zinc at the tops of cores accounted for only 40 to 64 percent of suspended-sediment concentrations, the least of any trace element shown. This suggests that zinc could be desorbing from sediment during transport or soon after deposition.

Concentrations of chlorinated hydrocarbons in suspended sediments were highly variable between storms at a given site and exceeded concentrations at the tops of cores in most cases (fig. 23). Among the chlorinated hydrocarbons, dieldrin and DDT were proportionally the least well represented in the cores, with median concentrations at the tops of cores less than 25 percent those of suspended sediment in all three lake inflows. Concentrations of PAHs in sediments from two of the three lakes were about one-third of the concentrations in influent suspended sediments, although in the third lake, Fosdic Lake, PAH concentrations in sediment cores were similar to or exceeded those in suspended sediments.

Two hypotheses are suggested to explain the differences between organic contaminant concentrations in the suspended sediment and in the tops of the sediment cores. The first is that the average suspended-sediment contamination might not be well represented by the four sampled storms. The organic contaminant concentrations associated with the suspended sediment were highly variable (figs. 5, 7, 10, 12, 16, and 18), and the sum of precipitation for the storms sampled at each site represents less than 7.5 percent of annual precipitation. Furthermore, contaminant loads to the lakes might be greatly influenced by larger storms (for example, 5- or 10-year floods), which were not sampled for this study. A second hypothesis is that once soil is exposed to the water column, there might be loss of some sorbed organic contaminants through various processes during transport and soon after deposition. These processes include desorption as organic carbon breaks down, bacterially mediated degradation, and bioaccumulation by benthic biota.

There is evidence, however, that relative concentration histories are preserved for some organic

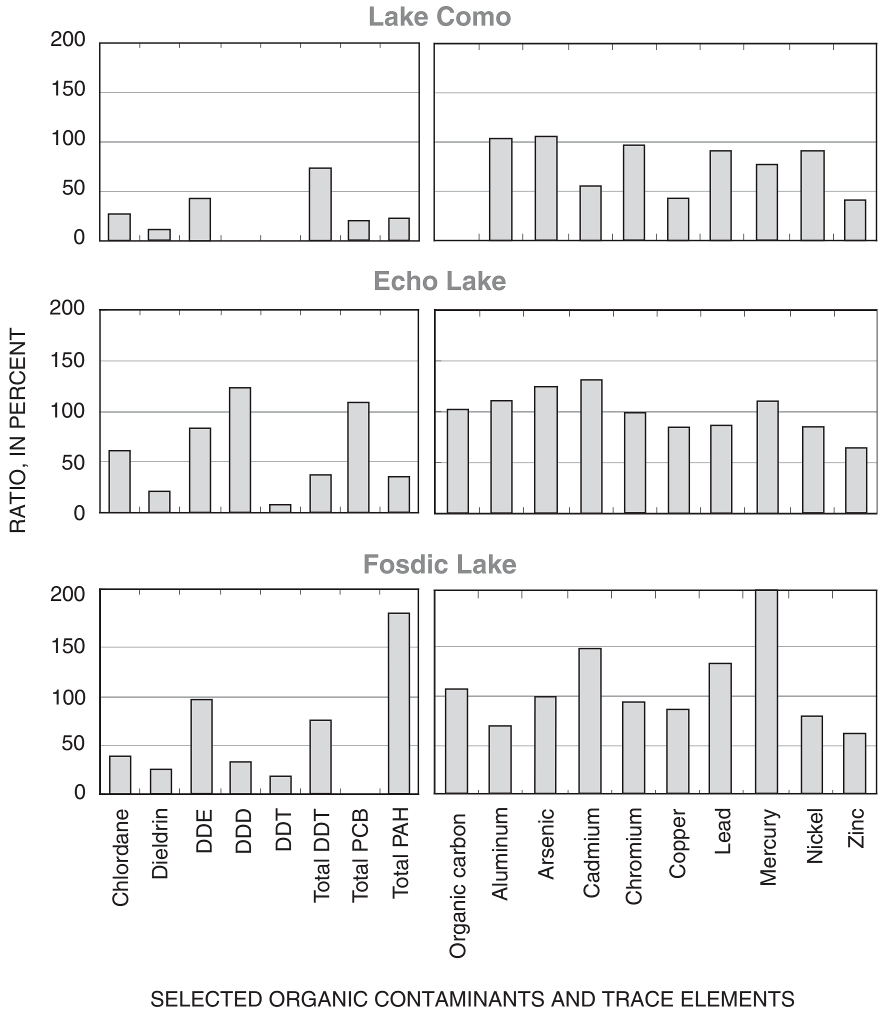

Figure 23. Ratio of median suspended-sediment concentrations (n = 4) to median top-of-core sediment concentrations (n = 3) of selected organic contaminants and trace elements.

contaminants. For example, the shape of the chlordane profiles down the cores, with pronounced temporal trends including large peaks in older sediments in two of the three lakes, suggests that chlordane could be stable once deposited and isolated from the water column. Stability of chlordane in sediment cores is consistent with the relatively stable and racemic chiral chlordane signatures seen in cores, including the Lake Como core (Ulrich and others, 2002). The same would appear to be true for PAHs (figs. 7, 12, and 18) and total DDT and PCBs (figs. 5, 10, and 16). Many researchers have noted that hydrophobic organic contaminants in sediment can be operationally divided into a "rapidly extractable" fraction and a "sequestered" fraction (for example, Rockne and others, 2002). Conceptually, it could be that some of this rapidly extractable fraction associated with soils and street dust, the precursors of suspended sediment, is lost to the water column during transport and soon after deposition and that the sequestered fraction dominates what remains in sediment cores.

DDT and dieldrin have much different trends in cores than the other organochlorine compounds (figs. 5, 10, and 16). Concentrations of both increase sharply at the very tops of the cores and are much greater in suspended sediments, when detected, than in the cores. Interpreting these results as increasing environmental occurrence would be inconsistent with historical use. DDT use peaked in the early 1960s, and its use was discontinued in 1972; dieldrin use was voluntarily canceled in May 1987 (U.S. Environmental Protection

Agency, 1990). Therefore, an increase in the occurrence of DDT and dieldrin in the environment in the 1990s seems unlikely. Instead, we suggest that the observed trends reflect the continued loss of these contaminants from the sediment after deposition and burial rather than an increase in occurrence. DDT degrades to DDD and DDE in a transformation that occurs slowly in aerated soils but more rapidly in the presence of water (Guenzi and Beard, 1976; Nowell and others, 1999). In those suspended-sediment samples in which DDT was detected, DDT accounted for 60 to 77 percent of total DDT (DDT + DDD + DDE) in suspended sediments from the three lake inflow sites with moderate concentrations. The high ratio of DDT to total DDT probably is an indication of recent entry into the hydrologic system rather than recent application (Nowell and others, 1999). In contrast, DDT accounted for zero (18 of 46 core samples were nondetections for DDT) to 26 percent of total DDT in the sediment cores and decreased down core. These data suggest that DDT persists in soils but is converted to DDD or DDE on a time scale of months to years after deposition in the lakes. However, trends in total DDT in cores, composed primarily of the more stable DDD and DDE, seem to be relatively conservative once isolated from the water column (figs. 5, 10, and 16). Although no breakdown products of dieldrin were measured, the shape of the core profiles and the concentrations of dieldrin in cores versus suspended sediments strongly suggest that dieldrin, although persistent in soils (Martijn and others, 1993), is not preserved in these lake sediments.

Fate: Sediments and Fish

Many of the contaminants evaluated had concentrations that exceeded sediment-quality guidelines, most commonly chlordane, lead, and PAHs. It is important to note what these guidelines can and cannot tell us. A concentration greater than the PEC implies that an adverse effect on biota is statistically likely (MacDonald and others, 2000). Most of the underlying data used to develop the sediment-quality guidelines are studies that matched measurements of sediment chemistry with biological effects. Often the biological effect used was a measure of toxicity in an indicator organism exposed to the sediment, for example, the amphipod, *Hyalella azteca* (Ingersoll and others, 2001). Thus, the most direct conclusion that can be drawn from an exceedance of a PEC is that the sediment could potentially cause a toxic response in benthic organisms in the receiving water body. It does not imply, for example, that fish, turtles, or people swimming in the water are threatened. Furthermore, it does not gage the relative potential for bioaccumulation of contaminants in fish, the problem of most immediate concern to regulators in these water bodies. Thus, although the sediment-quality guidelines provide a benchmark for the general level of sediment quality, they are not designed to evaluate the bioaccumulation potential of contaminants.

As noted in the introductory discussion of available historical fish-tissue data for the Fort Worth lakes and Trinity River, variability among these datasets is large; and supporting methods and quality assurance data are not available, which limits the interpretative value of the data. In terms of occurrence, several observations can be made: All of the legacy pollutants detected in fish samples in recent years are routinely detected in bottom-sediment cores and in suspended sediments. These include chlordane, dieldrin, DDE, and PCBs (appendix 1.4). DDD and DDT were less frequently detected in fish (appendix 3). Concentrations of all the legacy pollutants in fish appear to have decreased since the early 1990s. Chlordane is the most frequently detected legacy pollutant in recent years and at higher concentrations than the other legacy pollutants. In the 2001 sampling of the three lakes by Texas Department of Health, chlordane was detected in four of five samples in Lake Como and Fosdic Lake and in all five samples from Echo Lake (table 2).

Although sediments are recognized as the primary reservoir and source of hydrophobic organic contaminants to aquatic biota, relations between contaminant concentrations in sediments and fish vary widely (Wong and others, 2000). At least two major kinds of variation can affect this relation: The first is variation within fish from the same water body. Contaminant levels in fish are known to vary with species, trophic level, age, and sex. The second is variation in the bioavailability of contaminants in sediments. Chemical properties of the sediment, in particular organic carbon concentrations and type, and various chemical reactions that affect solubility of contaminants also can affect bioavailability (for example, pH and redox condition). The aging of organic contaminants in sediment has been shown to increase the sequestration (Rockne and others, 2002) (and therefore, reduce bioavailability) and could be a factor in the relative bioavailability of contaminants from "new" suspended versus "old" bottom sediments.

Contaminant concentrations among fish often vary greatly. In an intensive study of contamination in fish in Mountain Creek Lake in Dallas, 62 fish were collected from June 29 to Aug. 9, 1995, all of which were analyzed at the USGS NWQL for legacy pollutants (Jones and others, 1997). Fish species were largemouth bass (23 fish), common carp (10 fish), and channel catfish (29 fish), and sample types consisted of fillets with skin off and on and whole fish. Total PCB concentrations, computed by summing Aroclors 1242, 1254, and 1260 and treating nondetections as zeros, varied from a single nondetection (<15 µg/kg for each Aroclor) to 2,634 µg/kg. The median was 131 µg/kg, and the mean was 325 µg/kg. Concentrations in five fish exceeded 1,000 µg/kg. Variation in chlordane concentrations was almost as large. Concentrations ranged from six nondetections at <5 µg/kg to a maximum of 580 µg/kg with a median of 15 µg/kg. These data indicate that variations of two orders of magnitude can occur in a single lake.

Large variations in fish-tissue concentrations and lack of detailed information on sampling methodologies, analytical methods, and quality assurance for the various historical fish datasets collected from the Fort Worth area make developing meaningful relations between sediment concentrations and fish difficult. What is clear, however, from both the fish and sediment data, is that legacy pollutants continue to enter the Fort Worth area water bodies at levels that are only slowly decreasing, if at all, and that these same legacy pollutants continue to be detected in fish, albeit infrequently at most sites.

Chlordane concentrations in fish tissues sampled from Lake Como, Echo Lake, and Fosdic Lake are shown in figure 24. Largemouth bass were the most frequently sampled species of fish, but the type of tissue analyzed is variable (appendix 4). Concentrations span three orders of magnitude, and concentrations in samples collected in 1997 are exceptionally high compared with those in other samples. This amount of variability between sample sets and the smaller variability within sample sets suggest substantial differences in sampling or analytical methodology. Because of the methodological uncertainties and the short time spans covered by the data, testing for trends of legacy pollutants in fish was not done.

PCB concentrations in fish tissues collected from the Trinity River show spatial variability consistent with land-use differences between sites. Fish were sampled from two locations in the Trinity River in June 2000 (fig. 25). PCBs were not detected in five fish collected downstream of Benbrook Dam (upstream of greater

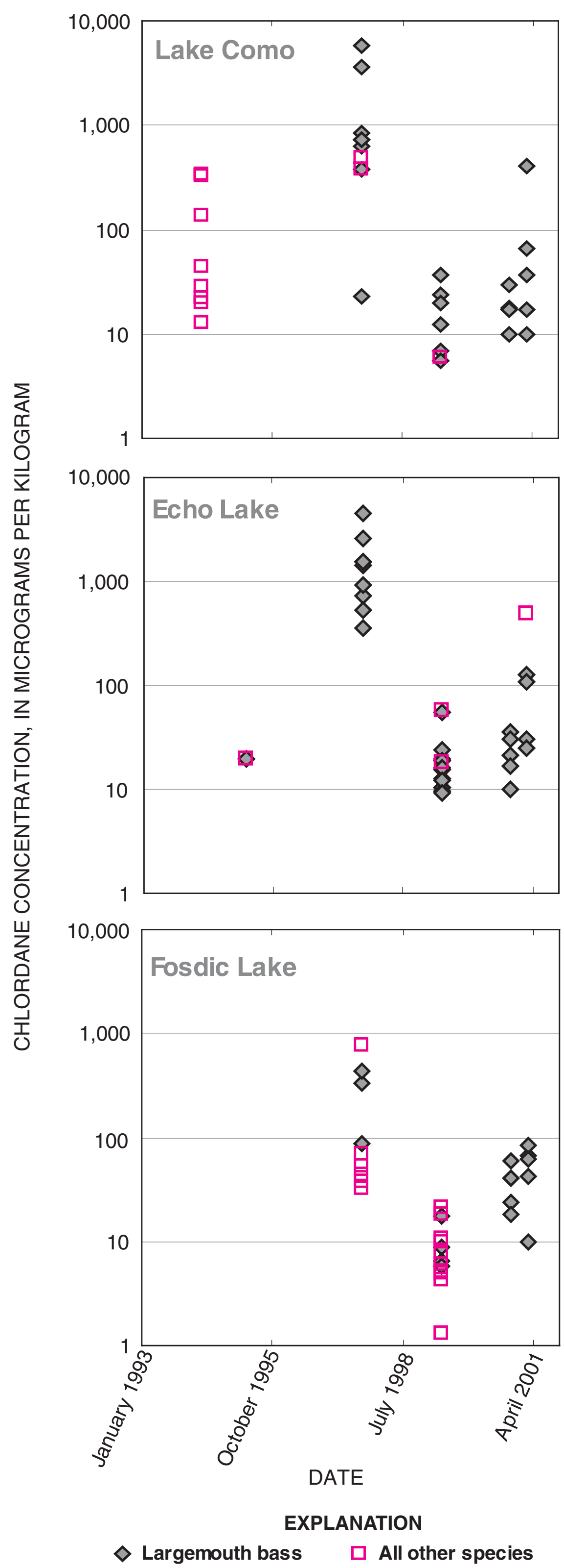

Figure 24. Concentration of chlordane in fish tissues collected from Lake Como, Echo Lake, and Fosdic Lake.

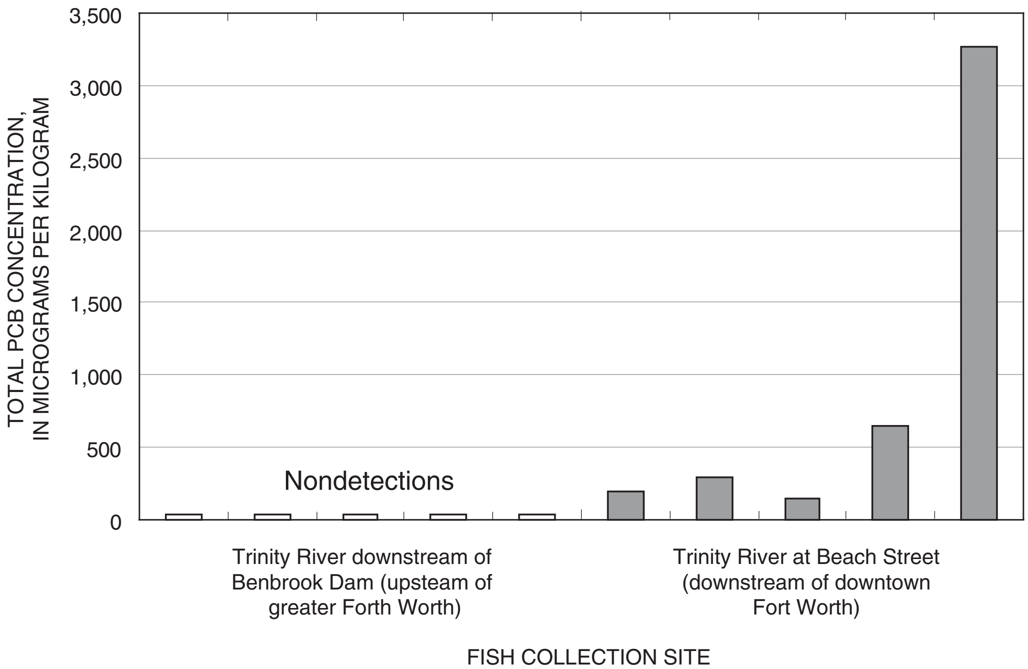

Figure 25. Concentrations of total PCBs in fish tissues collected from two sites in the Trinity River near and in Fort Worth, Texas.

Fort Worth) at a laboratory reporting level of 40 µg/kg, although those collected 16 days earlier at Beach Street (downstream of downtown Fort Worth) had concentrations ranging from 150 to 3,270 µg/kg (appendix 3). The large CEF for PCBs in sediment (table 11) appears to translate into enrichment in fish as well.

Rates of decrease of some legacy pollutants computed from cores collected during this study and another (Van Metre and others, 1998) suggest 10- to 19-year half-lives for these contaminants in new sediment delivered to streams and lakes. However, the continued occurrence of legacy pollutants in suspended and recent reservoir sediments and the rate models discussed previously do not necessarily tell us that it will be another 1 to 2 decades before levels of legacy pollutants in fish decrease by one-half from current levels. Too many uncertainties are in these data and models, and too many unknowns are in the relations between sediments and fish to make that prediction. They do indicate, though, that 13 to 30 years after they were banned, legacy pollutants still occur in the urban environment at environmentally significant levels and will likely continue to occur and at only slowly decreasing levels for many years to come. The primary source of these contaminants is most likely erosion of historically contaminated soils. However, lack of decreasing trends in chlordane at two of three lakes and the occurrence of all of the legacy pollutants in suspended sediments, frequently at high levels, suggest that continued use or releases also could be occurring.

SUMMARY AND CONCLUSIONS

Several lakes and stream segments in Fort Worth, Tex., have fish consumption bans because of elevated levels of chlordane, dieldrin, DDE, and PCBs, collectively known as legacy pollutants because their use has been heavily restricted or banned. This study was undertaken to evaluate the occurrence, trends, and sources in these long-banned contaminants. Sampling included suspended sediments at 11 sites in streams and bottom-sediment cores in Lake Como, Echo Lake, and Fosdic Lake. Suspended-sediment monitoring sites were the inflows to the three lakes, five relatively small streams or culverts flowing into Clear Fork Trinity River, and three larger streams flowing into West Fork Trinity River. The three lake inflows and the two largest streams, Sycamore Creek and Big Fossil Creek, were sampled using automated samplers that allowed for collection of storm-event-composite samples and computation of contaminant loads. Six streams and culverts were sampled using passive samplers that collect a point sample during the initial rise in stream stage after rainfall. Sediment samples were analyzed for chlorinated hydrocarbons including the legacy pollutants, major and trace elements, and PAHs. The sediment cores were age dated to evaluate trends and used in combination with sediment surveys to estimate long-term-average loads and yields of contaminants to the lakes. Suspended-sediment samples were used at five sites in combination with streamflow data to estimate loads and at all sites to evaluate relations between sediment chemistry and watershed land use.

All four legacy pollutants responsible for fish consumption bans frequently were detected. Concentrations of chlordane, lead, and PAHs most frequently exceeded sediment-quality guidelines. Concentrations of chlordane exceeded the higher-level consensus-based sediment-quality guideline or PEC (as opposed to the lower-level guideline, the TEC) by more than an order of magnitude in more than 20 percent of samples. One suspended-sediment sample at Fosdic Lake inflow had a (parent) DDT concentration of 13,000 µg/kg and a toxaphene concentration of 12,000 µg/kg, suggesting a possible spill or unregulated disposal. Concentrations of some metals, in particular cadmium in Echo Lake, are very high, reaching a peak in about 1970 of 186 µg/g.

Trends in DDE and PCBs since the 1960s generally are decreasing, and trends in chlordane are mixed with a decreasing trend in Lake Como, no trend in Echo Lake, and an increasing trend in Fosdic Lake. The decreases in legacy pollutants, where they are occurring, were modeled as a first-order decay process. The models indicate that decreasing trends are progressing with a half-life of 10 to 19 years. Significant trends in trace elements are all decreasing, and significant trends in PAHs are mostly increasing. The increasing trends in PAHs probably result from urban growth and increasing vehicle traffic.

Percent urban land use correlates strongly with the contaminants tested for the 11 suspended-sediment sites and for those sites plus reservoir-sediment samples deposited since 1990. More specific source areas are suggested for organochlorine pesticides by significant correlations to residential land use, whereas PCBs, cadmium, lead, zinc, and PAHs more often correlate significantly with commercial and industrial land uses. The amount of enrichment in these contaminants associated with a change from 30- to 100-percent urban land use was estimated using regression equations and is large, ranging from increases in concentrations of 3.6 to 6.9 for PCBs and heavy metals to about 15 for chlordane, total DDT, and PAHs.

Sedimentation surveys were conducted on each of the three lakes and used in combination with sediment core data to compute contaminant mass balances on the lakes. These were used to estimate long-term-average loads and yields of sediment and recent loads and yields of selected contaminants. The comparison of these average annual yield estimates with yield estimates from suspended-sediment and streamflow data at the inflow sites indicates that relatively little of the annual contaminant transport was captured by the storms sampled. A review of precipitation data supports this conclusion indicating that only 2.7 to 7.5 percent of annual rainfall occurred during the four storms sampled.

Concentrations in suspended sediments were similar to those at the tops of cores for most trace elements but were two to three times larger for many hydrophobic organic contaminants. As a result, for these fluvial systems, sediment cores probably provide a historical record of trace element contamination but could underestimate historical concentrations of organic contaminants. However, down-core profiles suggest that relative concentration histories are preserved in these sediment cores for many organic contaminants (such as chlordane and total DDT) but not all (dieldrin). Desorption, degradation of organic matter, and degradation of the contaminants all could be contributing to the loss of organic contaminants on soils washed into streams and lakes.

The data presented here indicate that urbanization is having a substantial negative effect on sediment and water quality and that legacy pollutants are being actively transported to streams and lakes 13 to 30 years after their use was restricted or banned. The data further suggest that fish in the lakes and Trinity River segments will continue to be exposed to legacy pollutants in sediment for many years to come.

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APPENDIX 1—
Chemical Data

Appendix 1.1. Cesium-137 concentrations in bottom sediments

[cm, centimeters; pCi/g, picocuries per gram]

Core ID	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Cs-137 (pCi/g)	Uncertainity estimate[1] (pCi/g)	Deposition date
			Como Lake			
Upper Lake Site:						
CMO.5	0	10	5.0	0.131	0.049	2000.0
CMO.5	30	40	35.0	.209	.060	1990.0
CMO.5	40	50	45.0	.092	.034	1965.0
Middle Lake Site:						
CMO.3	0	10	5.0	.152	.061	1999.0
CMO.3	40	50	45.0	.686	.140	1970.0
CMO.3	90	100	95.0	.031	.036	1950.0
Primary (Lower) Lake Site:						
CMO.1	0	5	2.5	.199	.100	2000.8
CMO.1	10	15	12.5	.300	.088	1998.7
CMO.1	20	25	22.5	.345	.089	1995.3
CMO.1	30	35	32.5	.500	.094	1990.6
CMO.1	40	45	42.5	.435	.099	1985.3
CMO.1	50	55	52.5	.258	.073	1979.6
CMO.1	60	65	62.5	.350	.098	1974.1
CMO.1 dup	60	65	62.5	.408	.097	1974.1
CMO.1	70	75	72.5	.791	.130	1969.1
CMO.1	80	85	82.5	2.06	.270	1964.0
CMO.1	90	95	92.5	1.71	.240	1958.6
			Echo Lake			
Upper Lake Site:						
ECO.3	0	5	2.5	.105	.085	1999
ECO.3	25	30	27.5	.155	.077	1988
ECO.3	50	55	52.5	.597	.111	1972
Middle Lake Site:						
ECO.4	0	8	4.0	.130	.055	1999
ECO.4	40	48	44.0	.698	.120	1972
ECO.4	72	80	76.0	.029	.060	1952
Primary (Lower) Lake Site:						
ECO.1	0	5	2.5	.157	.094	1999.7
ECO.1	10	15	12.5	.171	.095	1996.4

Footnote at end of table.

Appendix 1.1. Cesium-137 concentrations in bottom sediments—Continued

Core ID	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Cs-137 (pCi/g)	Uncertainity estimate[1] (pCi/g)	Deposition date
Echo Lake—Continued						
Primary (Lower) Lake Site—Continued						
ECO.1	10	15	12.5	0.129	0.068	1996.4
ECO.1	20	25	22.5	.657	.138	1991.7
ECO.1	30	35	32.5	.432	.114	1985.9
ECO.1	40	45	42.5	.574	.102	1980.6
ECO.1	50	55	52.5	.932	.156	1975.3
ECO.1	60	65	62.5	1.27	.188	1969.7
ECO.1	70	75	72.5	3.24	.411	1964.0
ECO.1	80	85	82.5	1.08	.163	1958.1
ECO.1	90	97	93.5	.368	.103	1951.4
Fosdic Lake						
Upper Lake Site:						
FOS.5	0	10	5.0	.301	.078	2000
FOS.5	50	60	55.0	1.74	.264	1965
FOS.5	80	90	85.0	.007	.042	1920
Primary (Mid) Lake Site:						
FOS.4	5	10	7.5	.397	.152	1998.4
FOS.4	20	25	22.5	.336	.126	1991.0
FOS.4	30	35	32.5	.644	.141	1983.3
FOS.4	40	45	42.5	.968	.161	1973.6
FOS.4	50	55	52.5	2.65	.343	1964.0
FOS.4	60	65	62.5	1.46	.203	1955.2
FOS.4	70	75	72.5	.269	.069	1944.6
FOS.4	80	85	82.5	.007	.038	1933.6
FOS.4	90	95	92.5	-.030	.053	1923.1
FOS.4	100	105	102.5	-.034	.041	1912.6
Lower Lake Site:						
FOS.2	0	10	5.0	.219	.132	2000
FOS.2 dup	0	10	5.0	.428	.14	2000
FOS.2	50	60	55.0	2.64	.353	1965
FOS.2	110	110	110.0	.024	.048	1920

[1] All known uncertainties asociated with the preparation and analysis of the sample are propagated to give a measure of the uncertainity associated with the result. The uncertainity is absolute and in the same units as the result. Uncertainity was estimated by Severn Trent Laboratories, Inc., Richland, Wash., following the approach described in Taylor and Kuyatt (1994).

Appendix 1.2. Grain-size distribution in selected sediment core samples

[cm, centimeters; mm, millimeters]

Sample name	Mid depth (cm)	Percent sand	Percent silt and clay (<0.063 mm)	Percent clay (<0.004 mm)
Lake Como				
Upper Lake Site:				
CMO.5 0–10	5.0	26.9	73.1	26.5
CMO.5 20–30	25.0	48.4	51.6	19.4
CMO.5 40–50	45.0	87.4	12.6	5.9
Mid Lake Site:				
CMO.3 0–10	5.0	9.3	90.7	51.9
CMO.3 40–50	45.0	4.7	95.3	57.0
CMO.3 90–100	95.0	.1	99.9	85.9
Primary (Lower Lake) Site:				
CMO.1 0–5	2.5	.3	99.7	68.4
CMO.1 20–25	22.5	.5	99.5	66.9
CMO.1 45–50	47.5	5.8	94.2	43.5
CMO.1 45–50 dup	47.5	5.8	94.2	42.9
CMO.1 70–75	72.5	.6	99.4	73.5
CMO.1 90–95	92.5	.1	99.9	80.6
Echo Lake				
Upper Lake Site:				
ECO.3 0–5	2.5	11.7	88.3	39.6
ECO.3 25–30	27.5	13.2	86.8	41.1
ECO.3 50–55	52.5	14.1	85.9	32.9
Mid Lake Site:				
ECO.4 0–8	4.0	1.1	98.9	62.3
ECO.4 40–48	44.0	.8	99.2	58.7
ECO.4 72–80	76.0	.9	99.1	66.8
Primary (Lower) Lake Site:				
ECO.1 5–10	7.5	.3	99.7	69.2
ECO.1 45–50	47.5	.2	99.8	76.8
ECO.1 85–90	87.5	.3	99.7	77.0
Fosdic Lake				
Upper Lake Site:				
FOS.5 0–10	5.0	21.8	78.2	39.2
FOS.5 50–60	55.0	7.2	92.8	46.6
FOS.5 80–90	85.0	2.8	97.2	63.0
Primary (Mid) Lake Site:				
FOS.4 0–5	2.5	7.0	93.0	59.7
FOS.4 25–30	27.5	15.9	84.1	54.5
FOS.4 45–50	47.5	3.0	97.0	64.3
FOS.4 65–70	67.5	.7	99.3	71.4
FOS.4 95–100	97.5	1.2	98.8	52.6
Lower Lake Site:				
FOS.2 0–10	5.0	3.2	96.8	68.0
FOS.2 50–60	55.0	.5	99.5	75.1
FOS.2 100–110	105.0	.2	99.8	75.1

Appendix 1.3. Suspended-sediment concentrations and selected grain-size distributions in suspended sediment

[For passive sites, multiple samples during one storm were collected during sample processing. For automated sites, multiple samples with the same time were before and after sample processing for a given discrete or composite sample. Average concentration is the mean of multiple samples from a given discrete or composite sample; mg/L, milligrams per liter]

Site	Date	Time	Concentration (mg/L)	Average concentration (mg/L)	Percent sand	Percent silt and clay
Automated Sampler Sites						
Lake Como Inflow	08/30/01	0810	58	55	15.4	84.6
Lake Como Inflow	08/30/01	0810	52		12.4	87.6
Lake Como Inflow	09/20/01	1240	90	92	5.0	95.0
Lake Como Inflow	09/20/01	1240	93		5.4	94.6
Lake Como Inflow	11/09/01	0917	126	133	6.9	93.1
Lake Como Inflow	11/09/01	0917	140		7.7	92.3
Lake Como Inflow	01/23/02	1750	203	212	4.0	96.0
Lake Como Inflow	01/23/02	1750	221		3.5	96.5
Echo Lake Inflow	05/28/01	0200	2,080	2,200	27.2	72.8
Echo Lake Inflow	05/28/01	0200	2,320		37.5	62.5
Echo Lake Inflow	08/17/01	0745	274	389	4.6	95.4
Echo Lake Inflow	08/17/01	0745	503		21.6	78.4
Echo Lake Inflow	09/20/01	1335	197	200	10.1	89.9
Echo Lake Inflow	09/20/01	1335	203		10.8	89.2
Echo Lake Inflow	10/11/01	0450	465	501	25.2	74.8
Echo Lake Inflow	10/11/01	0450	536		27.3	72.7
Fosdic Lake Inflow	08/11/01	1710	188	188	.6	99.4
Fosdic Lake Inflow	08/11/01	1710	188		1.7	98.3
Fosdic Lake Inflow	09/18/01	1855	816	844	27.2	72.8
Fosdic Lake Inflow	09/18/01	1855	871		35.7	64.3
Fosdic Lake Inflow	10/11/01	2000	327	323	4.6	95.4
Fosdic Lake Inflow	10/11/01	2000	319		4.5	95.5
Fosdic Lake Inflow	12/06/01	0108	124	125	2.3	97.7
Fosdic Lake Inflow	12/06/01	0108	126		3.3	96.7
Big Fossil Creek	05/04/01	0000	445	445	.3	99.7
Big Fossil Creek	08/11/01	1550	351	308	3.4	96.6
Big Fossil Creek	08/11/01	1550	264		.5	99.5

Appendix 1.3. Suspended-sediment concentrations and selected grain-size distributions in suspended sediment—Continued

Site	Date	Time	Concentration (mg/L)	Average concentration (mg/L)	Percent sand	Percent silt and clay
			Automated Sampler Sites—Continued			
Big Fossil Creek	09/18/01	1855	577	561	0	100
Big Fossil Creek	09/18/01	1855	544		0	100
Big Fossil Creek	10/11/01	0055	375	380	1.3	98.7
Big Fossil Creek	10/11/01	0055	384		1.9	98.1
Sycamore Creek #1	05/04/01	2104	40		0	100
Sycamore Creek #2	05/04/01	2204	1,130		7.4	92.6
Sycamore Creek #3	05/04/01	2304	381		2.3	97.7
Sycamore Creek #4&5	05/05/01	0034	463		.8	99.2
Sycamore Creek #6&7	05/05/01	0234	95		0	100
Sycamore Creek #1	08/16/01	0002	47	48	0	100
Sycamore Creek #1	08/16/01	0002	49		0	100
Sycamore Creek #2	08/16/01	0032	39	38	2.1	97.9
Sycamore Creek #2	08/16/01	0032	36		0	100
Sycamore Creek #3	08/16/01	0102	120	112	0	100
Sycamore Creek #3	08/16/01	0102	104		0	100
Sycamore Creek #4	08/16/01	0728	102	98	0	100
Sycamore Creek #4	08/16/01	0728	95		0	100
Sycamore Creek #1	08/30/01	0829	393	410	3.8	96.2
Sycamore Creek #1	08/30/01	0829	426		5.2	94.8
Sycamore Creek #2	08/30/01	1029	829	846	5.7	94.3
Sycamore Creek #2	08/30/01	1029	862		5.8	94.2
Sycamore Creek #3	08/30/01	1329	914	911	12.8	87.2
Sycamore Creek #3	08/30/01	1329	908		10.4	89.6
Sycamore Creek #4	08/30/01	1645	120	123	0	100
Sycamore Creek #4	08/30/01	1645	126		0	100
Sycamore Creek #5	08/30/01	1855	41	41	0	100
Sycamore Creek #5	08/30/01	1855	41		0	100
			Passive Sampler Sites			
Site 1, Benbrook	10/15/00	2300	1,760	1,760	14.6	85.4
Site 1, Benbrook	10/15/00	2300	1,760		10.7	89.3
Site 1, Benbrook	03/08/01	1300	2,140	2,030	13.5	86.5
Site 1, Benbrook	03/08/01	1300	1,920		13.6	86.4
Site 1, Benbrook	08/17/01	1250	2,260	2,330	.8	99.2
Site 1, Benbrook	08/17/01	1250	2,400		.4	99.6
Site 2, Levee	10/15/00	2300	625	616	15.3	84.7

Appendix 1.3. Suspended-sediment concentrations and selected grain-size distributions in suspended sediment—Continued

Site	Date	Time	Concentration (mg/L)	Average concentration (mg/L)	Percent sand	Percent silt and clay
			Passive Sampler Sites—Continued			
Site 2, Levee	10/15/00	2300	607		17.4	82.6
Site 2, Levee	03/08/01	1300	41	44	3.7	96.3
Site 2, Levee	03/08/01	1300	47		3.2	96.8
Site 2, Levee	05/28/01	0200	281	280	12.5	87.5
Site 2, Levee	05/28/01	0200	279		12.0	88.0
Site 3, Como Outfall	10/15/00	2300	1,530	1,470	16.3	83.7
Site 3, Como Outfall	10/15/00	2300	1,410		13.8	86.2
Site 3, Como Outfall	05/28/01	0200	507	517	15.2	84.8
Site 3, Como Outfall	05/28/01	0200	526		15.6	84.4
Site 4, Zoo	10/15/00	2300	4,460	4,390	7.0	93.0
Site 4, Zoo	10/15/00	2300	4,320		4.3	95.7
Site 4, Zoo	03/09/01	1515	876	912	3.8	96.2
Site 4, Zoo	03/09/01	1515	905		4.6	95.4
Site 4, Zoo	03/09/01	1515	917		4.1	95.9
Site 4, Zoo	03/09/01	1515	950		6.1	93.9
Site 4, Zoo	05/28/01	0200	884	902	15.0	85.0
Site 4, Zoo	05/28/01	0200	920		18.3	81.7
Site 5 Downtown	10/15/00	2300	776	656	12.9	87.1
Site 5 Downtown	10/15/00	2300	535		13.6	86.4
Site 5 Downtown	05/04/01	2100	287	287	16.6	83.4
Site 5 Downtown	08/16/01	0846	419	422	2.8	97.2
Site 5 Downtown	08/16/01	0846	425		4.0	96.0
Site 5 Downtown dup.	08/16/01	0847	633	645	15.7	84.3
Site 5 Downtown dup.	08/16/01	0847	656		17.3	82.7
Site 6, Little Fossil	10/15/00	2300	453	512	.2	99.8
Site 6, Little Fossil	10/15/00	2300	571		2.4	97.6
Site 6, Little Fossil	03/08/01	1300	245	248	2.8	97.2
Site 6, Little Fossil	03/08/01	1300	251		2.9	97.1
Site 6, Little Fossil	05/28/01	0200	630	618	2.9	97.1
Site 6, Little Fossil	05/28/01	0200	606		4.0	96.0

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments

[Concentrations in micrograms per kilogram. Bold type indicates concentration exceeds probable effect concentration (MacDonald and others, 2000); SS, suspended sediment; cm, centimeters; Remarks: =, detection above laboratory reporting level; E, estimated; <, nondetection at indicated value; nd, not detected; isa, insufficient sediment for analysis]

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Age of interval or sample date	Laboratory set number	Mass of sample	Remark chlordane	Technical chlordane	Remark dieldrin	Dieldrin	Remark DDE	DDE
Lake Como												
Primary (Lower) Lake Core Site:												
CMO.1	0	5	2.5	2000.8	200120409		=	**150**	E	12	=	6.3
CMO.1	5	10	7.5	1999.9	200120409		=	**130**	E	2.7	=	7.3
CMO.1	10	15	12.5	1998.7	200120107		=	**130**	E	1.4	=	8.8
CMO.1	20	25	22.5	1995.3	200120409		=	**160**	E	1.6	=	13
CMO.1	30	35	32.5	1990.6	200120107		=	**330**	<	.8	=	19
CMO.1dup	30	35	32.5	1990.6	200120107		=	**290**	<	.7	=	19
CMO.1	45	50	47.5	1982.5	200128405		=	**185**	=	1.8	E	17
CMO.1dup	45	50	47.5	1982.5	200128405		=	**180**	=	2.2	E	16
CMO.1	60	65	62.5	1974.1	200120409		=	**120**	E	1.4	=	7.6
CMO.1	75	80	77.5	1969.1	200120409		=	**600**	<	.8	=	30
CMO.1	90	95	92.5	1958.6	200120409		=	**150**	<	.6	=	22
Mid Lake Core Site:												
CMO.3	0	10	5	1999	200120409		=	**140**	E	6.2	=	7.3
CMO.3	40	50	45	1970	200120409		=	**250**	<	1.0	=	22
CMO.3	90	100	95	1950	200120409		<	5.0	<	.5	E	.2
Upper Lake Core Site:												
CMO.5	0	10	5	2000	200120409		=	**150**	E	5.7	=	8.0
CMO.5	20	30	25	1990	200120409		=	**140**	<	.5	=	14
CMO.5	40	50	45	1965	200120409		=	**110**	E	1.9	E	21
Como Lake Inflow SS:												
Lake Como Inflow				08/30/01	200207106	0.406	=	**410**	E	58	E	18
Lake Como Inflow				09/20/01	200207106	.295	=	**740**	E	**94**	E	16
Lake Como Inflow				11/09/01	200208407	.186	=	**750**	E	**66**	E	22
Lake Como Inflow				01/23–24/02	200208407	2.287	=	**84**	E	6.3	E	4.3

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Remark DDD	DDD	Remark DDT	DDT	Remark PCB 1242	PCB 1242	Remark PCB 1254	PCB 1254	Remark PCB 1260	PCB 1260	Calculated values				
											Remark total PCB	Total PCB	Remark total DDT	Total DDT	Total DDT (percent)
Lake Como—Continued															
Primary (Lower) Lake Core Site—Continued															
CMO.1	E	2.6	<	1.5	<	15	E	18	E	19	E	37	E	8.9	nd
CMO.1	E	6.0	<	1.5	<	15	E	21	E	20	E	41	E	13.3	nd
CMO.1	E	9.1	<	1.0	E	6.6	=	25	=	27	E	59	E	17.9	nd
CMO.1	E	14	<	.6	E	12	=	46	=	43	E	101	E	27.0	nd
CMO.1	=	**36**	<	.5	=	26	=	77	=	63	=	166	E	55.0	nd
CMO.1dup	=	**37**	<	.6	=	22	=	74	=	58	=	154	E	56.0	nd
CMO.1	<	.5	=	.85	E	33	=	57	=	26	E	116	E	18.4	5
CMO.1dup	<	.5	=	1.5	E	34	=	54	=	23	E	111	E	18.0	8
CMO.1	E	6.0	<	.5	E	5.9	=	26	=	18	E	50	E	13.6	nd
CMO.1	E	**65**	<	1.1	=	57	=	120	=	68	=	245	E	95.0	nd
CMO.1	E	**83**	E	1.2	=	45	=	110	=	300	=	455	E	106.2	1
Mid Lake Core Site:															
CMO.3	E	5.0	<	1.3	<	10	E	23	E	23	E	46	E	12.3	nd
CMO.3	E	14	<	.9	=	18	=	78	=	64	=	160	E	36.0	nd
CMO.3	E	.4	<	.5	<	5.0	<	5.0	<	5.0	<	0	E	.6	nd
Upper Lake Core Site:															
CMO.5	E	4.6	E	2.7	E	7.7	=	25	=	27	E	60	E	15.3	18
CMO.5	E	24	<	.7	E	9.4	=	26	=	27	E	62	E	38.0	nd
CMO.5	E	**74**	E	.9	<	5.0	E	530	E	250	E	**785**	E	95.9	1
Como Lake Inflow SS:															
Lake Como Inflow	<	30	<	30	E	85	E	75	E	70	E	230	E	18	nd
Lake Como Inflow	<	42	<	42	E	140	E	79	E	73	E	292	E	16	nd
Lake Como Inflow	<	67	<	67	<	670	<	670	<	670	<	0	E	22	nd
Lake Como Inflow	<	5.0	<	5.0	E	19	E	15	E	16	E	50	E	4.3	nd

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Age of interval or sample date	Laboratory set number	Mass of sample	Remark chlordane	Technical chlordane	Remark dieldrin	Diel-drin	Remark DDE	DDE
Echo Lake												
Upper Lake Core Site:												
ECO.3	0	5	2.5	1999	2.1141		=	**130**	=	5.1	=	24
ECO.3	25	30	27.5	1988	2.1141		=	**410**	<	.5	=	**39**
ECO.3	50	55	52.5	1972	1.1142		=	**220**	<	.5	=	**68**
Middle Lake Core Site:												
ECO.4	0	8	4	1999	1.1142		=	**99**	E	1.7	=	20
ECO.4	40	48	44	1972	2.1141		=	**120**	<	.5	=	**77**
ECO.4	72	80	76	1952	2.1141		<	5.0	<	.5	=	4.1
Primary (Lower) Lake Core Site:												
ECO.1	0	5	2.5	1999.7	2.1141		=	**130**	=	3.3	=	20
ECO.1	5	10	7.5	1998.3	1.1142		=	**85**	E	.7	=	16
ECO.1	10	15	12.5	1996.4	1.1142		=	**85**	E	.6	=	25
ECO.1	20	25	22.5	1991.7	1.1142		=	**66**	<	.5	=	23
ECO.1	30	35	32.5	1985.9	2.1141		=	**100**	<	.5	=	33
ECO.1	40	45	42.5	1980.6	2.1141		=	**230**	<	.5	=	**40**
ECO.1	55	60	57.5	1972.5	2.1141		=	**33**	<	.5	=	**85**
ECO.1	65	70	67.5	1966.8	1.1142		<	9.3	<	.5	=	22
ECO.1	75	80	77.5	1961.1	1.1142		<	5.0	<	.5	=	25
ECO.1	90	97	93.5	1951.4	1.1142		<	5.0	<	.5	=	6.0
Echo Lake Inflow SS:												
Echo Lake Inflow				05/28/01	200121505	5.96	=	**79**	E	6.1	=	6.8
Echo Lake Inflow				08/17/01	200205006	2.558	=	**220**	=	10	=	33
Echo Lake Inflow				09/20/01	200207106	1.141	E	**260**	E	28	=	19
Echo Lake Inflow				10/11/01	200207106	3.943	E	**220**	E	23	=	30

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Remark DDD	DDD	Remark DDT	DDT	Remark PCB 1242	PCB 1242	Remark PCB 1254	PCB 1254	Remark PCB 1260	PCB 1260	Calculated values: Remark total PCB	Calculated values: Total PCB	Calculated values: Remark total DDT	Calculated values: Total DDT	Calculated values: Total DDT (percent)
Echo Lake—Continued															
Upper Lake Core Site—Continued															
ECO.3	E	9.8	E	12	<	10	=	71	=	43	E	114	E	46	26
ECO.3	E	12	E	3.4	=	24	=	60	=	62	=	146	E	54	6
ECO.3	E	25	E	1.4	=	110	E	290	E	300	E	**700**	E	94	1
Middle Lake Core Site:															
ECO.4	E	5.4	E	2.3	<	5.0	=	92	=	44	E	136	E	28	8
ECO.4	E	18	E	2.3	=	64	=	170	=	130	=	364	E	97	2
ECO.4	E	13	E	.6	<	5.0	E	15	E	8.0	E	23	E	18	3
Primary (Lower) Lake Core Site:															
ECO.1	E	6.3	E	3.2	<	15	=	110	=	46	E	156	E	30	11
ECO.1	E	4.7	E	1.4	<	10	=	150	=	49	E	199	E	22	6
ECO.1	E	6.1	E	1.2	E	11	E	470	=	88	E	569	E	32	4
ECO.1	E	7.8	E	1.5	E	11	=	33	=	35	E	79	E	32	5
ECO.1	E	7.9	E	1.0	=	40	=	58	=	45	=	143	E	42	2
ECO.1	E	20	<	.5	=	29	=	75	=	65	=	169	E	60	1
ECO.1	=	**130**	E	2.9	=	110	=	210	=	170	=	490	E	218	1
ECO.1	=	**30**	E	.9	=	48	=	91	=	102	=	241	E	53	2
ECO.1	=	**80**	E	1.2	=	22	=	110	=	170	=	302	E	106	1
ECO.1	=	8.4	E	.6	<	5.0	E	14	=	24	E	38	E	15	4
Echo Lake Inflow SS:															
Echo Lake Inflow	<	2.0	E	10	E	15	E	25	E	20	E	60	E	17	60
Echo Lake Inflow	E	5.2	=	**130**	E	30	=	110	E	59	E	199	E	168	77
Echo Lake Inflow	<	16	E	42	<	100	E	54	E	60	E	114	E	61	69
Echo Lake Inflow	<	18	E	78	E	19	=	66	=	57	E	142	E	108	72

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Age of interval or sample date	Laboratory set number	Mass of sample	Remark chlordane	Technical chlordane	Remark dieldrin	Dieldrin	Remark DDE	DDE
Fosdic Lake												
Upper Lake Core Site:												
FOS.5	0	10	5	2000	5.1137		=	**140**	=	5.1	=	19
FOS.5	40	50	45	1970	5.1137		=	**120**	=	1.9	=	55
Primary (Mid) Lake Core Site:												
FOS.4	0	5	2.5	2000.4	5.1137		=	**140**	=	9.0	=	19
FOS.4	5	10	7.5	1998.4	5.1137		=	**150**	=	4.7	=	25
FOS.4	10	15	12.5	1996.2	5.1137		=	**120**	=	3.3	=	24
FOS.4	20	25	22.5	1991.0	1.1136		=	**98**	=	1.7	=	21
FOS.4	30	35	32.5	1983.3	5.1137		=	**68**	=	1.8	=	**38**
FOS.4	45	50	47.5	1968.9	1.1136		=	**47**	=	1.6	=	**67**
FOS.4	55	60	57.5	1959.8	5.1137		=	**19**	=	.5	=	**48**
FOS.4	70	75	72.5	1944.6	1.1136		<	5.0	<	.5	=	13
FOS.4	85	90	87.5	1928.3	5.1137		<	5.0	<	.5	E	4
FOS.4	100	105	102.5	1912.6	5.1137		<	5.0	<	.5	<	5
Lower Lake Core Site:												
FOS.2	0	10	5	2000	5.1137		=	**170**	=	6.5	=	21
FOS.2	50	60	55	1965	5.1137		=	**31**	=	1.0	=	**56**
FOS.2	100	110	105	1920	5.1137		<	5.0	<	.5	<	5
Fosdic Lake Inflow SS:												
Fosdic Lake Inflow				08/11/01	200208407	0.107	<	1,100	<	110	<	110
Fosdic Lake Inflow				09/18/01	200207106	2.036	=	**380**	E	34	=	12
Fosdic Lake Inflow				10/10/01	200207106	.996	E	**450**	<	12	=	**620**
Fosdic Lake Inflow				12/06/01	200207706	.189	E	**300**	E	23	E	20

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Remark DDD	DDD	Remark DDT	DDT	Remark PCB 1242	PCB 1242	Remark PCB 1254	PCB 1254	Remark PCB 1260	PCB 1260	Calculated values: Remark total PCB	Total PCB	Remark total DDT	Total DDT	Total DDT (percent)
Fosdic Lake—Continued															
Upper Lake Core Site—Continued															
FOS.5	<	6.1	E	3.0	<	10	=	37	=	52	=	89	E	22.0	14
FOS.5	<	15	E	1.3	<	12	=	130	=	120	=	250	E	56.3	2
Primary (Mid) Lake Core Site:															
FOS.4	<	8.3	=	3.0	<	15	=	40	=	59	=	99	=	22.0	14
FOS.4	<	6.1	=	3.4	<	15	=	51	=	70	=	121	=	28.4	12
FOS.4	<	7.4	<	1.5	<	10	=	48	=	72	=	120	=	24	nd
FOS.4	<	3.3	<	1.0	<	15	=	38	=	54	=	92	=	21.0	nd
FOS.4	<	7.6	=	1.5	<	10	=	100	=	110	=	210	=	40	4
FOS.4	E	8.8	=	1.4	<	30	=	170	=	160	=	330	E	77.2	2
FOS.4	E	23	=	.6	<	14	=	56	=	87	=	143	=	71.6	1
FOS.4	=	17	<	.5	<	9.3	E	13.4	=	17	E	30	=	30	nd
FOS.4	=	.5	<	.5	<	5.0	<	5.0	<	5.0	<	15	E	.9	nd
FOS.4	<	.5	<	.5	<	5.0	<	5.0	<	5.0	<	15	<	0	nd
Lower Lake Core Site:															
FOS.2	<	6.1	<	.5	<	15	=	48	=	66	=	114	=	21	nd
FOS.2	E	**33**	=	1.7	<	21	=	92	=	94	=	186	E	90.7	2
FOS.2	<	.5	<	.5	<	5.0	<	5.0	<	5.0	<	15	<	0	nd
Fosdic Lake Inflow SS:															
Fosdic Lake Inflow	<	110	<	110	<	1,100	<	1,100	<	1,100	<	3,300	<	330	nd
Fosdic Lake Inflow	<	6.0	E	18	<	60	<	60	<	60	<	180	E	30	60
Fosdic Lake Inflow	E	**460**	=	**13,000**	<	120	<	120	<	120	<	360	E	**14,080**	92
Fosdic Lake Inflow	<	66	<	150	<	660	<	660	<	660	<	2,000	E	20	nd

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Age of interval or sample date	Laboratory set number	Mass of sample	Remark chlordane	Technical chlordane	Remark dieldrin	Dieldrin	Remark DDE	DDE
Passive SS Sampling Sites												
Site 1, Benbrook				10/15/00	7.1120	3.633	<	30	<	3.0	E	0.9
Site 1, Benbrook				03/08/01	7.1120	4.419	<	25	<	2.5	E	.8
Site 1, Benbrook				08/17/01	200205006	7.796	<	15	<	1.5	<	1.5
Site 2, Levee				10/15/00	7.1120	.263	<	480	<	48	E	9.5
Site 2, Levee				03/08/01	1.1136	.551	=	**220**	=	25	E	8.4
Site 2, Levee				05/28/01	200121505	.944	E	**130**	E	9.9	E	6.9
Site 3, Como Outfall				10/15/00	7.1120	1.176	E	**29**	E	4.2	E	5.2
Site 3, Como Outfall				05/28/01	200121505	1.88	E	**45**	E	4.1	E	3.8
Site 4, Zoo				10/15/00	7.1120	6.113	E	**28**	=	2.8	=	4.6
Site 4, Zoo				03/09/01	1.1136	3.342	=	**150**	=	14	=	17
Site 4, Zoo				05/28/01	200121505	2.21	E	**90**	E	6.4	=	7.2
Site 5, Downtown				10/15/00	7.1120	1.176	E	**52**	E	3.9	E	3.2
Site 5, Downtown				05/04/01	200121505	.644	E	**120**	E	4.4	E	6.4
Site 5, Downtown dup.				05/04/01	200121505	.702	E	**190**	E	10	E	9.4
Site 5, Downtown				08/16/01	200205006	1.204	=	**150**	E	2.0	E	11
Site 5, Downtown dup.				08/16/01	200205006	3.110	=	**160**	=	5.8	E	9.4
Site 6, Little Fossil				10/15/00	7.1120	1.262	E	**54**	=	38	E	4.6
Site 6, Little Fossil				03/08/01	1.1136	1.323	=	**180**	<	9.0	=	6.9
Site 6, Little Fossil				05/28/01	200121505	2.62	E	**49**	E	3.1	E	2.0

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments—Continued

											Calculated values				
Core ID or SS site	Remark DDD	DDD	Remark DDT	DDT	Remark PCB 1242	PCB 1242	Remark PCB 1254	PCB 1254	Remark PCB 1260	PCB 1260	Remark total PCB	Total PCB	Remark total DDT	Total DDT	Total DDT (percent)
Passive SS Sampling Sites—Continued															
Site 1, Benbrook	<	3.0	<	3.0	<	30	<	30	<	30	<	90	E	0.9	nd
Site 1, Benbrook	<	2.5	<	2.5	<	25	<	25	<	25	<	75	E	.8	nd
Site 1, Benbrook	<	1.5	<	1.5	<	15	<	15	<	15	<	45	<	4.5	nd
Site 2, Levee	<	48	<	48	<	480	=	950	E	270	E	**1,220**	E	9.5	nd
Site 2, Levee	<	22	<	22	<	220	<	220	<	220	<	660	E	8.4	nd
Site 2, Levee	<	13	<	13	<	130	E	42	E	24	E	66	E	6.9	nd
Site 3, Como Outfall	<	10	<	10	<	100	<	100	<	100	<	300	E	5.2	nd
Site 3, Como Outfall	<	6.5	<	6.5	<	65	<	65	<	65	<	195	E	3.8	nd
Site 4, Zoo	=	2.2	E	1.4	E	4.6	E	10	E	10	E	25	E	8.2	17
Site 4, Zoo	E	11	=	41	<	35	E	25	E	34	E	59	E	69	59
Site 4, Zoo	<	5.5	<	5.5	<	55	E	23	E	29	E	52	E	7.2	nd
Site 5, Downtown	<	9.5	<	9.5	<	95	E	72	E	48	E	120	E	3.2	nd
Site 5, Downtown	<	19	<	19	<	190	E	72	E	70	E	142	E	6.4	nd
Site 5, Downtown dup.	<	18	<	18	<	180	E	86	E	82	E	168	E	9.4	nd
Site 5, Downtown	<	10	E	9.3	E	82	=	310	=	350	E	**742**	E	20.3	46
Site 5, Downtown dup.	<	4.0	=	13	=	64	=	470	=	230	=	**764**	E	22.4	58
Site 6, Little Fossil	<	9.5	<	9.5	<	95	E	29	E	19	E	48	E	4.6	nd
Site 6, Little Fossil	<	9.0	<	9.0	<	90	E	18	E	20	E	38	E	6.9	nd
Site 6, Little Fossil	<	4.5	<	4.5	<	45	E	69	E	22	E	91	E	2.0	nd

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Age of interval or sample date	Labor-atory set number	Mass of sample	Remark chlor-dane	Tech-nical chlor-dane	Remark dieldrin	Diel-drin	Remark DDE	DDE	Remark DDD	DDD
Automated SS Sampling Sites														
Big Fossil				05/04/01	1.1136	3.809	<	30	<	3.0	E	1.2	<	3.4
Big Fossil				08/11/01	200128405	1.910	E	**54**	<	6.5	E	4.3	<	6.5
Big Fossil				09/18-09/19/01	200207106	3.269	E	11	<	3.5	E	.6	<	3.5
Big Fossil				10/11/01	200207106	2.401	E	**51**	<	5.0	E	1.7	<	5.0
Sycamore discrete #1				05/04/01		isa								
Sycamore discrete #2				05/04/01	200121505	2.08	=	**140**	E	7.8	=	18.0	<	6.1
Sycamore discrete #3				05/04/01	200121505	.301	E	**170**	E	20	E	25	<	41
Sycamore discrete #4&5				05/05/01	200121505	1.27	=	**170**	E	5.8	E	11	<	9.5
Sycamore discrete #6&7				05/05/01	200122506	.210	<	590	<	59.0	E	8.7	<	59
Sycamore discrete #1				08/16/01		isa								
Sycamore discrete #2				08/16/01	200205006	.058	<	2,000	<	200	<	200	<	200
Sycamore discrete #3				08/16/01	200205006	.267	<	460	<	46	E	16	<	46
Sycamore discrete #4				08/16/01	200205006	.188	<	330	<	33	<	33	<	33
Sycamore discrete #1				08/30/01	200207106	3.961	=	**91**	E	6.3	=	15	<	6.0
Sycamore discrete #2				08/30/01	200207106	3.533	=	**72**	E	4.3	=	12	<	6.8
Sycamore discrete #3				08/30/01	200207106	2.199	=	**78**	E	5.4	=	13	<	6.8
Sycamore discrete #4				08/30/01	200205006	.860	E	**41**	<	14	E	8.0	<	14
Sycamore discrete #5				08/30/01	200207106	.299	<	410	<	41	E	6.4	<	41
Sediment-Quality Guidelines														
Threshold effect concentration (TEC)								3.24		1.9		3.16		4.88
Probable effect concentration (PEC)								17.6		61.8		31.3		28

Appendix 1.4. Selected chlorinated hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Remark DDT	DDT	Remark PCB 1242	PCB 1242	Remark PCB 1254	PCB 1254	Remark PCB 1260	PCB 1260	Calculated values: Remark total PCB	Total PCB	Remark total DDT	Total DDT	Total DDT (percent)
Automated SS Sampling Sites—Continued													
Big Fossil	<	3.0	<	30	<	30	<	30	<	90	E	1.2	nd
Big Fossil	E	4.0	<	65	E	43	E	57	E	100	E	8.3	48
Big Fossil	<	3.5	<	35	<	35	<	35	<	105	E	.6	nd
Big Fossil	E	6.0	<	50	<	50	<	50	<	150	E	7.7	78
Sycamore discrete #1													
Sycamore discrete #2	E	8.9	E	29	E	32	E	34	E	95	E	27	33
Sycamore discrete #3	<	41	<	410	<	410	<	410	<	1,230	E	25	nd
Sycamore discrete #4&5	<	9.5	<	95	E	23	E	26	E	49	E	11	nd
Sycamore discrete #6&7	<	59	<	590	<	590	E	94	E	94	E	8.7	nd
Sycamore discrete #1													
Sycamore discrete #2	<	200	<	2,000	<	2,000	<	2,000	<	6,000	<	600	nd
Sycamore discrete #3	E	14	<	460	<	460	<	460	<	1,380	E	30	47
Sycamore discrete #4	<	33	<	330	<	330	<	330	<	990	<	99	nd
Sycamore discrete #1	E	18	E	8.6	E	18	E	30	E	57	E	33	55
Sycamore discrete #2	E	12	E	6.8	E	14	E	25	E	46	E	24	50
Sycamore discrete #3	E	15	E	8.9	E	12	E	23	E	44	E	28	54
Sycamore discrete #4	E	9.4	<	140	<	140	E	38	E	38	E	17.4	54
Sycamore discrete #5	E	25	<	410	<	410	<	410	<	1,230	E	31	80
Sediment-Quality Guidelines													
Threshold effect concentration (TEC)		4.16								59.8		5.28	
Probable effect concentration (PEC)		62.9								676		572	

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments

[Concentrations in micrograms per gram. Bold type indicates concentration exceeds probable effect concentration (MacDonald and others, 2000); SS, suspended sediment; cm, centimeters; na, not applicable or not analyzed; isa, insufficient sediment for analysis]

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Deposition date of interval or sample date	Sample time	Laboratory set number	Total carbon (percent)	Carbonate (percent)	Organic carbon (percent)	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium
Lake Como															
Upper Lake Core Site:															
CMO.5	0	10	5	2000		3427	9.82	4.24	5.58	31,700	156,000	19,000	6,750	4,050	1,180
CMO.5	20	30	25	1990		3427	9.31	4.01	5.31	21,700	155,000	14,000	4,960	3,020	960
CMO.5	40	50	45	1965		3427	8.63	7.65	.98	8,470	273,000	11,900	1,900	2,440	823
CMO.5 repl.	40	50	45	1965		3427	na	na	na	8,420	268,000	11,800	1,790	2,390	807
CMO.5 repl.	40	50	45	1965		3427	na	na	na	8,430	263,000	11,500	1,830	2,360	806
Mid Lake Core Site:															
CMO.3	0	10	5	1999		3427	9.16	4.32	4.84	41,700	166,000	24,300	8,150	4,970	1,080
CMO.3	40	50	45	1970		3427	9.45	4.69	4.76	42,600	184,000	25,500	8,120	5,010	1,070
CMO.3	90	100	95	1950		3427	6.59	3.98	2.61	65,500	142,000	42,000	10,600	6,860	801
Primary (Lower Lake) Core Site:															
CMO.1	0	5	2.5	2000.8		3427	10.2	4.51	5.69	49,000	168,000	28,100	8,900	5,630	1,010
CMO.1	5	10	7.5	1999.9		3427	9.92	4.39	5.53	48,300	164,000	28,700	8,740	5,560	939
CMO.1	10	15	12.5	1998.7		3427	10.0	4.59	5.41	47,200	204,000	29,000	8,530	5,580	1,030
CMO.1	20	25	22.5	1995.3		3427	8.42	4.80	3.62	48,800	191,000	27,400	8,920	5,640	913
CMO.1	30	35	32.5	1990.6		3427	8.66	5.24	3.42	39,700	203,000	22,200	7,960	4,710	1,100
CMO.1	45	50	47.5	1982.5		3427	8.77	5.44	3.33	35,100	204,000	20,200	7,290	4,350	1,070
CMO.1	60	65	62.5	1974.1		3427	7.79	5.30	2.50	53,000	205,000	27,800	10,700	5,990	750
CMO.1	75	80	77.5	1969.1		3427	10.1	4.89	5.21	47,500	178,000	29,200	8,320	5,500	796
CMO.1	90	95	92.5	1958.6		3427	7.82	5.03	2.79	55,800	179,000	31,000	9,060	6,170	734
Como Lake Inflow SS:															
Lake Como Inflow				08/30/01	0810	3744	isa	isa	isa	41,800	126,000	25,100	8,400	6,110	1,550
Lake Como Inflow				09/20/01	1240	3744	isa	isa	isa	38,000	147,000	24,200	8,150	5,120	1,590
Lake Como Inflow				11/09/01	0917	3744	isa	isa	isa	40,900	124,000	24,800	8,570	5,430	1,340
Lake Como Inflow				01/23/02	1750	3818				39,800	185,000	24,000	7,660	5,950	1,100
Lake Como Inflow, dup.				01/23/02	1750	3818	na	na	na	39,200	183,000	23,700	7,560	5,890	1,080

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Phos-phorus	Tita-nium	Arse-nic	Bari-um	Beryl-lium	Cad-mium	Co-balt	Chro-mium	Cop-per	Mer-cury	Lith-ium	Manga-nese	Nick-el	Lead	Scan-dium	Stron-tium	Vana-dium	Zinc
Lake Como—Continued																		
Upper Lake Core Site:																		
CMO.5	946	2,030	7.61	253	1.14	.965	6.83	51.4	35.9	0.09	20.6	447	22.5	**131**	5.72	280	55.3	229
CMO.5	815	1,260	7.26	205	.751	1.13	5.91	41.2	31.6	.10	13.4	297	18.3	**144**	3.90	244	38.4	193
CMO.5	436	472	5.80	97.7	.401	.455	3.75	28.7	9.27	.05	5.67	367	18.0	112	2.09	379	28.0	52.4
CMO.5 repl.	437	484	6.61	99.7	.456	.472	3.66	27.0	9.08	na	5.50	362	17.9	108	2.12	386	28.1	53.2
CMO.5 repl.	434	460	6.50	102	.394	.466	3.62	27.8	9.00	na	5.38	354	17.9	111	2.06	379	26.9	51.3
Mid Lake Core Site:																		
CMO.3	1,150	2,210	11.4	297	1.31	1.05	8.34	62.1	38.8	.10	27.1	568	26.2	127	7.36	280	72.8	247
CMO.3	1,370	2,390	12.4	304	1.31	2.02	8.56	96.5	52.0	.22	25.4	587	28.8	**620**	7.50	278	71.1	291
CMO.3	967	2,720	19.9	362	1.97	.625	11.5	70.4	23.1	.09	37.7	1,100	31.4	76.8	11.0	169	112	132
Primary (Lower Lake) Core Site:																		
CMO.1	1,440	2,400	13.6	407	1.52	1.17	8.79	68.0	38.8	.12	32.2	718	29.4	124	8.29	305	83.7	262
CMO.1	1,470	2,570	14.8	386	1.58	1.46	9.39	71.8	45.8	.12	30.3	685	30.6	**156**	8.30	292	84.6	291
CMO.1	2,080	2,460	15.2	396	1.56	1.66	9.25	76.6	54.5	.13	28.7	769	30.3	**186**	8.16	341	79.5	293
CMO.1	1,430	2,240	16.2	318	1.72	1.30	9.33	74.0	34.0	.14	30.7	696	28.8	**195**	8.28	261	83.5	217
CMO.1	1,070	2,240	11.8	272	1.34	1.26	8.33	91.1	34.1	.14	23.1	565	26.0	**410**	7.25	264	67.8	199
CMO.1	968	2,250	9.51	247	1.27	1.05	7.81	70.0	31.9	.15	20.8	504	24.6	**241**	6.34	282	60.1	171
CMO.1	1,130	2,740	13.4	304	1.67	.902	9.70	76.9	29.7	.10	31.1	682	29.9	**159**	9.17	276	90.7	164
CMO.1	1,810	2,280	16.9	364	1.65	2.34	9.42	118	46.4	.17	29.0	745	29.7	**1,220**	8.14	273	82.1	319
CMO.1	1,170	2,530	18.2	338	1.76	1.17	11.2	120	24.0	.09	33.0	828	31.2	**303**	9.52	211	97.1	168
Como Lake Inflow SS:																		
Lake Como Inflow	2,440	3,040	9.83	368	1.46	2.72	9.86	73.6	104	isa	25.5	1,110	29.8	**147**	7.69	284	72.8	**637**
Lake Como Inflow	2,310	1,900	12.2	335	1.34	1.88	9.11	63.8	86.0	isa	22.2	1,230	27.7	**133**	6.92	290	67.3	**657**
Lake Como Inflow	2,000	2,650	11.4	344	1.46	1.88	9.22	65.4	94.6	isa	23.6	559	28.1	**172**	7.36	316	71.0	**590**
Lake Como Inflow	1,350	1,920	10.4	300	1.48	1.46	8.95	56.7	63.6	.13	23.3	820	29.4	121	6.70	327	67.9	421
Lake Como Inflow, dup.	1,370	1,960	10.6	296	1.54	1.42	8.88	55.7	64.1	na	22.7	816	28.9	121	6.62	326	68.4	412

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Deposition date of interval or sample date	Sample time	Laboratory set number	Total carbon (percent)	Carbonate (percent)	Organic carbon (percent)	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium
Echo Lake															
Upper Lake Core Site:															
ECO.3 0–5	0	5	2.5	1999		3202	5.76	9.36	3.60	34,000	90,300	18,900	5,820	6,590	1,760
ECO.3 25–30	25	30	27.5	1988		3202	4.95	8.49	3.54	34,400	91,600	18,200	6,180	6,350	1,860
ECO.3 50–55	50	55	57.5	1972		3202	5.48	9.04	3.56	30,400	91,100	16,900	5,590	5,750	2,020
Middle Lake Core Site:															
ECO.4 0–8	0	8	4	1999		3202	4.9	8.77	3.87	45,900	107,000	26,500	7,390	7,410	1,470
ECO.4 40–48	40	48	44	1972		3202	3.93	8.06	4.13	46,600	109,000	25,800	7,570	7,630	1,490
ECO.4 72–80	72	80	76	1952		3202	2.18	4.94	2.76	58,000	72,400	33,200	9,300	8,510	1,500
Primary (Lower) Lake Core Site:															
ECO.1 0–5	0	5	2.5	1999.7		3202	4.99	8.49	3.50	57,800	103,000	31,900	8,910	7,590	1,070
ECO.1 0–5 repl	0	5	2.5	1999.7		3202	na	na	na	57,000	98,600	31,800	8,640	8,160	1,180
ECO.1 0–5 repl	0	5	2.5	1999.7		3202	na	na	na	55,600	96,800	31,100	8,440	7,970	1,160
ECO.1 5–10	5	10	7.5	1998.3		3202	4.85	8.46	3.61	58,200	109,000	32,500	8,830	7,420	1,070
ECO.1 10–15	10	15	12.5	1996.4		3202	4.1	7.73	3.63	56,500	110,000	32,000	9,070	6,920	987
ECO.1 20–25	20	25	22.5	1991.7		3202	3.31	7.05	3.74	61,400	111,000	31,000	9,680	8,150	1,130
ECO.1 30–35	30	35	32.5	1985.9		3202	3.87	7.8	3.93	58,800	114,000	31,100	8,940	7,810	1,010
ECO.1 40–45	40	45	42.5	1980.6		3202	3.74	7.61	3.87	58,200	113,000	31,800	9,120	8,010	1,110
ECO.1 55–60	55	60	57.5	1972.5		3202	3.88	7.8	3.92	56,500	113,000	31,400	8,970	8,170	1,070
ECO.1 65–70	65	70	67.5	1966.8		3202	3.02	6.43	3.41	63,100	96,700	32,800	10,400	8,950	1,200
ECO.1 75–80	75	80	77.5	1961.1		3202	3.62	7.16	3.54	59,100	100,000	32,300	8,550	8,610	953
ECO.1 90–97	90	96	93.5	1951.4		3202	2.56	5.47	2.91	64,700	76,600	34,300	9,780	9,710	1,240
Echo Lake Inflow SS:															
Echo Lake Inflow				05/28/01	0200	3711	6.4	3.42	2.98	37,700	118,000	21,800	6,710	4,660	1,220
Echo Lake Inflow				08/17/01	0745–0935	3711	7.87	3.76	4.11	54,700	132,000	29,000	10,200	6,530	1,120
Echo Lake Inflow				09/20/01	1335	3711	isa	isa	isa	39,200	151,000	25,500	7,750	5,600	1,170
Echlo Lake Inflow				10/11/01	0450	3744	11.8	isa	isa	43,800	152,000	26,600	8,450	5,210	1,060

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Phos-phorus	Tita-nium	Arse-nic	Bari-um	Beryl-lium	Cad-mium	Co-balt	Chro-mium	Cop-per	Mer-cury	Lith-ium	Manga-nese	Nick-el	Lead	Scan-dium	Stron-tium	Vana-dium	Zinc
Echo Lake—Continued																		
Upper Lake Core Site:																		
ECO.3 0–5	649	2,570	10.2	290	1.66	2.78	7.68	54.3	44.0	0.09	27.7	446	25.8	**137**	6.32	232	54.7	292
ECO.3 25–30	573	2,400	11.0	283	1.68	4.53	7.97	55.8	45.0	.14	27.5	336	22.2	**185**	6.21	226	55.8	265
ECO.3 50–55	667	2,240	12.8	302	1.80	11.8	7.04	92.6	39.6	.12	24.9	335	21.0	**721**	5.67	191	48.7	241
Middle Lake Core Site:																		
ECO.4 0–8	847	2,980	13.0	348	2.05	3.21	8.98	63.1	56.9	.1	35.3	636	29.1	**134**	7.99	248	73.9	307
ECO.4 40–48	828	2,780	16.9	336	2.28	**19.3**	8.94	86.0	47.0	.15	37.1	528	26.5	**742**	8.02	221	71.8	336
ECO.4 72–80	630	3,210	14.2	376	2.68	.978	9.40	63.2	23.1	.07	47.1	958	24.3	77.7	10.1	160	82.7	108
Primary (Lower) Lake Core Site:																		
ECO.1 0–5	1,010	3,220	15.9	413	2.42	3.18	10.6	72.1	39.9	.11	42.5	731	30.7	124	9.86	238	87.6	297
ECO.1 0–5 repl	1,030	3,380	16.5	434	2.24	3.30	10.3	71.7	39.8	na	43.1	734	29.6	126	9.66	237	90.2	292
ECO.1 0–5 repl	1,010	3,220	16.1	422	2.20	3.27	10.1	70.5	38.6	na	42.3	720	28.6	124	9.47	231	88.0	287
ECO.1 5–10	1,040	3,170	15.8	400	2.32	4.80	10.9	75.0	45.8	.14	41.7	685	32.4	144	9.76	241	88.0	352
ECO.1 10–15	982	2,900	15.7	386	2.19	4.20	10.4	73.1	39.1	.13	40.2	633	29.6	**129**	10.2	230	84.6	305
ECO.1 20–25	832	2,880	15.6	366	2.38	**6.64**	11.1	74.2	38.6	.15	46.2	634	30.7	**165**	10.4	232	89.0	276
ECO.1 30–35	915	2,720	18.5	375	2.31	**54.7**	10.3	101	43.7	.14	42.5	668	29.3	**303**	9.62	233	85.9	**519**
ECO.1 40–45	964	2,680	18.5	385	2.35	**16.1**	10.2	83.7	42.6	.14	44.2	673	30.1	**464**	9.82	223	86.3	322
ECO.1 55–60	1,160	2,730	20.9	373	2.35	**33.0**	10.4	136	42.8	.15	43.9	729	32.4	**706**	9.58	232	83.9	315
ECO.1 65–70	1,570	3,130	19.8	399	2.70	**182**	10.4	240	53.6	.14	51.1	728	38.0	**305**	10.5	204	88.2	351
ECO.1 75–80	1,500	3,000	20.3	402	2.57	**80.8**	9.94	114	45.2	.12	45.2	771	29.4	**307**	9.79	199	84.4	215
ECO.1 90–97	750	3,440	18.2	412	3.05	1.96	10.1	70.0	24.9	.09	51.6	791	26.7	111	10.7	172	89.7	129
Echo Lake Inflow SS:																		
Echo Lake Inflow	538	2,060	7.64	303	1.28	1.33	7.45	54.6	40.6	.07	28.1	401	24.2	79.6	6.99	432	53.7	269
Echo Lake Inflow	840	2,710	11.6	345	1.87	2.42	11.2	68.2	42.8	.11	40.5	627	35.9	**146**	9.98	264	75.9	375
Echo Lake Inflow	1,080	2,340	10.5	347	1.52	2.68	10.1	59.8	62.4	isa	27.2	858	34.7	**166**	7.44	322	61.8	**607**
Echlo Lake Inflow	1,140	2,420	10.4	339	1.38	2.45	10.3	69.0	60.5	isa	29.5	733	34.0	**212**	8.02	334	67.5	**554**

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Deposition date of interval or sample date	Sample time	Laboratory set number	Total carbon (percent)	Carbonate (percent)	Organic carbon (percent)	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium
Fosdic Lake															
Upper Lake Core Site:															
FOS.5 0–10	0	10	5	2000		3188	9.08	2.25	6.84	43,200	73,200	25,200	6,230	4,180	1,120
FOS.5 50–60	50	60	55	1965		3188	6.41	2.56	3.86	47,600	78,400	25,700	7,170	4,170	1,260
FOS.5 80–90	80	90	85	1920		3188	3.78	2.03	1.76	61,300	59,400	33,700	8,120	4,430	1,260
Primary (Mid) Lake Core Site:															
FOS.4 0–5	0	5	2.5	2000.4		3186	9.85	7.18	2.67	51,000	94,600	29,900	7,670	4,430	1,050
FOS.4 0–5 repl	0	5	2.5	2000.4		3186	na	na	na	48,900	86,300	27,900	6,660	4,570	1,060
FOS.4 0–5 repl	0	5	2.5	2000.4		3186	na	na	na	48,200	83,900	27,300	6,490	4,630	1,060
FOS.4 5–10	5	10	7.5	1998.4		3186	10.6	7.98	2.62	47,600	84,900	26,900	6,880	4,540	1,080
FOS.4 10–15	10	15	12.5	1996.2		3186	10.3	7.81	2.49	42,500	83,400	19,200	6,700	3,950	1,000
FOS.4 20–25	20	25	22.5	1991.0		3186	8.71	6.5	2.21	46,900	72,600	25,500	7,120	4,410	1,110
FOS.4 30–35	30	35	32.5	1983.3		3186	7.31	4.65	2.66	52,300	84,900	27,200	7,780	4,720	1,040
FOS.4 45–50	45	50	47.5	1968.9		3186	6.21	3.62	2.59	60,700	85,000	31,600	9,390	5,100	1,160
FOS.4 55–60	55	60	57.5	1959.8		3188	6.05	3.08	2.97	60,200	93,400	31,000	8,150	5,140	1,070
FOS.4 55–60 repl	55	60	57.5	1959.8		3188	na	na	na	60,900	93,000	31,300	8,150	5,090	1,060
FOS.4 55–60 repl	55	60	57.5	1959.8		3188	na	na	na	60,500	92,900	31,000	8,140	5,080	1,060
FOS.4 70–75	70	75	72.5	1944.6		3188	4.07	2.16	1.91	69,400	67,900	36,900	8,960	5,160	1,130
FOS.4 85–90	85	90	87.5	1928.3		3188	4.42	2.08	2.34	72,000	67,000	36,500	9,640	5,350	1,140
FOS.4 100–105	100	105	102.5	1912.6		3188	3.2	1.16	2.04	66,600	42,100	30,800	8,570	5,430	1,320
FOS.4 105–112	105	112	108.5	1900.0		3188	3.37	1.17	2.20	52,200	41,200	27,100	8,240	3,920	1,120
Lower Lake Core Site:															
FOS.2 0–10	0	10	5	2000		3188	11	2.73	8.27	51,100	88,900	29,500	7,000	4,750	915
FOS.2 50–60	50	60	55	1965		3188	5.66	2.59	3.08	67,100	80,400	34,200	9,520	5,770	1,030
FOS.2 100–110	100	110	105	1920		3188	3.77	1.53	2.25	80,000	50,000	39,100	9,660	5,670	1,030
Fosdic Lake Inflow SS:															
Fosdic Lake Inflow				08/11/01	1710	3744	isa	isa	isa	68,800	33,800	31,500	12,800	6,810	2,570
Fosdic Lake Inflow				09/18/01	1855	3744	6.15	1.34	4.81	78,000	50,800	37,600	8,980	5,110	1,360
Fosdic Lake Inflow				10/10/01	2000	3744	11	2.75	8.25	68,400	101,000	33,800	8,920	4,760	905
Fosdic Lake Inflow				12/16/01	0108	3784	isa	isa	isa	91,800	56,500	42,800	10,200	6,640	1,810

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Phos-phorus	Tita-nium	Arse-nic	Bari-um	Beryl-lium	Cad-mium	Co-balt	Chro-mium	Cop-per	Mer-cury	Lith-ium	Manga-nese	Nick-el	Lead	Scan-dium	Stron-tium	Vana-dium	Zinc
Fosdic Lake—Continued																		
Upper Lake Core Site:																		
FOS.5 0–10	1,200	2,420	11.7	218	1.63	1.64	9.41	64.3	35.1	0.23	33.7	648	23.1	123	7.64	187	65.8	218
FOS.5 50–60	923	2,760	13.8	235	1.79	2.92	9.02	74.3	32.7	.4	39.7	448	22.8	**410**	8.48	148	69.3	177
FOS.5 80–90	520	3,290	11.3	267	2.15	.286	10.7	61.1	17.5	.06	47.1	989	24.0	52.5	11.1	121	89.2	79.0
Primary (Mid) Lake Core Site:																		
FOS.4 0–5	1,620	2,990	13.0	260	1.51	1.70	10.4	87.0	38.5	.24	36.9	869	26.3	108	9.19	222	78.5	223
FOS.4 0–5 repl	1,480	2,500	12.2	248	1.75	1.72	9.60	70.2	35.9	na	36.8	823	23.8	108	8.90	208	73.9	208
FOS.4 0–5 repl	1,450	2,900	12.1	246	1.70	1.68	9.30	71.2	35.2	na	37.0	799	23.2	111	8.72	204	74.5	203
FOS.4 5–10	1,500	2,270	12.2	245	1.65	2.11	9.31	73.8	47.7	.28	35.8	774	24.0	**129**	8.41	202	68.9	247
FOS.4 10–15	1,300	2,310	11.4	233	1.40	2.27	8.71	71.0	42.5	.31	31.6	570	22.9	**140**	7.51	192	61.6	244
FOS.4 20–25	1,310	2,330	12.0	243	1.77	2.85	9.00	81.2	43.9	.37	37.4	517	23.6	**196**	8.53	161	69.4	248
FOS.4 30–35	1,140	2,500	12.5	253	1.85	3.68	9.94	86.3	45.3	.41	42.0	494	26.8	**285**	9.40	159	76.4	218
FOS.4 45–50	1,260	2,950	15.3	277	1.93	4.12	10.8	96.0	40.0	.55	48.9	592	28.9	**379**	10.6	160	85.2	206
FOS.4 55–60	781	3,060	**220**	253	2.16	.902	10.6	66.4	21.8	.16	48.3	572	25.9	**243**	10.5	154	89.8	130
FOS.4 55–60 repl	784	2,990	**223**	257	2.11	.905	10.6	65.0	21.4	na	48.6	576	25.6	**244**	10.5	156	88.9	130
FOS.4 55–60 repl	775	3,010	**218**	255	2.07	.932	10.6	65.4	21.1	na	48.5	571	25.4	**240**	10.6	156	89.7	130
FOS.4 70–75	666	3,560	31.5	286	2.38	.467	11.7	71.2	20.0	.09	51.3	834	27.8	88.6	12.1	136	102	99.8
FOS.4 85–90	633	3,940	27.9	288	2.33	.237	12.0	73.4	16.4	.06	55.0	566	28.4	39.3	12.8	133	104	87.1
FOS.4 100–105	547	4,050	20.9	866	2.00	.212	10.7	63.9	15.8	.04	51.8	520	24.7	26.8	11.4	110	89.2	69.9
FOS.4 105–112	475	3,070	12.1	276	1.98	.143	9.93	54.6	13.5	.04	41.1	446	22.0	20.2	9.47	95.6	76.2	53.4
Lower Lake Core Site:																		
FOS.2 0–10	1,650	2,590	14.9	272	1.68	1.99	9.14	79.1	39.0	.24	39.1	767	25.5	105	8.83	210	78.0	225
FOS.2 50–60	998	3,470	18.3	285	2.25	1.79	11.5	79.8	26.7	.21	57.0	594	28.2	**290**	11.8	151	96.8	149
FOS.2 100–110	680	4,070	17.7	302	2.75	.236	12.1	78.8	16.7	.05	61.9	533	29.4	39.3	13.8	120	112	91.8
Fosdic Lake Inflow SS:																		
Fosdic Lake Inflow	5,530	3,440	12.9	278	2.80	2.23	10.1	89.2	197	isa	48.4	394	23.8	127	11.8	153	126	**596**
Fosdic Lake Inflow	1,120	4,080	13.4	288	2.69	.639	13.4	81.2	26.7	.11	59.4	808	30.4	71.9	13.6	143	106	184
Fosdic Lake Inflow	1,290	3,380	12.4	280	2.05	1.08	13.0	77.5	39.6	.13	48.1	637	35.2	80.0	12.2	278	107	374
Fosdic Lake Inflow	1,780	4,600	13.1	286	2.61	1.26	14.4	93.2	51.4	na	60.7	1,130	34.5	84.5	14.6	202	116	340

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Deposition date of interval or sample date	Sample time	Laboratory set number	Total carbon (percent)	Carbonate (percent)	Organic carbon (percent)	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium
Passive SS Sampling Sites															
Site 1, Benbrook				10/15/00		3209	8.09	5.46	2.63	37,600	191,000	18,700	8,010	4,770	927
Site 1, Benbrook				03/08/01		3201	2.98	7.95	4.97	34,300	143,000	15,900	6,450	5,660	1,270
Site 1, Benbrook repl.				03/08/01		3201	na	na	na	34,200	140,000	15,600	6,280	5,940	1,310
Site 1, Benbrook repl.				03/08/01		3201	na	na	na	33,500	137,000	15,300	6,180	5,920	1,300
Site 1, Benbrook				08/17/01		3711	7.16	5.94	1.22	50,800	206,000	23,500	11,300	6,620	662
Site 2, Levee				10/15/00		3210	nes	nes	nes	36,200	168,000	16,600	7,230	5,340	1,030
Site 2, Levee				05/28/01		3711	9.63	4.48	5.15	35,900	164,000	18,100	7,050	4,750	1,050
Site 3, Como Outfall				10/15/00		3209	6.85	3.94	2.91	40,800	137,000	16,700	9,210	5,080	1,420
Site 3, Como Outfall				05/28/01		3711	7.51	4.09	3.42	41,400	145,000	19,400	8,600	5,420	1,270
Site 4, Zoo				10/15/00		3209	7.45	4.37	3.08	52,200	156,000	22,600	11,100	6,260	1,090
Site 4, Zoo				03/09/01		3201	3.93	8.82	4.89	34,300	139,000	18,200	6,540	6,360	1,430
Site 4, Zoo				05/28/01		3711	9.15	4.51	4.64	35,100	156,000	19,500	7,470	4,920	1,210
Site 5, Downtown				10/15/00		3209	9.76	4.23	5.53	38,800	148,000	20,700	8,430	5,380	1,370
Site 5, Downtown				05/04/01		3342	11.5	nes	nes	27,900	125,000	17,000	6,270	3,880	1,150
Site 5, Downtown dup.				05/04/01		3342	11.5	4.21	7.3	32,900	144,000	20,700	7,150	4,780	1,390
Site 5, Downtown				08/16/01		3711	12.2	4.21	7.99	43,200	150,000	27,300	8,230	6,050	1,160
Site 5, Downtown dup.				08/16/01		3711	12.2	4.21	7.99	39,600	150,000	26,500	7,970	5,940	1,190
Site 5, Downtown dup. rep.				08/16/01		3711	na	na	na	41,000	151,000	26,800	7,990	6,200	1,260
Site 5, Downtown dup. rep.				08/16/01		3711	na	na	na	38,600	147,000	26,400	7,770	5,750	1,160
Site 6, Little Fossil				10/15/00		3209	7.87	3.73	4.14	52,600	134,000	23,300	11,200	6,250	1,300
Site 6, Little Fossil				03/08/01		3201	4.74	8.36	3.62	50,700	107,000	25,600	8,100	8,280	1,330
Site 6, Little Fossil				05/28/01		3711	6.7	3.66	3.04	50,700	128,000	25,900	10,200	6,420	1,330
Sediment-Quality Guidelines															
Threshold effect concentration (TEC)															
Probable effect concentration (PEC)															

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Phos-phorus	Tita-nium	Arse-nic	Bari-um	Beryl-lium	Cad-mium	Co-balt	Chro-mium	Cop-per	Mer-cury	Lith-ium	Manga-nese	Nick-el	Lead	Scan-dium	Stron-tium	Vana-dium	Zinc
Passive SS Sampling Sites—Continued																		
Site 1, Benbrook	709	2,140	18.4	230	1.24	0.229	10.4	44.1	15.1	0.03	25.0	1,350	20.7	17.8	7.28	262	62.6	98.3
Site 1, Benbrook	610	1,950	9.30	230	1.50	.333	6.57	39.4	13.0	.03	23.7	566	18.0	15.3	6.35	232	52.5	78.9
Site 1, Benbrook repl.	586	2,060	8.93	232	1.50	.365	6.39	39.8	12.8	na	24.8	556	17.3	15.1	6.27	228	52.9	78.5
Site 1, Benbrook repl.	582	1,930	8.92	232	1.38	.349	6.23	38.6	12.5	na	24.2	544	16.6	15.0	6.19	224	52.1	76.4
Site 1, Benbrook	732	2,310	10.6	217	1.72	.154	9.91	60.0	13.3	.04	31.7	596	26.4	13.0	8.66	291	82.0	67.3
Site 2, Levee	1,160	1,820	8.27	231	1.17	1.80	13.6	50.1	37.8	isa	23.7	502	21.9	**133**	6.62	288	62.9	286
Site 2, Levee	1,220	1,740	7.95	240	1.12	.553	5.56	44.9	23.0	.08	25.0	387	19.3	64.9	6.31	252	55.4	173
Site 3, Como Outfall	912	2,180	7.64	215	1.27	.286	6.05	45.7	16.9	.04	27.7	430	18.0	31.5	7.72	196	60.5	100
Site 3, Como Outfall	1,090	1,870	7.94	236	1.37	.437	6.82	46.1	20.3	.07	29.7	694	19.9	35.8	7.40	217	62.1	166
Site 4, Zoo	924	2,590	11.6	284	1.72	.435	9.15	57.3	29.0	.05	35.0	617	25.7	44.5	9.77	264	74.9	131
Site 4, Zoo	805	2,040	10.5	270	1.42	.834	7.22	45.0	33.1	.08	24.8	584	22.1	64.2	6.37	271	55.4	167
Site 4, Zoo	1,190	1,940	8.83	258	1.28	.987	7.25	47.2	29.7	.09	23.0	686	21.0	69.5	6.54	278	52.7	177
Site 5, Downtown	996	2,230	11.2	333	1.41	1.90	10.2	61.0	60.9	.26	25.1	928	27.2	**172**	7.60	275	62.1	**575**
Site 5, Downtown	1,650	1,890	7.01	240	.911	1.33	6.12	46.6	61.3	isa	16.6	324	21.1	114	4.80	252	43.6	**536**
Site 5, Downtown dup.	1,890	1,830	8.18	279	1.17	1.68	7.41	55.1	72.1	.22	19.7	386	26.5	**134**	5.46	296	50.8	**636**
Site 5, Downtown	2,020	2,390	11.7	383	1.52	2.73	11.4	77.0	**281**	.31	27.3	588	32.2	**237**	7.85	335	68.6	**1,600**
Site 5, Downtown dup.	1,900	2,480	11.5	370	1.49	2.52	11.0	72.4	**257**	.32	26.7	585	31.9	**236**	7.49	319	66.8	**1,560**
Site 5, Downtown dup. rep.	1,900	2,520	12.2	380	1.51	2.59	11.2	71.9	**265**	na	27.0	595	32.0	**249**	7.71	330	67.2	**1,600**
Site 5, Downtown dup. rep.	1,900	2,480	11.4	370	1.41	2.47	10.9	70.2	**253**	na	25.9	580	30.8	**237**	7.48	315	65.4	**1,440**
Site 6, Little Fossil	797	2,470	11.3	304	1.72	.731	10.4	60.1	24.8	.04	34.6	986	28.7	58.6	9.96	258	75.1	236
Site 6, Little Fossil	867	2,690	11.7	331	2.11	.784	8.49	58.8	23.1	.07	37.0	591	25.0	60.4	8.75	257	71.1	214
Site 6, Little Fossil	708	2,620	11.1	303	1.68	.575	9.87	56.5	20.7	.06	35.2	676	27.4	52.2	9.43	251	71.7	166
Sediment-Quality Guidelines																		
Threshold effect concentration (TEC)			9.79			.99		43.4	31.6	.18			22.7	35.8				121
Probable effect concentration (PEC)			33			4.98		111	149	1.06			48.6	128				459

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Depth min (cm)	Depth max (cm)	Depth mid (cm)	Deposition date of interval or sample date	Sample time	Laboratory set number	Total carbon (percent)	Carbonate (percent)	Organic carbon (percent)	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium
Automated SS Sampling Sites															
Big Fossil				05/04/01	2144	3210	2.73	4.89	2.16	75,800	97,700	36,200	15,100	7,900	1,350
Big Fossil				08/11/01	1550	3744	7.12	isa	isa	64,000	114,000	30,300	13,000	7,590	2,120
Big Fossil				09/18/01	1855	3744	5.22	2.45	2.77	75,900	85,900	35,600	15,700	9,750	1,660
Big Fossil				10/11/01	0055	3744	5.55	2.70	2.85	70,600	93,900	33,700	15,300	9,700	1,640
Sycamore Creek #1 or #3?				05/04/01	missing	3342	9.1	3.68	5.42	44,500	112,000	24,800	8,800	4,870	1,080
Sycamore Creek #2				05/04/01	2204	3209	8.15	4.05	4.1	47,800	139,000	23,300	10,200	5,730	1,360
Sycamore Creek #4&5				05/05/01	0034	3209	7.36	3.44	3.92	60,300	124,000	27,100	12,800	7,500	1,430
Sycamore Creek #6&7				05/05/01	0234	3209	isa	isa	isa	67,300	108,000	30,900	13,200	8,050	1,280
Sycamore Creek #1				08/16/01	0002	3711	isa	isa	isa	62,000	93,700	37,400	12,900	8,860	1,630
Sycamore Creek #2				08/16/01	0032	3744	isa	isa	isa	57,400	133,000	30,400	12,200	11,100	3,290
Sycamore Creek #3				08/16/01	0102	3711	7.74	isa	isa	70,500	128,000	35,200	13,300	8,410	1,230
Sycamore Creek #4				08/16/01	0728	3711	7.83	isa	isa	93,200	56,800	45,200	16,400	10,300	1,570
Sycamore Creek #1				08/30/01	0829	3744	7.93	3.80	4.13	62,300	139,000	32,800	12,500	7,790	1,420
Sycamore Creek #1 dup.				08/30/01	0829	3744	na	na	na	55,600	125,000	29,500	11,300	6,620	1,280
Sycamore Creek #2				08/30/01	1029	3744	6.71	3.54	3.17	59,200	123,000	30,500	12,500	8,250	1,490
Sycamore Creek #3				08/30/01	1329	3744	6.38	3.11	3.27	55,500	128,000	28,900	12,100	8,320	1,660
Sycamore Creek #4				08/30/01	1645	3744	isa	isa	isa	68,300	108,000	34,100	14,100	9,150	1,380
Sycamore Creek #5				08/30/01	1855	3744	isa	isa	isa	74,600	88,200	37,200	15,000	9,440	1,540
Sediment-Quality Guidelines															
Threshold effect concentration (TEC)															
Probable effect concentration (PEC)															

Appendix 1.5. Selected major and trace element concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Phos-phorus	Tita-nium	Arse-nic	Bari-um	Beryl-lium	Cad-mium	Co-balt	Chro-mium	Cop-per	Mer-cury	Lith-ium	Manga-nese	Nick-el	Lead	Scan-dium	Stron-tium	Vana-dium	Zinc
Automated SS Sampling Sites—Continued																		
Big Fossil	725	3,300	13.4	328	2.48	0.355	12.9	81.7	20.1	0.04	59.3	704	32.1	37.9	13.3	234	105	118
Big Fossil	879	3,110	11.2	326	1.82	.807	11.5	68.5	26.7	isa	46.8	676	29.6	67.7	11.3	267	84.2	230
Big Fossil	635	3,220	13.0	366	3.20	.372	13.3	77.6	19.5	.04	69.0	627	34.6	28.6	13.5	232	98.7	110
Big Fossil	699	3,040	13.3	355	2.75	.271	12.9	73.6	20.2	.05	62.6	681	33.1	36.8	12.8	260	93.9	119
Sycamore Creek #1 or #3?	1,070	2,240	9.88	261	1.42	1.06	9.86	54.4	37.9	.05	31.2	838	25.7	95.3	7.82	268	65.4	246
Sycamore Creek #2	989	2,480	11.4	323	1.57	.893	9.85	64.3	39.7	.12	33.8	571	27.8	109	9.41	296	69.1	260
Sycamore Creek #4&5	1,020	3,100	12.0	320	1.84	.931	11.7	75.9	37.5	.06	43.2	883	32.8	76.2	11.5	276	87.1	288
Sycamore Creek #6&7	1,320	3,630	13.6	340	2.49	.902	13.2	86.9	43.8	isa	50.0	972	36.7	77.0	11.4	248	97.8	344
Sycamore Creek #1	2,730	2,970	13.6	366	2.45	1.57	11.6	79.1	83.2	isa	41.4	673	35.9	**138**	11.7	231	99.0	**552**
Sycamore Creek #2	1,370	2,460	10.3	386	2.28	1.47	16.0	81.4	65.0	isa	55.1	1,750	9.00	**189**	10.2	302	88.8	352
Sycamore Creek #3	1,070	2,940	13.4	351	2.38	.725	13.6	78.7	58.6	isa	48.2	878	34.2	**187**	12.0	306	105	286
Sycamore Creek #4	2,000	4,110	16.0	364	3.24	.786	14.2	110	54.9	isa	61.2	550	42.9	118	15.5	227	148	309
Sycamore Creek #1	974	3,710	13.9	365	2.25	.924	13.9	73.2	41.4	.10	46.0	1,050	34.2	107	11.6	311	92.6	258
Sycamore Creek #1 dup.	885	3,360	12.0	324	1.96	.811	12.1	66.4	36.6	na	39.1	945	30.4	93.7	10.6	276	84.2	223
Sycamore Creek #2	769	2,740	12.2	333	2.43	.770	12.7	68.4	35.9	.07	46.3	916	32.7	72.8	11.0	291	80.9	195
Sycamore Creek #3	600	2,650	12.2	312	2.40	.485	11.8	62.5	27.1	.05	44.5	717	29.3	56.7	10.4	293	77.0	146
Sycamore Creek #4	875	2,930	14.0	350	2.72	.707	13.4	74.3	28.5	isa	55.8	852	33.9	61.7	12.3	259	94.3	188
Sycamore Creek #5	1,300	3,310	16.1	428	3.12	.766	14.3	81.7	36.6	isa	60.2	1,100	36.5	74.5	12.9	243	104	220
Sediment-Quality Guidelines																		
Threshold effect concentration (TEC)			9.79			.99		43.4	31.6	.18			22.7	35.8				121
Probable effect concentration (PEC)			33			4.98		111	149	1.06			48.6	128				459

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments

[Concentrations in micrograms per kilogram. Bold type indicates concentration exceeds probable effect concentration (MacDonald and others, 2000); SS, suspended sediment; cm, centimeters; E, estimated; <, nondetection at indicated value; na, not applicable or not available; isa, insufficient sediment for analysis]

Core ID or SS site	Top of interval (cm)	Bottom of interval (cm)	Mid depth of interval (cm)	Deposition date of interval or sample date	Laboratory batch number	Mass of sample	Naph-thalene	9H-Fluorene	Phenan-threne	Anthra-cene
Lake Como										
Upper Lake Core Site:										
CMO.5	0	10	5	2000.0	8022R01205		33.4	93.4	**1,360**	196
CMO.5	20	30	25	1990.0	8022R01205		19.0	84.8	**1,240**	191
CMO.5	40	50	45	1965.0	8022R01205		19.0	44.0	372	83
Mid Lake Core Site:										
CMO.3	0	10	5	1999.0	8022R01205		26.8	78.0	798	140
CMO.3	40	50	45	1970.0	8022R01205		14.3	59.4	402	106
CMO.3	90	100	95	1950.0	8022R01205		E4.4	15.0	37.8	19.6
Primary (Lower Lake) Core Site:										
CMO.1	0	5	2.5	2000.8	8022R01205		18.9	37.4	417	76.5
CMO.1	5	10	7.5	1999.9	8022R01205		27.1	96.2	1,080	239
CMO.1	10	15	12.5	1998.7	8022R01206		21.7	52.4	611	120
CMO.1	20	25	22.5	1995.3	8022R01205		10.2	31.1	290	81.2
CMO.1	30	35	32.5	1990.6	8022R01206		17.8	57.6	537	131
CMO.1 dup	30	35	32.5	1990.6	8022R01206		17.0	63.4	484	134
CMO.1	45	50	47.5	1982.5	8022R01234		21.1	71.1	745	188
CMO.1 dup	45	50	47.5	1982.5	8022R01234		21.5	69.7	715	183
CMO.1	60	65	62.5	1974.1	8022R01205		E7.2	45.0	402	115
CMO.1	75	80	77.5	1969.1	8022R01205		11.9	102	949	265
CMO.1	90	95	92.5	1958.6	8022R01205		11.4	27.4	124	30.9
Como Lake Inflow SS:										
Lake Como Inflow				08/30/01	8022R01261	0.406	E169	E156	**2,970**	541
Lake Como Inflow				09/20/01	8022R01261	.295	E213	E179	**2,740**	488
Lake Como Inflow				11/09/01	8022R01235	.186	E189	E163	**2,340**	E387
Lake Como Inflow				01/23/02	8022R01235	2.287	77.5	82.0	**1,800**	238

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Fluoran-thene	Pyrene	Benz(a)-anthracene	Chrysene	Benzo(a)-pyrene	Dibenzo(a,h)-anthracene	Coronene	Total PAH	Combustion PAH	(2+3)/ combustion PAH
Lake Como—Continued										
Upper Lake Core Site:										
CMO.5	**4,460**	**2,530**	**1,710**	**2,560**	**2,020**	377	E329	**30,204**	22,810	0.189
CMO.5	**4,260**	**3,360**	**1,740**	**2,360**	**1,990**	345	E265	**30,403**	23,560	.164
CMO.5	640	474	288	282	267	37.5	E9.5	4,317	2,980	.334
Mid Lake Core Site:										
CMO.3	2,000	1,420	948	**1,510**	1,140	222	E68.0	17,564	12,831	.271
CMO.3	710	561	333	502	371	66.6	E24.9	12,144	4,155	1.761
CMO.3	61.3	58.8	44.1	75.7	42.7	E8.3	E3.7	1,302	507	1.135
Primary (Lower Lake) Core Site:										
CMO.1	1,080	814	426	884	564	165	E78.6	10,824	6,850	.424
CMO.1	**2,660**	**1,920**	**1,300**	**2,030**	**1,460**	299	E77.0	**24,569**	16,970	.334
CMO.1	1,680	1,260	977	**1,500**	1,030	316	E82.4	20,410	11,981	.316
CMO.1	751	576	350	610	439	99.6	E71.5	9,079	4,920	.642
CMO.1	1,180	938	754	889	629	132	E52.7	16,118	7,217	.748
CMO.1 dup	1,020	802	495	731	550	81.8	E31.8	15,199	5,966	1.026
CMO.1	E2,020	**E1,540**	730	1,120	E800	201	E119	17,311	10,080	.555
CMO.1 dup	E1,900	E1,430	701	1,070	E798	167	E74.2	16,756	9,636	.583
CMO.1	873	619	513	659	466	86.1	E20.0	9,276	5,256	.626
CMO.1	1,240	965	647	808	577	100	E112	19,444	6,602	1.708
CMO.1	192	179	93.5	193	105	23.8	E22.2	5,718	1,303	2.799
Como Lake Inflow SS:										
Lake Como Inflow	**10,400**	**8,250**	**3,640**	**6,730**	**5,120**	1,110	E1,510	**94,778**	63,590	.137
Lake Como Inflow	**9,190**	**7,360**	**2,560**	**6,210**	**4,010**	983	E1,240	**87,543**	55,010	.196
Lake Como Inflow	**7,660**	**6,060**	**2,340**	**4,930**	**3,510**	779	E1,640	**72,667**	45,880	.223
Lake Como Inflow	**5,630**	**4,310**	**1,760**	**3,340**	**2,620**	607	E510	**45,827**	32,070	.155

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Top of interval (cm)	Bottom of interval (cm)	Mid depth of interval (cm)	Deposition date of interval or sample date	Laboratory batch number	Mass of sample	Naph-thalene	9H-Fluorene	Phenan-threne	Anthra-cene
Echo Lake										
Upper Lake Core Site:										
ECO.3	0	5	2.5	1999.0	8022R01141		50.6	79.1	1,020	230
ECO.3	25	30	27.5	1988.0	8022R01141		63.9	78.8	965	222
ECO.3	50	55	52.5	1972.0	8022R01142		68.7	77.6	752	145
ECO.3 dup	50	55	52.5	1972.0	8022R01142		50.5	70.9	721	132
Middle Lake Core Site:										
ECO.4	0	8	4	1999.0	8022R01142		27.8	59.3	487	145
ECO.4	40	48	44	1972.0	8022R01141		25.4	32.2	220	98.7
ECO.4	72	80	76	1952.0	8022R01141		10.4	18.7	126	48.0
ECO.4 dup	72	80	76	1952.0	8022R01141		E8.8	18.2	124	47.9
Primary (Lower) Lake Core Site:										
ECO.1	0	5	2.5	1999.7	8022R01141		24.8	38.9	308	150
ECO.1	5	10	7.5	1998.3	8022R01142		18.8	28.3	233	94.3
ECO.1	10	15	12.5	1996.4	8022R01142		15.5	25.7	222	90.3
ECO.1	20	25	22.5	1991.7	8022R01142		13.0	19.7	182	71.4
ECO.1	30	35	32.5	1985.9	8022R01141		16.6	38.8	325	128
ECO.1	40	45	42.5	1980.6	8022R01141		14.7	37.0	213	107
ECO.1	55	60	57.5	1972.5	8022R01141		17.9	30.5	166	75.1
ECO.1	65	70	67.5	1966.8	8022R01142		10.7	18.2	126	44.2
ECO.1	75	80	77.5	1961.1	8022R01142		18.4	18.3	98.9	38.4
ECO.1	90	97	93.5	1951.4	8022R01142		E8.1	15.2	111	36.0
Echo Lake Inflow SS:										
Echo Lake Inflow				05/28/01	8022R01215	5.96	E7.6	21.8	63.2	51.8
Echo Lake Inflow				08/17/01	8022R01235	2.558	68.2	111	**1,820**	387
Echo Lake Inflow				09/20/01	8022R01261	1.141	150	E105	**1,880**	342
Echo Lake Inflow				10/11/01	8022R01261	3.943	118	128	**2,020**	407

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Fluoran-thene	Pyrene	Benz(a)-anthracene	Chrysene	Benzo(a)-pyrene	Dibenzo(a,h)-anthracene	Coronene	Total PAH	Combustion PAH	(2+3)/ combustion PAH
Echo Lake—Continued										
Upper Lake Core Site:										
ECO.3	**3,280**	**2,490**	**1,350**	2,420	1,520	283	E231	**33,174**	19,460	0.329
ECO.3	**2,440**	**1,930**	984	1,500	1,060	180	E208	**25,609**	12,697	.496
ECO.3	1,120	904	553	762	534	75.4	E27.9	19,219	6,127	1.389
ECO.3 dup	1,190	961	571	791	564	116	E29.8	22,618	6,481	1.632
Middle Lake Core Site:										
ECO.4	1,520	1,200	673	1,280	794	149.0	E139	17,667	9,956	.508
ECO.4	465	433	252	390	276	91.0	E73.0	13,599	3,173	1.398
ECO.4	300	262	165	188	163	31.9	E20.5	4,612	1,747	.430
ECO.4 dup	290	257	165	185	162	32.4	E12.8	4,522	1,789	.409
Primary (Lower) Lake Core Site:										
ECO.1	1,030	832	435	972	535	206	E81.2	17,754	7,091	.641
ECO.1	793	610	318	695	385	78.9	E50.9	8,971	5,083	.448
ECO.1	742	560	306	642	357	117	E57.8	8,226	4,328	.496
ECO.1	483	384	238	387	257	76.2	E28.2	6,740	3,101	.674
ECO.1	719	581	401	539	394	100	E52.7	13,617	4,558	1.002
ECO.1	352	334	197	312	212	39.1	E29.3	17,860	2,531	2.958
ECO.1	355	343	208	350	242	75.3	E46.0	10,403	2,711	1.164
ECO.1	236	229	120	160	121	18.2	E11.4	5,356	1,472	1.545
ECO.1	198	205	97.7	177	102	15.8	E12.9	4,258	1,317	.985
ECO.1	240	213	146	159	150	23.8	E26.1	3,555	1,580	.467
Echo Lake Inflow SS:										
Echo Lake Inflow	801	92.4	<440	<700	<2,400	<210	77.88	**23,512**	4,587	2.157
Echo Lake Inflow	**6,310**	**4,650**	**2,300**	**3,900**	**2,920**	642	E833	**54,444**	35,330	.139
Echo Lake Inflow	**6,050**	**4,570**	**1,830**	**3,960**	**2,300**	495	E531	**50,963**	32,970	.175
Echo Lake Inflow	**8,130**	**6,330**	**2,880**	**5,470**	**3,390**	662	E477	**67,694**	45,610	.149

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Top of interval (cm)	Bottom of interval (cm)	Mid depth of interval (cm)	Deposition date of interval or sample date	Laboratory batch number	Mass of sample	Naph-thalene	9H-Fluorene	Phenan-threne	Anthra-cene
Fosdic Lake										
Upper Lake Core Site:										
FOS.5	0	10	5	2000.0	8022R01137		21.5	65.1	1,090	212
FOS.5	40	50	45	1965.0	8022R01137		15.0	38.6	289	77.8
Primary (Mid) Lake Core Site:										
FOS.4	0	5	2.5	2000.4	8022R01137		21.2	34.4	434	120
FOS.4	5	10	7.5	1998.4	8022R01137		21.9	44.2	675	162
FOS.4	10	15	12.5	1996.2	8022R01137		24.1	66.0	1,010	196
FOS.4	20	25	22.5	1991.0	8022R01136		20.2	57.3	464	106
FOS.4	30	35	32.5	1983.3	8022R01137		12.5	48.1	349	84.1
FOS.4	45	50	47.5	1968.9	8022R01136		E8.6	25.9	156	41.8
FOS.4.dup	45	50	47.5	1968.9	8022R01136		E8.3	27.7	148	38.5
FOS.4	55	60	57.5	1959.8	8022R01137		E6.1	16.8	88.2	31.2
FOS.4	70	75	72.5	1944.6	8022R01136		E3.1	E8.1	31.4	11.4
FOS.4	85	90	87.5	1928.3	8022R01137		E4.4	13.5	15.4	E8.1
FOS.4	100	105	102.5	1912.6	8022R01137		E4.8	10.3	16.9	E5.6
Lower Lake Core Site:										
FOS.2	0	10	5	2000.0	8022R01137		36.8	81.5	882	208
FOS.2	50	60	55	1965.0	8022R01137		E6.2	17.1	73.3	26.8
FOS.2	100	110	105	1920.0	8022R01137		E4.3	11.1	13.9	E9.1
FOS.2 .dup	100	110	105	1920.0	8022R01137		E4.7	12.4	15.0	10.4
Fosdic Lake Inflow SS:										
Fosdic Lake Inflow				08/11/01	8022R01235	0.107	E68.0	E139	E478	E256
Fosdic Lake Inflow				09/18/01	8022R01261	2.0	E11.8	E32.5	394	87.6
Fosdic Lake Inflow				10/10/01	8022R01261	1.0	E48.4	E52.0	609	134
Fosdic Lake Inflow				12/06/01	8022R01243	.2	E45.3	E159	955	E274

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Fluoran-thene	Pyrene	Benz(a)-anthracene	Chrysene	Benzo(a)-pyrene	Dibenzo(a,h)-anthracene	Coronene	Total PAH	Combustion PAH	(2+3)/ combustion PAH
Fosdic Lake—Continued										
Upper Lake Core Site:										
FOS.5	3,300	2,600	1,010	1,550	1,620	327	E125	27,541	17,924	0.208
FOS.5	735	586	302	332	285	50.6	E27.2	8,583	3,500	.843
Primary (Mid) Lake Core Site:										
FOS.4	1,510	1,190	487	851	799	217	E74.6	16,004	9,081	.349
FOS.4	**2,430**	**1,920**	766	1,280	1,280	300	E198	22,693	13,786	.277
FOS.4	**3,200**	**2,500**	936	**1,510**	**1,530**	328	E439	**25,873**	16,486	.244
FOS.4	1,710	1,240	601	797	670	138	E79.5	13,699	8,447	.280
FOS.4	1,050	791	314	436	396	74.7	E47.0	9,372	4,765	.473
FOS.4	410	336	126	192	180	36.8	E30.0	5,327	2,028	.815
FOS.4.dup	408	352	123	196	169	30.3	E22.9	4,882	1,963	.807
FOS.4	257	240	84.8	145	121	22.1	E16.2	4,693	1,389	1.281
FOS.4	85.8	77.3	40.3	44.8	37.6	E9.8	E10.8	1,466	498	.966
FOS.4	40.7	40.3	16.0	21.1	18.9	E5.2	E4.4	882	226	1.574
FOS.4	39.7	31.2	11.8	15.4	15.0	E4.2	E3.6	571	186	1.141
Lower Lake Core Site:										
FOS.2	**2,850**	**2,180**	806	**1,510**	1,290	283	E105	**27,245**	15,552	.358
FOS.2	315	295	69.2	128	110	21.5	12.8	4,168	1,423	1.017
FOS.2	35.6	39.3	12.9	22.9	16.4	E4.7	E7.0	1,008	216	2.086
FOS.2 .dup	39.4	43.3	14.4	25.1	18.6	E5.4	E8.3	1,122	242	2.023
Fosdic Lake Inflow SS:										
Fosdic Lake Inflow	E1,080	E954	E389	E614	E722	E205	E345	11,776	6,553	.519
Fosdic Lake Inflow	1,130	933	416	761	600	142	E103	11,866	7,170	.267
Fosdic Lake Inflow	1,730	1,300	496	1,100	775	170	E201	17,605	9,992	.305
Fosdic Lake Inflow	**3,010**	**2,350**	**1,100**	**1,880**	**1,710**	E529	E464	**29,636**	19,370	.213

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Top of interval (cm)	Bottom of interval (cm)	Mid depth of interval (cm)	Deposition date of interval or sample date	Laboratory batch number	Mass of sample	Naph-thalene	9H-Fluorene	Phenan-threne	Anthra-cene
Passive SS Sampling Sites										
Site 1, Benbrook				10/15/00	8022R01112	3.633	E24.3	E17.9	73.7	E18.0
Site 1, Benbrook				03/08/01	8022R01112	4.419	E9.3	E10.9	75.3	E18.8
Site 1, Benbrook				08/17/01	8022R01235	7.8	E1.6	<15	E7.3	E3.6
Site 2, Levee				10/15/00	8022R01112	.263	E96.2	E149	1,010	E334
Site 2, Levee				03/08/01	8022R01136	.55	E56.7	E85.0	1,240	246
Site 2, Levee				05/28/01	8022R01215	.994	E9.7	E18.3	<125	E41.2
Site 3, Como Outfall				10/15/00	8022R01112	1.176	E8.8	E28.6	132	E54.6
Site 3, Como Outfall				05/28/01	8022R01215	1.880	E3.8	E8.5	<65	E16.7
Site 4, Zoo				10/15/00	8022R01112	6.113	E12.6	21.6	202	45.8
Site 4, Zoo				03/09/01	8022R01136	3.34	40.9	64.9	1,060	184
Site 4, Zoo				05/28/01	8022R01215	2.210	E6.2	E16.5	<60	E35.7
Site 5, Downtown				10/15/00	8022R01112	1.176	444	171	**3,100**	683
Site 5, Downtown				05/04/01	8022R01215	.702	E47.4	E86.2	<200	206
Site 5, Downtown dup.				05/04/01	8022R01215	.644	E38.1	E79.9	<200	E169
Site 5, Downtown				08/16/01	8022R01235	1.2	354	403	**7,400**	**1,630**
Site 5, Downtown dup.				08/16/01	8022R01235	3.1	248	327	**4,660**	**1,110**
Site 6, Little Fossil				10/15/00	8022R01112	1.262	72	200	**4,900**	657
Site 6, Little Fossil				03/08/01	8022R01136	1.3	E108	294	**5,020**	623
Site 6, Little Fossil				05/28/01	8022R01215	2.620	E4.8	E11.6	<50	E20.9

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Fluoranthene	Pyrene	Benz(a)-anthracene	Chrysene	Benzo(a)-pyrene	Dibenzo(a,h)-anthracene	Coronene	Total PAH	Combustion PAH	(2+3)/ combustion PAH
Passive SS Sampling Sites—Continued										
Site 1, Benbrook	102	108	34.9	97	53.4	E18.7	E24.2	2,507	767	1.389
Site 1, Benbrook	168	147	E14.4	95.3	89.5	E21.0	E15.2	1,428	756	.208
Site 1, Benbrook	E10.6	E12.2	E7.5	E8.6	E8.8	<15	E6.6	266	88.4	1.224
Site 2, Levee	**3,370**	**2,620**	**1,150**	**2,060**	**1,850**	E419	E237	**34,048**	19,830	.342
Site 2, Levee	**3,640**	**2,880**	962	**2,200**	**1,970**	412	E286	**36,112**	22,512	.279
Site 2, Levee	382	<125	<260	455	<1,300	<125	65.55	16,627	3,824	1.451
Site 3, Como Outfall	477	369	183	302	268	69.3	E32.3	4,330	2,770	.159
Site 3, Como Outfall	164	<65	<100	124	<330	<65	59.62	3,488	795	1.660
Site 4, Zoo	560	431	157	276	253	41.1	E16.6	4,754	2,662	.367
Site 4, Zoo	**2,840**	**2,110**	1,040	**1,420**	1,170	255	E150	**27,472**	14,617	.403
Site 4, Zoo	489	<60	<200	412	<1,000	<60	56.22	10,764	2,512	1.669
Site 5, Downtown	**8,370**	**6,810**	**3,300**	**4,590**	**4,290**	621	E211	**76,086**	47,690	.267
Site 5, Downtown	na	<180	<1,780	2,710	<8,700	<714	119.7	**92,711**	18,050	2.096
Site 5, Downtown dup.	na	<200	<1,200	2,680	<6,800	<700	75.06	**80,287**	15,820	2.082
Site 5, Downtown	**19,700**	**15,500**	**6,800**	**11,800**	**8,250**	1,840	E2,380	**178,155**	106,930	.215
Site 5, Downtown dup.	**12,600**	**10,400**	**4,430**	**8,050**	**5,790**	1,070	E1,520	**115,844**	69,920	.218
Site 6, Little Fossil	**14,000**	**10,000**	**4,280**	**6,420**	**5,490**	605	E1,110	**88,797**	68,500	.105
Site 6, Little Fossil	**14,700**	**10,700**	**4,030**	**6,540**	**5,950**	1,120	E753	**108,221**	74,310	.166
Site 6, Little Fossil	385	<50	<150	311	<1,000	<50	55.42	11,695	2,571	1.671

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Top of interval (cm)	Bottom of interval (cm)	Mid depth of interval (cm)	Deposition date of interval or sample date	Laboratory batch number	Mass of sample	Naph-thalene	9H-Fluorene	Phenan-threne	Anthra-cene
Automated SS Sampling Sites										
Big Fossil Creek				05/04/01	8022R01136	3.8	E6.3	E10.6	95.5	E24.7
Big Fossil Creek				08/11/01	8022R01234	1.91	E14.8	E14.1	237	E60.6
Big Fossil Creek				09/18/01	8022R01261	3.3	E4.2	E8.2	E34.5	E16.4
Big Fossil Creek				10/11/01	8022R01261	2.4	E5.3	E11.2	75.4	E28.8
Sycamore Creek #1				05/04/01	na	isa	isa	isa	isa	isa
Sycamore Creek #2				05/04/01	8022R01215	2.080	E10.4	E29.6	<65	E60.1
Sycamore Creek #3				05/04/01	8022R01215	.301	E26.6	E38.7	<400	E88.8
Sycamore Creek #4&5				05/05/01	8022R01215	1.270	E8.6	E18.6	<100	E47.6
Sycamore Creek #6&7				05/05/01	8022R01164	.21	E122	E66.6	E1,140	E230
Sycamore Creek #1				08/16/01	na	isa	isa	isa	isa	isa
Sycamore Creek #2				08/16/01	8022R01235	.06	E109	E364	E811	E441
Sycamore Creek #3				08/16/01	8022R01235	.27	E35.4	E84.3	E327	E136
Sycamore Creek #4				08/16/01	8022R01235	.19	E45.1	E108	E253	E153
Sycamore Creek #1				08/30/01	8022R01261	4.0	35.6	42.6	707	185
Sycamore Creek #2				08/30/01	8022R01261	3.5	44	E18.3	293	70.2
Sycamore Creek #3				08/30/01	8022R01261	2.2	E27.4	E22.4	312	80
Sycamore Creek #4				08/30/01	8022R01235	.86	E29.1	E41.1	262	E112
Sycamore Creek #5				08/30/01	8022R01261	.3	<420	<420	E120	E88.6
Sediment-Quality Guidelines										
Threshold effects concentration (TEC)							176	77.4	204	57.2
Probable effects concentration (PEC)							561	536	1,170	845

Appendix 1.6. Selected polycyclic aromatic hydrocarbon compound concentrations in bottom and suspended sediments—Continued

Core ID or SS site	Fluoran-thene	Pyrene	Benz(a)-anthracene	Chrysene	Benzo(a)-pyrene	Dibenzo(a,h)-anthracene	Coronene	Total PAH	Combustion PAH	(2+3)/ combustion PAH
Automated SS Sampling Sites—Continued										
Big Fossil Creek	242	191	77.1	140	124	30.4	E21.2	2,818	1,354	0.546
Big Fossil Creek	E759	E577	245	550	E399	92.1	E91.0	6,306	4,647	.249
Big Fossil Creek	113	94.2	44.4	75.6	67.4	E16.3	E17.5	1,294	729	.421
Big Fossil Creek	256	198	93.2	159	142	E32.4	E18.7	2,727	1,528	.332
Sycamore Creek #1	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek #2	1,260	<250	<300	632	<1,780	<160	73.31	14,856	3,878	1.600
Sycamore Creek #3	1,210	<400	<420	595	<1,440	<400	68.79	17,558	4,589	1.463
Sycamore Creek #4&5	783	<100	<430	623	<1,700	<100	64.63	16,816	4,040	1.624
Sycamore Creek #6&7	E3,090	E2,400	988	1,780	E1,320	E210	E97.0	27,389	16,295	.239
Sycamore Creek #1	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek #2	**E2,450**	**E1,830**	**E1,230**	**E15,90**	**E1,860**	620	E868	**26,829**	18,720	.142
Sycamore Creek #3	1,070	786	E397	676	600	E173	E159	12,785	6,777	.272
Sycamore Creek #4	809	E553	E339	E448	E498	E192	E135	9,964	5,183	.349
Sycamore Creek #1	2,260	**1,740**	852	**1,290**	1,020	195	E188	20,243	12,278	.216
Sycamore Creek #2	934	749	358	595	441	98	E104	9,057	5,535	.192
Sycamore Creek #3	1,050	840	400	606	485	97.1	E92.9	9,171	5,783	.194
Sycamore Creek #4	840	1,260	406	599	1,080	121	E870	13,283	8,845	.135
Sycamore Creek #5	E381	E317	E175	E241	E258	E78.1	E99.1	4,834	2,733	.284
Sediment-Quality Guidelines										
Threshold effects concentration (TEC)	423	195	108	166	150	33		1,610		
Probable effects concentration (PEC)	2,230	1,520	1,050	1,290	1,450	na		22,800		

APPENDIX 2—
Quality Assurance

Appendix 2.1. Sample groups for organics analyses and duplicate sample relative percent differences

[OC, organochlorine; PAH, polycyclic aromatic hydrocarbon; RPD, relative percent difference]

Samples grouped for analysis	OC set number	PAH batch number	Type of duplicate(s), range and median RPD
Sites 1, 2, 3, 4, 5, and 6 (10/15/00); Site 1 (03/08/01)	7.112	8022R01112	OC: No duplicate PAH: No duplicate
Sites 2 and 6 (03/08/01); Site 4 (03/09/01); Big Fossil (05/04/01); FOS.4 20–25, 45–50, 70–75	1.1136	8022R01136	OC: 0.0–55%, 6.1% PAH: 0.5–27%, 5.0%
FOS.2 0–10, 50–60, 100–110; FOS.4 0–5, 5–10, 10–15, 30–35, 55–60, 85–90, 100–105; FOS.5 0–10, 40–50	5.1137	8022R01137	OC: No detections PAH: 7.6–17%, 11%
ECO.1 0–5, 30–35, 40–45, 55–60; ECO.3 0–5, 25–30; ECO.4 40–48, 72–80	2.1141	8022R01141	OC: 0.0–7.4%, 5.1% PAH: 0.0–46%, 1.8%
ECO.1 5–10, 10–15, 20–25, 65–70, 75–80, 90–97; ECO.3 50–55; ECO.4 0–8	1.1142	8022R01142	OC: 0.0–33%, 17% PAH: 3.2–31%, 6.1%
Sycamore #6&7 (05/05/01)	200122506	8022R01164	OC: 0.0–35%, 5.7% PAH: No duplicate
CMO.1 0–5, 5–10, 20–25, 60–65, 75–80, 90–95; CMO.3 0–10, 40–50, 90–100; CMO.5 0–10, 20–30, 40–50	200120409	8022R01205	OC: No duplicate PAH: Ruined in preparation
CMO.1 10–15, 30–35	200120107	8022R01206	OC: 0.0–17%, 6.1%; PAH: 2.3–49%, 14%
Site 5 (05/04/01); Site 5 duplicate (05/04/01); Sycamore #2 and 3 (05/04/01); Sycamore #4&5 (05/05/01); Sites 2, 3, 4, and 6 (05/28/01); Echo Lake Inflow (05/28/01)	200121505	8022R01215	OC: 16–78%, 38% PAH: 0.5–13%, 3.7%
Big Fossil (08/11/01); CMO.1 45–50	200128405	8022R01234	OC: 2.7–55%, 6.1%; PAH: 0.3–46%, 4.1%
Site 5 (08/16/01); Site 5 duplicate (08/16/01); Sycamore #2, 3, and 4 (08/16/01); Site 1 (08/17/01); Echo Lake Inflow (08/17/01); Sycamore #4 (08/30/01)	200205006	8022R01235	OC: 6.5–97%, 33% PAH: 1.4–11%, 4.1%
Fosdic Lake Inflow (08/11/01); Lake Como Inflow (11/09/01, 01/23/02)	200208407	8022R01235	OC: 4.5% PAH: 1.4–11%, 4.1%
Fosdic Lake Inflow (12/06/01)	200207706	8022R01243	OC: 2.1–129%, 4.9% PAH: 2.6–19%, 16%
Sycamore #1, 2, 3, and 5 (08/30/01); Lake Como Inflow (08/30/01, 09/20/01); Big Fossil (09/18/01, 10/11/01); Fosdic Lake Inflow (09/18/01, 10/10/01); Echo Lake Inflow (09/20/01, 10/11/01)	200207106	8022R01261	OC: No duplicate PAH: No duplicate

Appendix 2.2. Chlorinated hydrocarbon quality control samples

[In micrograms per kilogram except as noted. Bold type indicates percentage outside statistical control limits; CRM, certified reference material]

Sample ID	Set number	Technical chlordane	Dieldrin	*p,p'*-DDE	*p,p'*-DDD	*p,p'*-DDT	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260
Blank	1.1136	<5.0	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	1.1136	Not spiked	80% (20–134%)	80% (15–150%)	90% (15–142%)	56% (15–150%)	83% (15–138%)	102% (15–150%)	98% (15–150%)
CRM 354 (Acceptable range)	1.1136	251 (146–434)	231 (120–360)	152 (93–235)	163 (94–264)	282 (114–465)	Not spiked	Not spiked	Not spiked
Blank	1.1142	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	1.1142	Not spiked	53% (20–134%)	71% (15–150%)	71% (15–142%)	45% (15–150%)	78% (15–138%)	139% (15–150%)	101% (15–150%)
CRM 354 (Acceptable range)	1.1142	188 (146–434)	187 (120–360)	108 (93–235)	148 (94–264)	210 (114–465)	Not spiked	Not spiked	Not spiked
Blank	2.1141	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	2.1141	Not spiked	64% (20–134%)	83% (15–150%)	69% (15–142%)	54% (15–150%)	81% (15–138%)	131% (15–150%)	100% (15–150%)
CRM 354 (Acceptable range)	2.1141	212 (146–434)	214 (120–360)	144 (93–235)	152 (94–264)	228 (114–465)	Not spiked	Not spiked	Not spiked
Blank	5.1137	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	5.1137	Not spiked	77% (20–134%)	91% (15–150%)	89% (15–142%)	61% (15–150%)	83% (15–138%)	118% (15–150%)	98% (15–150%)
CRM 354 (Acceptable range)	5.1137	225 (146–434)	216 (120–360)	158 (93–235)	162 (94–264)	241 (114–465)	Not spiked	Not spiked	Not spiked
Blank	7.1120	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	7.1120	Not spiked	72% (20–134%)	100% (15–150%)	80% (15–142%)	63% (15–150%)	89% (15–138%)	133% (15–150%)	123% (15–150%)
CRM 354 (Acceptable range)	7.1120	178 (146–434)	212 (120–360)	139 (93–235)	162 (94–264)	279 (114–465)	Not spiked	Not spiked	Not spiked
Blank	200120107	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	200120107	Not spiked	72% (20–134%)	90% (15–150%)	88% (15–142%)	59% (15–150%)	80% (15–138%)	145% (15–150%)	102% (15–150%)
CRM 354 (Acceptable range)	200120107	Not spiked	242 (120–360)	152 (93–235)	174 (94–264)	262 (114–465)	Not spiked	Not spiked	Not spiked
Blank	200120409	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	200120409	Not spiked	66% (20–134%)	77% (15–150%)	83% (15–142%)	65% (15–150%)	84% (15–138%)	143% (15–150%)	100% (15–150%)
CRM 354 (Acceptable range)	200120409	Not spiked	195 (120–360)	130 (93–235)	148 (94–264)	249 (114–465)	Not spiked	Not spiked	Not spiked

Appendix 2.2. Chlorinated hydrocarbon quality control samples—Continued

Sample ID	Set number	Technical chlordane	Dieldrin	*p,p'*-DDE	*p,p'*-DDD	*p,p'*-DDT	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260
Blank	200121505	<5.0	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	200121505	Not spiked	66% (20–134%)	113% (15–150%)	83% (15–142%)	76% (15–150%)	106% (15–138%)	138% (15–150%)	98% (15–150%)
CRM 354 (Acceptable range)	200121505	Not spiked	185 (120–360)	166 (93–235)	150 (94–264)	223 (114–465)	Not spiked	Not spiked	Not spiked
Blank	200122506	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	200122506	Not spiked	56% (20–134%)	83% (15–150%)	67% (15–142%)	62% (15–150%)	73% (15–138%)	136% (15–150%)	96% (15–150%)
CRM 354 (Acceptable range)	200122506	Not spiked	190 (120–360)	163 (93–235)	173 (94–264)	283 (114–465)	Not spiked	Not spiked	Not spiked
Blank	200128405	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	200128405	Not spiked	67% (20–134%)	126% (15–150%)	66% (15–142%)	65% (15–150%)	112% (15–138%)	**244% (15–150%)**	145% (15–150%)
CRM 354 (Acceptable range)	200128405	Ruined in preparation							
Blank	200205006	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	200205006	Not spiked	76% (15–150%)	77% (34–140%)	72% (22–158%)	63% (15–150%)	73% (17–145%)	87% (53–150%)	80% (33–150%)
CRM 362 (Acceptable range)	200205006	Not spiked	142 (93–256)	101 (74–194)	199 (120–401)	128 (94–261)	Not spiked	Not spiked	Not spiked
Blank	200207106	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	200207106	Not spiked	94% (15–150%)	89% (34–140%)	66% (22–158%)	72% (15–150%)	77% (17–145%)	88% (53–150%)	90% (33–150%)
CRM 362 (Acceptable range)	200207106	Not spiked	165 (93–256)	115 (74–194)	182 (120–401)	155 (94–261)	Not spiked	Not spiked	Not spiked
Blank	200207706	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	200207706	Not spiked	68% (15–150%)	97% (34–140%)	61% (22–158%)	65% (15–150%)	88% (17–145%)	84% (53–150%)	94% (33–150%)
CRM 362 (Acceptable range)	200207706	Not spiked	129 (93–256)	104 (74–194)	161 (120–401)	131 (94–261)	Not spiked	Not spiked	Not spiked
Blank	200208407	<5.0	<.5	<.5	<.5	<.5	<5.0	<5.0	<5.0
Spike, % Recovery (Control limits)	200208407	Not spiked	76% (15–150%)	94% (34–140%)	52% (22–158%)	69% (15–150%)	78% (17–145%)	84% (53–150%)	86% (33–150%)
CRM 362 (Acceptable range)	200208407	Not spiked	144 (93–256)	109 (74–194)	141 (120–401)	138 (94–261)	Not spiked	Not spiked	Not spiked

Appendix 2.3. Chlorinated hydrocarbon duplicate samples

[In micrograms per kilogram except as noted; E, estimated]

Sample ID	Set number	Technical chlordane	Dieldrin	*p,p'*-DDE	*p,p'*-DDD	*p,p'*-DDT	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260
FOS.4 45–50	1.1136	47	1.6	67	E8.8	1.4	<30	170	160
FOS.4 45–50 dup	1.1136	42	1.7	65	E13	E.8	<31	170	160
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 6.1**		**11.2**	**6.1**	**3.0**	**39**	**55**		**0**	**0**
FOS.2 100–110	5.1137	<5.0	<.5	<.5	<.5	<.5	<5	<5	<5
FOS.2 100–110 dup	5.1137	<5.0	<.5	<.5	<.5	<.5	<5	<5	<5
No detections									
ECO.4 72–80	2.1141	<5.0	<.5	4.1	E13	E.6	<5	E15	E8
ECO.4 72–80 dup	2.1141	<5.0	<.5	4.4	E14	E.6	<5	E15	E7.6
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 5.1**				**7.1**	**7.4**	**0**		**0**	**5.1**
ECO.3 50–55	1.1142	220	<.5	68	E25	E1.4	110	E290	E300
ECO.3 50–55 dup	1.1142	260	<.5	74	E35	E1.8	130	E310	E300
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 16.7**		**16.7**		**8.5**	**33.3**	**25.0**	**16.7**	**6.7**	**0**
Town Lake DC	200122506	18	E.5	9.2	2.9	E2.0	<5.0	E6.6	E4.9
Town Lake DC dup	200122506	17	E.5	9.4	2.5	E1.4	<5.0	E5.6	E4.8
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 5.7**		**5.7**	**0**	**2.2**	**14.8**	**35.3**		**16.4**	**2.1**
CMO.1 30–35	200120107	330	<.8	19	36	<.5	26	77	63
CMO.1 30–35 dup	200120107	290	<.7	19	37	<.6	22	74	58
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 6.1**		13		0	2.7		16.7	4	8

Appendix 2.3. Chlorinated hydrocarbon duplicate samples—Continued

Sample ID	Set number	Technical chlordane	Dieldrin	*p,p'*-DDE	*p,p'*-DDD	*p,p'*-DDT	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260
Site 5, Downtown 05/04/01 @ 2100	200121505	E120	E4.4	E6.4	<19	<19	<190	E72	E70
Site 5, Downtown 05/04/01 @ 2100 dup	200121505	E190	E10	E9.4	<18	<18	<180	E86	E82
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 38**		**45**	**78**	**38**				**18**	**16**
CMO.1 45–50	200128405	185	1.8	E17	<.5	.85	E33	57	26
CMO.1 45–50 dup	200128405	180	2.2	E16	<.5	1.5	E34	54	23
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 6.1**		**2.7**	**20**	**6.1**		**55**	**3.0**	**5.4**	**12**
Site 5, Downtown 08/16/01 @ 0846	200205006	150	E2.0	E11	<10	E9.3	E82	310	350
Site 5, Downtown 08/16/01 @ 0847 dup	200205006	160	5.8	E9.4	<4.0	13	64	470	230
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 33**		**6.5**	**97**	**16**		**33**	**25**	**41**	**41**
Onion Crk. 11/15/01 @ 1500	200208407	<10	<1.0	E.43	<1.0	<1.0	<10	<10	<10
Onion Crk. 11/15/01 @ 1500 dup	200208407	<10	<1.0	E.45	<1.0	<1.0	<10	<10	<10
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 4.5**				**4.5**					
LKH.5 0–5	200207706	<20	<2.0	4.9	E3.3	E5.4	E15	<20	<20
LKH.5 0–5 dup	200207706	<20	<2.0	4.8	E3.4	E25	E14	<20	<20
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 4.9**				**2.1**	**3.0**	**129**	**6.9**		

Appendix 2.4. Polycyclic aromatic hydrocarbon quality control samples

[In micrograms per kilogram except as noted. Bold type indicates detection; E, estimated; CRM, certified reference material]

Sample ID	Batch number	Naphtha-lene	9H-fluorene	Phenan-threne	Anthra-cene	Fluoran-thene	Pyrene	Benz(a)-anthra-cene	Chry-sene	Benzo(a)-pyrene	Coro-nene
Blank	8022R01112	**E0.29**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01112	62.77	57.51	65.05	60.11	71.72	73.41	64.32	70.41	67.20	E38.58
CRM 354 (Acceptable range)	8022R01112	55.14 (15–95)		77.74 (39–94)	50.18 (18–95)	87.23 (33–90)	84.57 (32–90)		75.75 (41–90)		
Blank	8022R01136	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01136	57.78	65.85	70.78	62.03	84.84	84.24	91.76	80.22	74.09	E43.00
CRM 354 (Acceptable range)	8022R01136	46.15 (15–95)		82.44 (39–94)	50.40 (18–95)	87.77 (33–90)	84.57 (32–90)		78.98 (41–90)		
Blank	8022R01137	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01137	62.17	69.54	71.17	54.21	81.42	80.50	65.68	71.12	66.69	E57.20
CRM 354 (Acceptable range)	8022R01137	54.53 (15–95)		75.76 (39–94)	46.21 (18–95)	85.52 (33–90)	83.98 (32–90)		72.02 (41–90)		
Blank	8022R01141	**E.28**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01141	69.68	61.95	73.08	60.74	73.97	73.34	72.77	78.45	60.47	E30.01
CRM 354 (Acceptable range)	8022R01141	43.33 (15–95)		73.72 (39–94)	43.23 (18–95)	74.30 (33–90)	72.14 (32–90)		75.39 (41–90)		
Blank	8022R01142	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01142	34.57	45.20	64.77	55.22	75.08	75.20	72.87	82.45	64.24	E32.76
CRM 354 (Acceptable range)	8022R01142	34.45(15–95)		64.48(39–94)	40.19(18–95)	79.57(33–90)	78.14(32–90)		79.84(41–90)		
Blank	8022R01164	**E.085**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01164	52.95	63.50	67.84	41.83	68.06	65.90	64.97	75.63	46.31	E27.30
CRM 354 (Acceptable range)	8022R01164	40.99(15–95)		67.83(39–94)	35.65(18–95)	78.23(33–90)	75.13(32–90)		76.64(41–90)		
Blank	8022R01205	**E.17**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01205	51.65	62.72	64.42	50.02	67.27	67.92	87.29	86.57	62.24	E17.84
CRM 354 (Acceptable range)	8022R01205	35.37(15–95)		75.59(39–94)	42.99(18–95)	76.59(33–90)	72.48(32–90)		89.58(41–90)		

Appendix 2.4. Polycyclic aromatic hydrocarbon quality control samples—Continued

Sample ID	Batch number	Naphtha-lene	9H-fluorene	Phenan-threne	Anthra-cene	Fluoran-thene	Pyrene	Benz(a)-anthra-cene	Chry-sene	Benzo(a)-pyrene	Coro-nene
Blank	8022R01206	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01206	57.44	62.25	66.70	53.67	66.29	65.60	73.57	88.91	64.87	E20.74
CRM 354 (Acceptable range)	8022R01206	38.75(15–95)		60.11(39–94)	37.40(18–95)	66.83(33–90)	64.73(32–90)		81.60(41–90)		
Blank	8022R01215	**E.020**	<5	**E.16**	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01215	60.22	60.00	63.88	53.26	68.50	68.91	72.53	74.48	66.84	E18.37
CRM 354 (Acceptable range)	8022R01215	37.18(15–95)		62.45(39–94)	37.24(18–95)	66.69(33–90)	65.93(32–90)		67.19(41–90)		
Blank	8022R01234	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01234	67.29	67.01	72.40	50.62	E69.34	E67.77	65.44	78.54	E44.38	E43.99
CRM 354	8022R01234	Ruined in preparation							Ruined in preparation		
Blank	8022R01235	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01235	67.20	79.37	75.51	67.44	78.30	76.56	96.79	84.76	72.56	E60.56
CRM 362 (Acceptable range)	8022R01235	52.92 (0–117)		65.92 (44–124)	52.64 (38–105)	70.99 (43–125)	68.25 (32–139)		73.43 (42–126)	48.11 (39–104)	
Blank	8022R01243	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01243	67.69	62.31	68.05	60.28	75.75	76.80	74.30	71.31	59.98	E29.45
CRM 362 (Acceptable range)	8022R01243	59.18 (0–117)		69.14 (44–124)	59.24 (38–105)	76.88 (43–125)	75.44 (32–139)		67.79 (42–126)	52.20 (39–104)	
Blank	8022R01261	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R01261	55.23	64.91	71.44	67.40	80.86	81.86	80.39	79.81	67.52	E54.50
CRM 362 (Acceptable range)	8022R01261	54.65 (0–117)		74.50 (44–124)	60.30 (38–105)	82.70 (43–125)	81.29 (32–139)		74.92 (42–126)	52.82 (39–104)	
Blank	8022R02192	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Spike, % Recovery	8022R02192	61.82	68.26	72.47	62.92	72.81	72.41	74.85	76.93	61.30	E42.13
CRM 362 (Acceptable range)	8022R02192	43.38 (0–117)		63.45 (44–124)	50.36 (38–105)	66.23 (43–125)	65.12 (32–139)		62.13 (42–126)	42.86 (39–104)	

Appendix 2.5. Polycyclic aromatic hydrocarbon duplicate samples

[In micrograms per kilogram except as noted; E, estimated]

Sample ID	Batch number	Naphtha-lene	9H-fluorene	Phenan-threne	Anthra-cene	Fluoran-thene	Pyrene	Benz(a)-anthra-cene	Chry-sene	Benzo(a)-pyrene	Coro-nene
FOS.4 45–50	8022R01136	E8.6	25.9	156	41.8	410	336	126	192	180	E30.0
FOS.4 45–50 dup.	8022R01136	E8.3	27.7	148	38.5	408	352	123	196	169	E22.9
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 5.0**		**3.6**	**6.7**	**5.3**	**8.2**	**.5**	**4.7**	**2.4**	**2.1**	**6.3**	**27**
FOS.2 100–110	8022R01137	E4.3	11.1	13.9	E9.1	35.6	39.3	12.9	22.9	16.4	E7.0
FOS.2 100–110 dup.	8022R01137	E4.7	12.4	15.0	10.4	39.4	43.3	14.4	25.1	18.6	E8.3
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 11**		**8.9**	**11**	**7.6**	**13**	**10**	**9.7**	**11**	**9.2**	**13**	**17**
ECO.4 72–80	8022R01141	10.4	18.7	126	48.0	300	262	165	188	163	E20.5
ECO.4 72–80 dup.	8022R01141	E8.8	18.2	124	47.9	290	257	165	185	162	E12.8
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 1.8**		**17**	**2.7**	**1.6**	**.2**	**3.4**	**1.9**	**0**	**1.6**	**.6**	**46**
ECO.3 50–55	8022R01142	68.7	77.6	752	145	1,120	904	553	762	534	E27.9
ECO.3 50–55 dup.	8022R01142	50.5	70.9	721	132	1,190	961	571	791	564	E29.8
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 6.1**		**31**	**9.0**	**4.2**	**9.4**	**6.1**	**6.1**	**3.2**	**3.7**	**5.5**	**6.6**
CMO.1 30–35	8022R01206	17.8	57.6	537	131	1,180	938	754	889	629	E52.7
CMO.1 30–35 dup.	8022R01206	17.0	63.4	484	134	1,020	802	495	731	550	E31.8
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 14**		**4.6**	**10**	**10**	**2.3**	**15**	**16**	**41**	**20**	**13**	**49**
Town Lake in Austin, TX	8022R01215	18.2	44.2	618	146	2,690	2,120	1,040	1,720	1,400	E93.0
Town Lake in Austin, TX dup.	8022R01215	18.3	44.9	640	151	2,780	2,220	1,110	1,790	1,490	E81.6
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 3.7**		**.5**	**1.6**	**3.5**	**3.4**	**3.3**	**4.6**	**6.5**	**4.0**	**6.2**	**13**

Appendix 2.5. Polycyclic aromatic hydrocarbon duplicate samples—Continued

Sample ID	Batch number	Naphtha-lene	9H-fluorene	Phenan-threne	Anthra-cene	Fluoran-thene	Pyrene	Benz(a)-anthra-cene	Chry-sene	Benzo(a)-pyrene	Coro-nene
CMO.1 45–50	8022R01234	21.1	71.1	745	188	E2,020	E1,540	730	1,120	E800	E119
CMO.1 45–50 dup.	8022R01234	21.5	69.7	715	183	E1,900	E1,430	701	1,070	E798	E74.2
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 4.1		**1.9**	**2.0**	**4.1**	**2.7**	**6.1**	**7.4**	**4.1**	**4.6**	**.3**	**46**
Busse Lake nr Chicago, IL	8022R01235	67.5	274	1,660	437	9,970	6,860	2,820	4,570	3,540	E624
Busse Lake nr Chicago, IL dup.	8022R01235	70	287	1,820	487	10,500	7,090	2,910	4,670	3,590	E694
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 4.1		**3.6**	**4.6**	**9.2**	**10.8**	**5.2**	**3.3**	**3.1**	**2.2**	**1.4**	**11**
Lake in the Hills nr Chicago, IL	8022R01243	E11.2	63.3	302	84.2	796	538	281	348	357	E51.0
Lake in the Hills nr Chicago, IL dup.	8022R01243	E9.5	60.1	256	71.2	675	456	233	339	301	E42.9
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 16		**16.4**	**5.2**	**16.5**	**16.7**	**16.5**	**16.5**	**18.7**	**2.6**	**17.0**	**17**
Town Lake in Austin, TX	8022R02192	E1.9	E1.9	E4.8	E5.8	20	19.4	11.2	13.8	12	E3.0
Town Lake in Austin, TX dup.	8022R02192	E1.7	E2.5	E7.1	E8.1	27.1	25.8	16	22.9	15.2	E3.2
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 29		**11**	**27**	**39**	**33**	**30**	**28**	**35**	**50**	**24**	**6.5**

Appendix 2.6. Sample groups for major and trace element analyses and duplicate and triplicate sample relative percent differences

[RPD, relative percent difference]

Samples grouped for analysis	Batch number	Range and median RPD	Comment
All Lake Como samples	3427	0.0–14.6%, 14.6%	Comparisons of 3 triplicate samples
All Echo Lake samples	3202	0.0–9.8%, 2.4 %	Comparisons of 3 triplicate samples
FOS.4 0–5, 5–10, 10–15, 20–25, 30–35, 45–50	3186	0.0–21.4%, 4.4%	Comparisons of 3 triplicate samples
FOS.4 55–60, 70–75, 85–90, 100–105, 105–112; FOS.2 0–10, 50–60, 100–110; FOS.5 0–10, 50–60, 80–90	3188	0.0–4.3%, 0.9%	Comparisons of 3 triplicate samples
Sites 1, 3, 4, 5, and 6 (10/15/00); Sycamore #2 (05/04/01); Sycamore #4&5 and 6&7 (05/05/01)	3209	0.0–8.4%, 1.3%	Comparisons of 3 triplicate samples
Site 2 (10/15/01); Big Fossil (05/04/01)	3210	0.0–15.4%, 2.1%	Comparisons of 3 triplicate samples
Sites 2, 3, 4, and 6 (05/28/01); Echo Lake Inflow (05/28/01, 08/17/01, 09/20/01); Site 5 (08/16/01); Site 5 duplicate (08/16/01); Sycamore #1, 3, and 4 (08/16/01); Site 1 (08/17/01)	3711	0.0–10.5%, 2.6%	Comparisons of duplicate samples and 3 triplicate samples
Sites 1 and 6 (03/08/01); Site 4 (03/09/01)	3201	0.0–9.2%, 2.4%	Comparisons of 3 triplicate samples
Site 5 (05/04/01); Site 5 duplicate (05/04/01); Sycamore #1 or #3? (05/04/01)	3342	0.0–24.9%, 16.3%	Comparison of duplicate samples
Big Fossil (08/11/01, 09/18/01, 10/11/01); Fosdic Lake Inflow (08/11/01, 09/18/01, 10/10/01); Lake Como Inflow (08/30/01, 09/20/01, 11/09/01); Sycamore #2 (08/16/01); Sycamore #1, 2, 3, 4, and 5 (08/30/01); Echo Lake Inflow (10/11/01)	3744	9.0–16.2%, 11.8%	Comparison of duplicate samples
Fosdic Lake Inflow (12/16/01)	3784	0.0–6.2%, 1.0%	Comparison of duplicate samples
Lake Como Inflow (01/23/02)	3818	0.0–4.0%, 1.3%	Comparison of duplicate samples

Appendix 2.7. Major and trace element quality control samples

[In micrograms per gram except as noted; RPD, relative percent difference]

Sample ID	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium	Phosphorus	Titanium	Arsenic	Barium	Beryllium	Cadmium
Batch No. 3202												
MAG-1 found	85,400	9,840	48,500	30,600	18,100	28,000	746	4,290	9.81	513	3.24	0.340
MAG-1 true (Potts and others, 1992)	86,660	9,790	47,600	29,500	18,090	28,400	711	4,500	9.2	479	3.20	.20
Relative Percent Difference	**1.5**	**.5**	**1.9**	**3.7**	**.1**	**1.4**	**4.8**	**4.8**	**6.4**	**6.9**	**1.2**	**50.9**
Percent Recovery	**98.5**	**100.5**	**101.9**	**103.7**	**100.1**	**98.6**	**104.9**	**95.3**	**106.6**	**107.1**	**101.3**	**168.3**
NIST 2704 found	60,200	24,400	40,700	19,100	12,600	5,730	1,000	3,000	22.2	428	2.08	3.78
NIST 2704 true (Potts and others, 1992)	61,090	26,000	41,100	20,000	12,000	5,470	1,000	4,580	23.4	414		3.45
Relative Percent Difference	**1.5**	**6.3**	**1.0**	**4.6**	**4.9**	**4.6**	**0**	**41.7**	**5.3**	**3.3**		**9.1**
Percent Recovery	**98.5**	**93.8**	**99.0**	**95.5**	**105.0**	**104.8**	**100.0**	**65.5**	**94.9**	**103.4**		**109.6**
SCO-1 found	72,700	17,400	37,200	22,300	17,400	6,840	934	3,940	12.6	614	1.98	.173
SCO-1 true (Potts and others, 1992)	72,370	18,700	35,900	23,000	16,400	6,670	899	3,760	12.4	570	1.84	.14
Relative Percent Difference	**.5**	**7.2**	**3.6**	**3.1**	**5.9**	**2.5**	**3.8**	**4.7**	**1.6**	**7.4**	**7.3**	**21.1**
Percent Recovery	**100.5**	**93.0**	**103.6**	**97.0**	**106.1**	**102.5**	**103.9**	**104.8**	**101.6**	**107.7**	**107.6**	**123.6**
GSD-8 found	40,600	1,460	14,400	21,700	1,770	3,590	138	3,970	2.80	482	2.26	.063
GSD-8 true (Potts and others, 1992)	40,800	1,790	15,380	23,500	1,510	3,490	130	3,660	2.4	480	2.00	.08
Relative Percent Difference	**.5**	**20.3**	**6.6**	**8.0**	**15.9**	**2.8**	**6.0**	**8.1**	**15.4**	**.4**	**12.2**	**25.0**
Percent Recovery	**99.5**	**81.6**	**93.6**	**92.3**	**117.2**	**102.9**	**106.2**	**108.5**	**116.7**	**100.4**	**113.0**	**77.8**
Median RPD	**1.0**	**6.8**	**2.7**	**4.1**	**5.4**	**2.7**	**4.3**	**6.5**	**5.8**	**5.1**	**7.3**	**23.0**
Mean % Recovery	**99.3**	**92.2**	**99.5**	**97.1**	**107.1**	**102.2**	**103.7**	**93.5**	**104.9**	**104.7**	**107.3**	**119.8**
Batch Nos. 3188 & 3186												
MAG-1 found	80,600	9,750	47,300	29,200	18,000	28,400	696	4,050	9.26	513	3.34	.290
MAG-1 true (Potts and others, 1992)	86,660	9,790	47,600	29,500	18,090	28,400	711	4,500	9.2	479	3.20	.20
Relative Percent Difference	**7.2**	**.4**	**.6**	**1.0**	**.5**	**0**	**2.1**	**10.5**	**.7**	**6.9**	**4.3**	**35.8**
Percent Recovery	**93.0**	**99.6**	**99.4**	**99.0**	**99.5**	**100.0**	**97.9**	**90.0**	**100.7**	**107.1**	**104.4**	**143.6**
NIST 2704 found	58,400	25,600	41,000	19,900	12,000	5,630	989	3,000	22.3	428	1.89	3.50
NIST 2704 true (Potts and others, 1992)	61,090	26,000	41,100	20,000	12,000	5,470	1,000	4,580	23.4	414		3.45
Relative Percent Difference	**4.5**	**1.6**	**.2**	**.5**	**0**	**2.9**	**1.1**	**41.7**	**4.8**	**3.3**		**1.4**
Percent Recovery	**95.6**	**98.5**	**99.8**	**99.5**	**100.0**	**102.9**	**98.9**	**65.5**	**95.3**	**103.4**		**101.4**
SCO-1 found	68,300	18,100	35,800	22,300	15,800	6,540	900	3,620	13.0	593	1.81	.147
SCO-1 true (Potts and others, 1992)	72,370	18,700	35,900	23,000	16,400	6,670	899	3,760	12.4	570	1.84	.14
Relative Percent Difference	**5.8**	**3.3**	**.3**	**3.1**	**3.7**	**2.0**	**.1**	**3.8**	**4.7**	**4.0**	**1.6**	**4.9**
Percent Recovery	**94.4**	**96.8**	**99.7**	**97.0**	**96.3**	**98.1**	**100.1**	**96.3**	**104.8**	**104.0**	**98.4**	**105.0**
GSD-8 found	38,900	2,030	12,600	24,600	1,480	3,090	126	3,940	2.48	458	2.07	.028
GSD-8 true (Potts and others, 1992)	40,800	1,790	15,380	23,500	1,510	3,490	130	3,660	2.4	480	2.00	.08
Relative Percent Difference	**4.8**	**12.6**	**19.9**	**4.6**	**2.0**	**12.2**	**3.1**	**7.4**	**3.3**	**4.7**	**3.4**	**97.2**
Percent Recovery	**95.3**	**113.4**	**81.9**	**104.7**	**98.0**	**88.5**	**96.9**	**107.7**	**103.3**	**95.4**	**103.5**	**34.6**
Median RPD	**5.3**	**2.4**	**.5**	**2.1**	**1.3**	**2.4**	**1.6**	**8.9**	**4.0**	**4.3**	**3.4**	**20.3**
Mean % Recovery	**94.6**	**102.1**	**95.2**	**100.0**	**98.5**	**97.4**	**98.5**	**89.9**	**101.0**	**102.5**	**102.1**	**96.1**

Appendix 2.7. Major and trace element quality control samples—Continued

Sample ID	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium	Phosphorus	Titanium	Arsenic	Barium	Beryllium	Cadmium
Batch No. 3744												
MAG-1 found	89,975	10,350	49,725	31,225	19,825	30,225	757	4,523	10	501	3	0
MAG-1 true (Potts and others, 1992)	86,660	9,790	47,600	29,500	18,090	28,400	711	4,500	9.2	479	3.20	.20
Relative Percent Difference	**3.8**	**5.6**	**4.4**	**5.7**	**9.2**	**6.2**	**6.3**	**.5**	**5.7**	**4.5**	**4.7**	**20.1**
Percent Recovery	**103.8**	**105.7**	**104.5**	**105.8**	**109.6**	**106.4**	**106.5**	**100.5**	**105.9**	**104.6**	**104.8**	**122.4**
NIST 2704 found	61,950	26,350	41,000	20,100	13,300	6,060	1,010	3,090	22	429	2	4
NIST 2704 true (Potts and others, 1992)	61,090	26,000	41,100	20,000	12,000	5,470	1,000	4,580	23.4	414		3.45
Relative Percent Difference	**1.4**	**1.3**	**.2**	**.5**	**10.3**	**10.2**	**1.0**	**38.9**	**6.4**	**3.4**		**4.1**
Percent Recovery	**101.4**	**101.3**	**99.8**	**100.5**	**110.8**	**110.8**	**101.0**	**67.5**	**93.8**	**103.5**		**104.2**
SCO-1 found	73,800	18,700	367,50	23,000	17,800	7,065	951	3,790	13	602	2	0
SCO-1 true (Potts and others, 1992)	72,370	18,700	359,00	23,000	16,400	6,670	899	3,760	12.4	570	1.84	.14
Relative Percent Difference	**2.0**	**0**	**2.3**	**0**	**8.2**	**5.8**	**5.6**	**.8**	**3.2**	**5.4**	**13.9**	**12.1**
Percent Recovery	**102.0**	**100.0**	**102.4**	**100.0**	**108.5**	**105.9**	**105.7**	**100.8**	**103.2**	**105.5**	**114.9**	**112.9**
GSD-8 found	40,750	1,545	15,600	24,100	1,525	3,320	129	4,145	3	459	2	0
GSD-8 true (Potts and others, 1992)	40,800	1,790	15,380	23,500	1,510	3,490	130	3,660	2.40	480	2.00	.08
Relative Percent Difference	**.1**	**14.7**	**1.4**	**2.5**	**1.0**	**5.0**	**.8**	**12.4**	**12.5**	**4.5**	**9.8**	**39.1**
Percent Recovery	**99.9**	**86.3**	**101.4**	**102.6**	**101.0**	**95.1**	**99.2**	**113.3**	**113.3**	**95.6**	**110.3**	**67.3**
Median % Difference	**1.7**	**3.4**	**1.9**	**1.5**	**8.7**	**6.0**	**3.3**	**6.6**	**6.0**	**4.5**	**9.8**	**16.1**
Mean % Recovery	**101.8**	**98.3**	**102.0**	**102.2**	**107.5**	**104.6**	**103.1**	**95.5**	**104.1**	**102.3**	**110.0**	**101.7**
Batch No. 3201												
MAG-1 found	85,400	9,840	48,500	30,600	18,100	28,000	746	4,290	9.81	513	3.24	.340
MAG-1 true (Potts and others, 1992)	86,660	9,790	47,600	29,500	18,090	28,400	711	4,500	9.2	479	3.20	.20
Relative Percent Difference	**1.5**	**.5**	**1.9**	**3.7**	**.1**	**1.4**	**4.8**	**4.8**	**6.4**	**6.9**	**1.2**	**50.9**
Percent Recovery	**98.5**	**100.5**	**101.9**	**103.7**	**100.1**	**98.6**	**104.9**	**95.3**	**106.6**	**107.1**	**101.3**	**168.3**
NIST 2704 found	60,200	24,400	40,700	19,100	12,600	5,730	1,000	3,000	22.2	428	2.08	3.78
NIST 2704 true (Potts and others, 1992)	61,090	26,000	41,100	20,000	12,000	5,470	1,000	4,580	23.4	414		3.45
Relative Percent Difference	**1.5**	**6.3**	**1.0**	**4.6**	**4.9**	**4.6**	**0**	**41.7**	**5.3**	**3.3**		**9.1**
Percent Recovery	**98.5**	**93.8**	**99.0**	**95.5**	**105.0**	**104.8**	**100.0**	**65.5**	**94.9**	**103.4**		**109.6**
SCO-1 found	72,700	17,400	37,200	22,300	17,400	6,840	934	3,940	12.6	614	1.98	.173
SCO-1 true (Potts and others, 1992)	72,370	18,700	35,900	23,000	16,400	6,670	899	3,760	12.4	570	1.84	.14
Relative Percent Difference	**.5**	**7.2**	**3.6**	**3.1**	**5.9**	**2.5**	**3.8**	**4.7**	**1.6**	**7.4**	**7.3**	**21.1**
Percent Recovery	**100.5**	**93.0**	**103.6**	**97.0**	**106.1**	**102.5**	**103.9**	**104.8**	**101.6**	**107.7**	**107.6**	**123.6**
GSD-8 found	40,600	1,460	14,400	21,700	1,770	3,590	138	3,970	2.80	482	2.26	.063
GSD-8 true (Potts and others, 1992)	40,800	1,790	15,380	23,500	1,510	3,490	130	3,660	2.4	480	2.00	.08
Relative Percent Difference	**.5**	**20.3**	**6.6**	**8.0**	**15.9**	**2.8**	**6.0**	**8.1**	**15.4**	**.4**	**12.2**	**25.0**
Percent Recovery	**99.5**	**81.6**	**93.6**	**92.3**	**117.2**	**102.9**	**106.2**	**108.5**	**116.7**	**100.4**	**113.0**	**77.8**
Median % Difference	**1.0**	**6.8**	**2.7**	**4.1**	**5.4**	**2.7**	**4.3**	**6.5**	**5.8**	**5.1**	**7.3**	**23.0**
Mean % Recovery	**99.3**	**92.2**	**99.5**	**97.1**	**107.1**	**102.2**	**103.7**	**93.5**	**104.9**	**104.7**	**107.3**	**119.8**

Appendix 2.7. Major and trace element quality control samples—Continued

Sample ID	Alumi-num	Cal-cium	Iron	Potas-sium	Mag-nesium	Sod-ium	Phos-phorus	Tita-nium	Arse-nic	Bar-ium	Beryl-lium	Cad-mium
Batch Nos. 3209 & 3210												
NIST 2704 found	61,750	25,650	42,450	19,900	12,850	5,720	1,021	3,235	22.35	421	1.955	3.53
NIST 2704 true (Potts and others, 1992)	61,090	26,000	41,100	20,000	12,000	5,470	1,000	4,580	23.4	414		3.45
Relative Percent Difference	**1.1**	**1.4**	**3.2**	**.5**	**6.8**	**4.5**	**2.1**	**34.4**	**4.6**	**1.7**		**2.3**
Percent Recovery	**101.1**	**98.7**	**103.3**	**99.5**	**107.1**	**104.6**	**102.1**	**70.6**	**95.5**	**101.7**		**102.3**
SCo-1 found	74,700	18,700	38,150	22,750	17,600	6,895	981	3,925	13.35	598	1.945	.1795
SCo-1 true (Potts and others, 1992)	72,370	18,700	35,900	23,000	16,400	6,670	899	3,760	12.4	570	1.84	.14
Relative Percent Difference	**3.2**	**0**	**6.1**	**1.1**	**7.1**	**3.3**	**8.7**	**4.3**	**7.4**	**4.8**	**5.5**	**24.7**
Percent Recovery	**103.2**	**100.0**	**106.3**	**98.9**	**107.3**	**103.4**	**109.1**	**104.4**	**107.7**	**104.9**	**105.7**	**128.2**
GSD-8 found	42,500	1,675	14,100	23,800	1,640	3,350	138.5	3,960	3	462	1.91	.0585
GSD-8 true (Potts and others, 1992)	40,800	1,790	15,380	23,500	1,510	3,490	130	3,660	2.4	480	2.00	.08
Relative Percent Difference	**4.1**	**6.6**	**8.7**	**1.3**	**8.3**	**4.1**	**6.3**	**7.9**	**22.2**	**3.8**	**4.6**	**32.3**
Percent Recovery	**104.2**	**93.6**	**91.7**	**101.3**	**108.6**	**96.0**	**106.5**	**108.2**	**125.0**	**96.3**	**95.5**	**72.2**
Median % Difference	**3.2**	**1.4**	**6.1**	**1.1**	**7.1**	**4.1**	**6.3**	**7.9**	**7.4**	**3.8**	**5.1**	**24.7**
Mean % Recovery	**102.8**	**97.4**	**100.4**	**99.9**	**107.7**	**101.3**	**105.9**	**94.4**	**109.4**	**101.0**	**100.6**	**100.9**
Batch Nos. 3342 & 3427												
MAG-1 found	91,000	10,400	51,100	31,900	19,000	29,600	786	4,900	10.4	487	3.21	.225
MAG-1 true (Potts and others, 1992)	86,660	9,790	47,600	29,500	18,090	28,400	711	4,500	9.2	479	3.20	.20
Relative Percent Difference	**4.9**	**6.0**	**7.1**	**7.8**	**4.9**	**4.1**	**10.0**	**8.5**	**12.2**	**1.7**	**.3**	**10.8**
Percent Recovery	**105.0**	**106.2**	**107.4**	**108.1**	**105.0**	**104.2**	**110.5**	**108.9**	**113.0**	**101.7**	**100.3**	**111.4**
NIST 2704 found	63,900	26,800	42,200	20,500	12,200	5,710	1,060	3,250	22.3	402	1.90	3.50
NIST 2704 true (Potts and others, 1992)	61,090	26,000	41,100	20,000	12,000	5,470	1,000	4,580	23.4	414		3.45
Relative Percent Difference	**4.5**	**3.0**	**2.6**	**2.5**	**1.7**	**4.3**	**5.8**	**34.0**	**4.8**	**2.9**		**1.4**
Percent Recovery	**104.6**	**103.1**	**102.7**	**102.5**	**101.7**	**104.4**	**106.0**	**71.0**	**95.3**	**97.1**		**101.4**
SCO-1 found	76,300	19,200	37,800	23,900	16,400	6,580	991	4,060	13.0	570	1.79	.149
SCO-1 true (Potts and others, 1992)	72,370	18,700	35,900	23,000	16,400	6,670	899	3,760	12.4	570	1.84	.14
Relative Percent Difference	**5.3**	**2.6**	**5.2**	**3.8**	**0**	**1.4**	**9.7**	**7.7**	**4.7**	**0**	**2.8**	**6.2**
Percent Recovery	**105.4**	**102.7**	**105.3**	**103.9**	**100.0**	**98.7**	**110.2**	**108.0**	**104.8**	**100.0**	**97.3**	**106.4**
GSD-8 found	43,400	1,550	15,600	25,000	1,360	2,970	145	4,070	2.88	414	1.73	.194
GSD-8 true (Potts and others, 1992)	40,800	1,790	15,380	23,500	1,510	3,490	130	3,660	2.4	480	2.00	.08
Relative Percent Difference	**6.2**	**14.4**	**1.4**	**6.2**	**10.5**	**16.1**	**10.9**	**10.6**	**18.2**	**14.8**	**14.5**	**82.2**
Percent Recovery	**106.4**	**86.6**	**101.4**	**106.4**	**90.1**	**85.1**	**111.5**	**111.2**	**120.0**	**86.3**	**86.5**	**239.5**
Median % Difference	**5.1**	**4.5**	**3.9**	**5.0**	**3.3**	**4.2**	**9.9**	**9.6**	**8.5**	**2.3**	**2.8**	**8.5**
Mean % Recovery	**105.4**	**99.6**	**104.2**	**105.2**	**99.2**	**98.1**	**109.6**	**99.8**	**108.3**	**96.3**	**94.7**	**139.7**

Appendix 2.7. Major and trace element quality control samples—Continued

Sample ID	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium	Phosphorus	Titanium	Arsenic	Barium	Beryllium	Cadmium
Batch No. 3711												
MAG-1 found	88,200	10,000	49,400	31,000	19,400	30,000	766	4,090	10.4	517	3.28	0.228
MAG-1 true (Potts and others, 1992)	86,660	9,790	47,600	29,500	18,090	28,400	711	4,500	9.2	479	3.20	.20
Relative Percent Difference	**1.8**	**2.1**	**3.7**	**5.0**	**7.0**	**5.5**	**7.4**	**9.5**	**12.2**	**7.6**	**2.5**	**12.1**
Percent Recovery	**101.8**	**102.1**	**103.8**	**105.1**	**107.2**	**105.6**	**107.7**	**90.9**	**113.0**	**107.9**	**102.5**	**112.9**
NIST 2704 found	61,700	26,400	40,700	20,000	12,200	5,650	1,020	3,230	22.8	419	1.90	3.56
NIST 2704 true (Potts and others, 1992)	61,090	26,000	41,100	20,000	12,000	5,470	1,000	4,580	23.4	414		3.45
Relative Percent Difference	**1.0**	**1.5**	**1.0**	**0**	**1.7**	**3.2**	**2.0**	**34.6**	**2.6**	**1.2**		**3.1**
Percent Recovery	**101.0**	**101.5**	**99.0**	**100.0**	**101.7**	**103.3**	**102.0**	**70.5**	**97.4**	**101.2**		**103.2**
SCO-1 found	73,200	18,400	36,300	23,100	15,900	6,380	926	3,560	12.9	589	1.96	.156
SCO-1 true (Potts and others, 1992)	72,370	18,700	35,900	23,000	16,400	6,670	899	3,760	12.4	570	1.84	.14
Relative Percent Difference	**1.1**	**1.6**	**1.1**	**.4**	**3.1**	**4.4**	**3.0**	**5.5**	**4.0**	**3.3**	**6.3**	**10.8**
Percent Recovery	**101.1**	**98.4**	**101.1**	**100.4**	**97.0**	**95.7**	**103.0**	**94.7**	**104.0**	**103.3**	**106.5**	**111.4**
GSD-8 found	40,200	1,470	15,100	24,000	1,470	3,050	129	3,620	2.89	447	2.12	.043
GSD-8 true (Potts and others, 1992)	40,800	1,790	15,380	23,500	1,510	3,490	130	3,660	2.4	480	2.00	.08
Relative Percent Difference	**1.5**	**19.6**	**1.8**	**2.1**	**2.7**	**13.5**	**.8**	**1.1**	**18.5**	**7.1**	**5.8**	**61.3**
Percent Recovery	**98.5**	**82.1**	**98.2**	**102.1**	**97.4**	**87.4**	**99.2**	**98.9**	**120.4**	**93.1**	**106.0**	**53.1**
Median % Difference	**1.3**	**1.9**	**1.5**	**1.3**	**2.9**	**5.0**	**2.5**	**7.5**	**8.1**	**5.2**	**5.8**	**11.5**
Mean % Recovery	**100.6**	**96.1**	**100.5**	**101.9**	**100.8**	**98.0**	**103.0**	**88.8**	**108.7**	**101.4**	**105.0**	**95.1**
Batch No. 3818												
NIST 2704 found	63,100	26,900	41,800	20,600	12,600	5,510	1,000	3,200	22.5	421	2.27	3.71
NIST 2704 true (Potts and others, 1992)	61,090	26,000	41,100	20,000	12,000	5,470	1,000	4,580	23.4	414		3.45
Relative Percent Difference	**3.2**	**3.4**	**1.7**	**3.0**	**4.9**	**.7**	**0**	**35.5**	**3.9**	**1.7**		**7.3**
Percent Recovery	**103.3**	**103.5**	**101.7**	**103.0**	**105.0**	**100.7**	**100.0**	**69.9**	**96.2**	**101.7**		**107.5**
SCO-1 found	75,700	19,400	38,400	23,600	17,300	6,660	963	3,790	13.0	593	2.15	.162
SCO-1 true (Potts and others, 1992)	72,370	18,700	35,900	23,000	16,400	6,670	899	3,760	12.4	570	1.84	.14
Relative Percent Difference	**4.5**	**3.7**	**6.7**	**2.6**	**5.3**	**.2**	**6.9**	**.8**	**4.7**	**4.0**	**15.5**	**14.6**
Percent Recovery	**104.6**	**103.7**	**107.0**	**102.6**	**105.5**	**99.9**	**107.1**	**100.8**	**104.8**	**104.0**	**116.8**	**115.7**
GSD-8 found	41,600	1,560	15,800	24,500	1,620	3,290	127	3,830	2.79	446	2.36	.101
GSD-8 true (Potts and others, 1992)	40,800	1,790	15,380	23,500	1,510	3,490	130	3,660	2.4	480	2.00	.08
Relative Percent Difference	**1.9**	**13.7**	**2.7**	**4.2**	**7.0**	**5.9**	**2.3**	**4.5**	**15.0**	**7.3**	**16.5**	**22.0**
Percent Recovery	**102.0**	**87.2**	**102.7**	**104.3**	**107.3**	**94.3**	**97.7**	**104.6**	**116.3**	**92.9**	**118.0**	**124.7**
MAG-1 found	92,900	10,300	50,800	31,800	20,500	30,500	779	4,680	10.1	506	3.51	.255
MAG-1 true (Potts and others, 1992)	86,660	9,790	47,600	29,500	18,090	28,400	711	4,500	9.2	479	3.20	.20
Relative Percent Difference	**7.0**	**5.1**	**6.5**	**7.5**	**12.5**	**7.1**	**9.1**	**3.9**	**9.3**	**5.5**	**9.2**	**23.2**
Percent Recovery	**107.2**	**105.2**	**106.7**	**107.8**	**113.3**	**107.4**	**109.6**	**104.0**	**109.8**	**105.6**	**109.7**	**126.2**
Median % Difference	**3.9**	**4.4**	**4.6**	**3.6**	**6.2**	**3.3**	**4.6**	**4.2**	**7.0**	**4.7**	**15.5**	**18.3**
Mean % Recovery	**104.3**	**99.9**	**104.5**	**104.4**	**107.8**	**100.6**	**103.6**	**94.8**	**106.8**	**101.1**	**114.8**	**118.5**

Appendix 2.7. Major and trace element quality control samples—Continued

Sample ID	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium	Phosphorus	Titanium	Arsenic	Barium	Beryllium	Cadmium
Batch No. 3784												
MAG-1 found	91,400	10,500	51,400	31,700	19,700	29,900	759	4,900	9.59	504	3.17	0.275
MAG-1 true (Potts and others, 1992)	86,660	9,790	47,600	29,500	18,090	28,400	711	4,500	9.2	479	3.20	.20
Relative Percent Difference	**5.3**	**7.0**	**7.7**	**7.2**	**8.5**	**5.1**	**6.5**	**8.5**	**4.2**	**5.1**	**.9**	**30.6**
Percent Recovery	**105.5**	**107.3**	**108.0**	**107.5**	**108.9**	**105.3**	**106.8**	**108.9**	**104.2**	**105.2**	**99.1**	**136.1**
NIST 2704 found	63,500	26,100	42,200	20,000	12,800	5,880	1,010	2,880	21.7	426	1.94	3.54
NIST 2704 true (Potts and others, 1992)	61,090	26,000	41,100	20,000	12,000	5,470	1,000	4,580	23.4	414		3.45
Relative Percent Difference	**3.9**	**.4**	**2.6**	**0**	**6.5**	**7.2**	**1.0**	**45.6**	**7.5**	**2.9**		**2.6**
Percent Recovery	**103.9**	**100.4**	**102.7**	**100.0**	**106.7**	**107.5**	**101.0**	**62.9**	**92.7**	**102.9**		**102.6**
SCO-1 found	79,900	19,300	39,400	24,000	18,200	7,080	978	3,940	13.0	610	1.84	.148
SCO-1 true (Potts and others, 1992)	72,370	18,700	35,900	23,000	16,400	6,670	899	3,760	12.4	570	1.84	.14
Relative Percent Difference	**9.9**	**3.2**	**9.3**	**4.3**	**10.4**	**6.0**	**8.4**	**4.7**	**4.7**	**6.8**	**0**	**5.6**
Percent Recovery	**110.4**	**103.2**	**109.7**	**104.3**	**111.0**	**106.1**	**108.8**	**104.8**	**104.8**	**107.0**	**100.0**	**105.7**
GSD-8 found	46,500	1,620	16,800	25,600	1,620	3,470	136	4,670	2.66	470	1.91	.047
GSD-8 true (Potts and others, 1992)	40,800	1,790	15,380	23,500	1,510	3,490	130	3,660	2.4	480	2.00	.08
Relative Percent Difference	**13.1**	**10.0**	**8.8**	**8.6**	**7.0**	**.6**	**4.5**	**24.2**	**10.3**	**2.1**	**4.6**	**53.1**
Percent Recovery	**114.0**	**90.5**	**109.2**	**108.9**	**107.3**	**99.4**	**104.6**	**127.6**	**110.8**	**97.9**	**95.5**	**58.0**
Median % Difference	**7.6**	**5.1**	**8.3**	**5.7**	**7.8**	**5.6**	**5.5**	**16.4**	**6.1**	**4.0**	**.9**	**18.1**
Mean % Recovery	**108.4**	**100.3**	**107.4**	**105.2**	**108.5**	**104.6**	**105.3**	**101.0**	**103.2**	**103.3**	**98.2**	**100.6**

Appendix 2.7. Major and trace element quality-control samples—Continued

Sample ID	Co-balt	Chro-mium	Cop-per	Lith-ium	Manga-nese	Nick-el	Lead	Scan-dium	Stron-tium	Vana-dium	Zinc
Batch No. 3202											
MAG-1 found	21.6	109	29.1	77.5	737	46.6	27.7	17.9	151	143	136
MAG-1 true (Potts and others, 1992)	20.4	97	30.0	79.0	760	53.0	24.0	17.2	146	140	130
Relative Percent Difference	**5.7**	**11.7**	**3.0**	**1.9**	**3.1**	**12.9**	**14.3**	**4.0**	**3.4**	**2.1**	**4.5**
Percent Recovery	**105.9**	**112.4**	**97.0**	**98.1**	**97.0**	**87.9**	**115.4**	**104.1**	**103.4**	**102.1**	**104.6**
NIST 2704 found	13.2	142	92.6	46.1	575	39.5	154	11.7	132	93.2	415
NIST 2704 true (Potts and others, 1992)	14.0	135	98.6	47.5	555	44.1	161.0	12.0	130	95.0	438
Relative Percent Difference	**5.9**	**5.1**	**6.3**	**3.0**	**3.5**	**11.0**	**4.4**	**2.5**	**1.5**	**1.9**	**5.4**
Percent Recovery	**94.3**	**105.2**	**93.9**	**97.1**	**103.6**	**89.6**	**95.7**	**97.5**	**101.5**	**98.1**	**94.7**
SCO-1 found	11.3	77.9	28.8	45.6	404	24.6	31.1	12.3	172	141	106
SCO-1 true (Potts and others, 1992)	10.5	68.0	28.7	45.0	410	27.0	31.0	10.8	174	131	103
Relative Percent Difference	**7.3**	**13.6**	**.3**	**1.3**	**1.5**	**9.3**	**.3**	**13.0**	**1.2**	**7.4**	**2.9**
Percent Recovery	**107.6**	**114.6**	**100.3**	**101.3**	**98.5**	**91.1**	**100.3**	**113.9**	**98.9**	**107.6**	**102.9**
GSD-8 found	3.26	6.94	5.54	12.9	336	1.62	21.8	4.73	48.5	24.0	48.1
GSD-8 true (Potts and others, 1992)	3.6	7.60	4.1	13.2	310	2.7	21.0	5.7	52.0	26	43.0
Relative Percent Difference	**9.9**	**9.1**	**29.9**	**2.3**	**8.0**	**50.0**	**3.7**	**18.6**	**7.0**	**8.0**	**11.2**
Percent Recovery	**90.6**	**91.3**	**135.1**	**97.7**	**108.4**	**60.0**	**103.8**	**83.0**	**93.3**	**92.3**	**111.9**
Median RPD	**6.6**	**10.4**	**4.7**	**2.1**	**3.3**	**11.9**	**4.1**	**8.5**	**2.4**	**4.7**	**5.0**
Mean % Recovery	**99.6**	**105.9**	**106.6**	**98.6**	**101.9**	**82.2**	**103.8**	**99.6**	**99.3**	**100.0**	**103.5**
Batch Nos. 3188 & 3186											
MAG-1 found	21.8	107	30.7	77.7	724	47.9	26.4	17.8	147	138	136
MAG-1 true (Potts and others, 1992)	20.4	97	30.0	79.0	760	53.0	24.0	17.2	146	140	130
Relative Percent Difference	**6.6**	**9.8**	**2.3**	**1.7**	**4.9**	**10.1**	**9.5**	**3.4**	**.7**	**1.4**	**4.5**
Percent Recovery	**106.9**	**110.3**	**102.3**	**98.4**	**95.3**	**90.4**	**110.0**	**103.5**	**100.7**	**98.6**	**104.6**
NIST 2704 found	13.6	143	95.7	45.0	578	41.1	156	12.3	134	91.6	443
NIST 2704 true (Potts and others, 1992)	14.0	135	98.6	47.5	555	44.1	161.0	12.0	130	95.0	438
Relative Percent Difference	**2.9**	**5.8**	**3.0**	**5.4**	**4.1**	**7.0**	**3.2**	**2.5**	**3.0**	**3.6**	**1.1**
Percent Recovery	**97.1**	**105.9**	**97.1**	**94.7**	**104.1**	**93.2**	**96.9**	**102.5**	**103.1**	**96.4**	**101.1**
SCO-1 found	11.2	74.6	29.5	44.7	347	25.1	31.2	12.2	166	138	105
SCO-1 true (Potts and others, 1992)	10.5	68.0	28.7	45.0	410	27.0	31.0	10.8	174	131	103
Relative Percent Difference	**6.5**	**9.3**	**2.7**	**.7**	**16.6**	**7.3**	**.6**	**12.2**	**4.7**	**5.2**	**1.9**
Percent Recovery	**106.7**	**109.7**	**102.8**	**99.3**	**84.6**	**93.0**	**100.6**	**113.0**	**95.4**	**105.3**	**101.9**
GSD-8 found	3.30	6.75	5.87	13.2	293	1.53	21.8	5.28	49.7	24.6	45.9
GSD-8 true (Potts and others, 1992)	3.6	7.60	4.1	13.2	310	2.7	21.0	5.7	52.0	26	43.0
Relative Percent Difference	**8.7**	**11.8**	**35.5**	**0**	**5.6**	**55.3**	**3.7**	**7.7**	**4.5**	**5.5**	**6.5**
Percent Recovery	**91.7**	**88.8**	**143.2**	**100.0**	**94.5**	**56.7**	**103.8**	**92.6**	**95.6**	**94.6**	**106.7**
Median % Difference	**6.5**	**9.5**	**2.9**	**1.2**	**5.2**	**8.7**	**3.4**	**5.5**	**3.8**	**4.4**	**3.2**
Mean % Recovery	**100.6**	**103.7**	**111.3**	**98.1**	**94.6**	**83.3**	**102.8**	**102.9**	**98.7**	**98.7**	**103.6**

Appendix 2.7. Major and trace element quality-control samples—Continued

Sample ID	Cobalt	Chromium	Copper	Lithium	Manganese	Nickel	Lead	Scandium	Strontium	Vanadium	Zinc
Batch No. 3744											
MAG-1 found	22	110	30	81	766	49	25	19	138	150	138
MAG-1 true (Potts and others, 1992)	20.4	97	30.0	79.0	760	53.0	24.0	17.2	146	140	130
Relative Percent Difference	**8.0**	**12.1**	**.4**	**1.9**	**.8**	**7.1**	**3.8**	**11.4**	**5.6**	**6.7**	**5.6**
Percent Recovery	**108.3**	**112.9**	**100.4**	**101.9**	**100.8**	**93.1**	**103.9**	**112.1**	**94.5**	**107.0**	**105.8**
NIST 2704 found	14	139	95	48	571	42	165	13	125	96	434
NIST 2704 true (Potts and others, 1992)	14.0	135	98.6	47.5	555	44.1	152	12.0	130	95.0	438
Relative Percent Difference	**1.4**	**2.6**	**3.7**	**.1**	**2.8**	**4.0**	**8.2**	**4.9**	**3.9**	**.6**	**.9**
Percent Recovery	**98.6**	**102.6**	**96.4**	**100.1**	**102.9**	**96.0**	**108.6**	**105.0**	**96.2**	**100.6**	**99.1**
SCO-1 found	12	74	30	47	393	26	36	13	164	140	109
SCO-1 true (Potts and others, 1992)	10.5	68.0	28.7	45.0	410	27.0	31.0	10.8	174	131	103
Relative Percent Difference	**10.0**	**8.5**	**3.9**	**3.7**	**4.2**	**4.7**	**13.8**	**16.9**	**5.9**	**6.6**	**5.7**
Percent Recovery	**110.5**	**108.9**	**104.0**	**103.8**	**95.9**	**95.4**	**114.8**	**118.5**	**94.3**	**106.9**	**105.8**
GSD-8 found	3	6	6	14	339	1.4	22	6	46	25	47
GSD-8 true (Potts and others, 1992)	3.60	7.60	4.10	13.2	310	2.70	21.0	5.54	52.0	26	43.0
Relative Percent Difference	**9.2**	**17.5**	**35.0**	**2.6**	**8.8**	**61.5**	**2.6**	**.5**	**13.3**	**5.7**	**9.5**
Percent Recovery	**91.3**	**83.9**	**142.4**	**102.7**	**109.2**	**53.0**	**102.6**	**99.5**	**87.5**	**94.4**	**110.0**
Median % Difference	**8.6**	**10.3**	**3.8**	**2.3**	**3.5**	**5.9**	**6.0**	**8.1**	**5.8**	**6.2**	**5.6**
Mean % Recovery	**102.2**	**102.1**	**110.8**	**102.1**	**102.2**	**84.4**	**107.5**	**108.8**	**93.1**	**102.2**	**105.2**
Batch No. 3201											
MAG-1 found	21.6	109	29.1	77.5	737	46.6	27.7	17.9	151	143	136
MAG-1 true (Potts and others, 1992)	20.4	97	30.0	79.0	760	53.0	24.0	17.2	146	140	130
Relative Percent Difference	**5.7**	**11.7**	**3.0**	**1.9**	**3.1**	**12.9**	**14.3**	**4.0**	**3.4**	**2.1**	**4.5**
Percent Recovery	**105.9**	**112.4**	**97.0**	**98.1**	**97.0**	**87.9**	**115.4**	**104.1**	**103.4**	**102.1**	**104.6**
NIST 2704 found	13.2	142	92.6	46.1	575	39.5	154	11.7	132	93.2	415
NIST 2704 true (Potts and others, 1992)	14.0	135	98.6	47.5	555	44.1	161.0	12.0	130	95.0	438
Relative Percent Difference	**5.9**	**5.1**	**6.3**	**3.0**	**3.5**	**11.0**	**4.4**	**2.5**	**1.5**	**1.9**	**5.4**
Percent Recovery	**94.3**	**105.2**	**93.9**	**97.1**	**103.6**	**89.6**	**95.7**	**97.5**	**101.5**	**98.1**	**94.7**
SCO-1 found	11.3	77.9	28.8	45.6	404	24.6	31.1	12.3	172	141	106
SCO-1 true (Potts and others, 1992)	10.5	68.0	28.7	45.0	410	27.0	31.0	10.8	174	131	103
Relative Percent Difference	**7.3**	**13.6**	**.3**	**1.3**	**1.5**	**9.3**	**.3**	**13.0**	**1.2**	**7.4**	**2.9**
Percent Recovery	**107.6**	**114.6**	**100.3**	**101.3**	**98.5**	**91.1**	**100.3**	**113.9**	**98.9**	**107.6**	**102.9**
GSD-8 found	3.26	6.94	5.54	12.9	336	1.62	21.8	4.73	48.5	24.0	48.1
GSD-8 true (Potts and others, 1992)	3.6	7.60	4.1	13.2	310	2.7	21.0	5.7	52.0	26	43.0
Relative Percent Difference	**9.9**	**9.1**	**29.9**	**2.3**	**8.0**	**50.0**	**3.7**	**18.6**	**7.0**	**8.0**	**11.2**
Percent Recovery	**90.6**	**91.3**	**135.1**	**97.7**	**108.4**	**60.0**	**103.8**	**83.0**	**93.3**	**92.3**	**111.9**
Median % Difference	**6.6**	**10.4**	**4.7**	**2.1**	**3.3**	**11.9**	**4.1**	**8.5**	**2.4**	**4.7**	**5.0**
Mean % Recovery	**99.6**	**105.9**	**106.6**	**98.6**	**101.9**	**82.2**	**103.8**	**99.6**	**99.3**	**100.0**	**103.5**

Appendix 2.7. Major and trace element quality-control samples—Continued

Sample ID	Cobalt	Chromium	Copper	Lithium	Manganese	Nickel	Lead	Scandium	Strontium	Vanadium	Zinc
Batch Nos. 3209 & 3210											
NIST 2704 found	13.55	141	101	45.45	592	41.25	151.5	12.3	132	96.2	422
NIST 2704 true (Potts and others, 1992)	14.0	135	98.6	47.5	555	44.1	161.0	12.0	130	95.0	438
Relative Percent Difference	**3.3**	**4.3**	**2.4**	**4.4**	**6.5**	**6.7**	**6.1**	**2.5**	**1.5**	**1.3**	**3.7**
Percent Recovery	**96.8**	**104.4**	**102.4**	**95.7**	**106.7**	**93.5**	**94.1**	**102.5**	**101.5**	**101.3**	**96.3**
SCo-1 found	11.35	77.55	30.65	45.55	391.5	25.25	31.45	13	168.5	144	107.5
SCo-1 true (Potts and others, 1992)	10.5	68.0	28.7	45.0	410	27.0	31.0	10.8	174	131	103
Relative Percent Difference	**7.8**	**13.1**	**6.6**	**1.2**	**4.6**	**6.7**	**1.4**	**18.5**	**3.2**	**9.5**	**4.3**
Percent Recovery	**108.1**	**114.0**	**106.8**	**101.2**	**95.5**	**93.5**	**101.5**	**120.4**	**96.8**	**109.9**	**104.4**
GSD-8 found	3.32	6.75	5.925	13.4	331	1.52	22	5.335	47.75	25.5	46.65
GSD-8 true (Potts and others, 1992)	3.6	7.60	4.1	13.2	310	2.7	21.0	5.7	52.0	26	43.0
Relative Percent Difference	**8.1**	**11.8**	**36.4**	**1.5**	**6.6**	**55.9**	**4.7**	**6.6**	**8.5**	**1.9**	**8.1**
Percent Recovery	**92.2**	**88.8**	**144.5**	**101.5**	**106.8**	**56.3**	**104.8**	**93.6**	**91.8**	**98.1**	**108.5**
Median % Difference	**7.8**	**11.8**	**6.6**	**1.5**	**6.5**	**6.7**	**4.7**	**6.6**	**3.2**	**1.9**	**4.3**
Mean % Recovery	**99.0**	**102.4**	**117.9**	**99.5**	**103.0**	**81.1**	**100.1**	**105.5**	**96.7**	**103.1**	**103.1**
Batch Nos. 3342 & 3427											
MAG-1 found	22.4	114	31.0	78.3	768	49.4	19.4	19.2	148	155	142
MAG-1 true (Potts and others, 1992)	20.4	97	30.0	79.0	760	53.0	24.0	17.2	146	140	130
Relative Percent Difference	**9.3**	**16.1**	**3.3**	**.9**	**1.0**	**7.0**	**21.2**	**11.0**	**1.4**	**10.2**	**8.8**
Percent Recovery	**109.8**	**117.5**	**103.3**	**99.1**	**101.1**	**93.2**	**80.8**	**111.6**	**101.4**	**110.7**	**109.2**
NIST 2704 found	13.8	146	103	45.2	581	42.4	158	12.8	133	99.8	447
NIST 2704 true (Potts and others, 1992)	14.0	135	98.6	47.5	555	44.1	161.0	12.0	130	95.0	438
Relative Percent Difference	**1.4**	**7.8**	**4.4**	**5.0**	**4.6**	**3.9**	**1.9**	**6.5**	**2.3**	**4.9**	**2.0**
Percent Recovery	**98.6**	**108.1**	**104.5**	**95.2**	**104.7**	**96.1**	**98.1**	**106.7**	**102.3**	**105.1**	**102.1**
SCO-1 found	11.5	77.8	29.8	44.0	403	25.6	29.8	13.2	174	145	110
SCO-1 true (Potts and others, 1992)	10.5	68.0	28.7	45.0	410	27.0	31.0	10.8	174	131	103
Relative Percent Difference	**9.1**	**13.4**	**3.8**	**2.2**	**1.7**	**5.3**	**3.9**	**20.0**	**0**	**10.1**	**6.6**
Percent Recovery	**109.5**	**114.4**	**103.8**	**97.8**	**98.3**	**94.8**	**96.1**	**122.2**	**100.0**	**110.7**	**106.8**
GSD-8 found	3.27	6.38	5.83	12.3	334	< 1	19.6	5.38	45.6	24.0	47.3
GSD-8 true (Potts and others, 1992)	3.6	7.60	4.1	13.2	310	2.7	21.0	5.7	52.0	26	43.0
Relative Percent Difference	**9.6**	**17.5**	**34.8**	**7.1**	**7.5**		**6.9**	**5.8**	**13.1**	**8.0**	**9.5**
Percent Recovery	**90.8**	**83.9**	**142.2**	**93.2**	**107.7**		**93.3**	**94.4**	**87.7**	**92.3**	**110.0**
Median % Difference	**9.2**	**14.8**	**4.1**	**3.6**	**3.1**	**5.3**	**5.4**	**8.7**	**1.8**	**9.1**	**7.7**
Mean % Recovery	**102.2**	**106.0**	**113.5**	**96.3**	**102.9**	**94.7**	**92.1**	**108.7**	**97.8**	**104.7**	**107.0**

Appendix 2.7. Major and trace element quality-control samples—Continued

Sample ID	Cobalt	Chromium	Copper	Lithium	Manganese	Nickel	Lead	Scandium	Strontium	Vanadium	Zinc
Batch No. 3711											
MAG-1 found	22.2	107	30.5	78.6	742	48.4	28.2	18.7	150	145	138
MAG-1 true (Potts and others, 1992)	20.4	97	30.0	79.0	760	53.0	24.0	17.2	146	140	130
Relative Percent Difference	**8.5**	**9.8**	**1.7**	**.5**	**2.4**	**9.1**	**16.1**	**8.4**	**2.7**	**3.5**	**6.0**
Percent Recovery	**108.8**	**110.3**	**101.7**	**99.5**	**97.6**	**91.3**	**117.5**	**108.7**	**102.7**	**103.6**	**106.2**
NIST 2704 found	13.5	138	95.8	45.7	570	41.6	158	12.7	136	94.2	446
NIST 2704 true (Potts and others, 1992)	14.0	135	98.6	47.5	555	44.1	161.0	12.0	130	95.0	438
Relative Percent Difference	**3.6**	**2.2**	**2.9**	**3.9**	**2.7**	**5.8**	**1.9**	**5.7**	**4.5**	**.8**	**1.8**
Percent Recovery	**96.4**	**102.2**	**97.2**	**96.2**	**102.7**	**94.3**	**98.1**	**105.8**	**104.6**	**99.2**	**101.8**
SCO-1 found	11.4	75.0	29.7	45.1	390	25.9	32.0	13.0	172	139	111
SCO-1 true (Potts and others, 1992)	10.5	68.0	28.7	45.0	410	27.0	31.0	10.8	174	131	103
Relative Percent Difference	**8.2**	**9.8**	**3.4**	**.2**	**5.0**	**4.2**	**3.2**	**18.5**	**1.2**	**5.9**	**7.5**
Percent Recovery	**108.6**	**110.3**	**103.5**	**100.2**	**95.1**	**95.9**	**103.2**	**120.4**	**98.9**	**106.1**	**107.8**
GSD-8 found	3.28	6.15	5.22	12.9	327	1.22	21.5	5.44	47.4	23.9	45.4
GSD-8 true (Potts and others, 1992)	3.6	7.60	4.1	13.2	310	2.7	21.0	5.7	52.0	26	43.0
Relative Percent Difference	**9.3**	**21.1**	**24.0**	**2.3**	**5.3**	**75.5**	**2.4**	**4.7**	**9.3**	**8.4**	**5.4**
Percent Recovery	**91.1**	**80.9**	**127.3**	**97.7**	**105.5**	**45.2**	**102.4**	**95.4**	**91.2**	**91.9**	**105.6**
Median % Difference	**8.3**	**9.8**	**3.2**	**1.4**	**3.8**	**7.5**	**2.8**	**7.0**	**3.6**	**4.7**	**5.7**
Mean % Recovery	**101.2**	**100.9**	**107.4**	**98.4**	**100.2**	**81.7**	**105.3**	**107.6**	**99.3**	**100.2**	**105.3**
Batch No. 3818											
NIST 2704 found	13.9	145	95.0	47.0	591	42.0	151	12.6	134	97.6	431
NIST 2704 true (Potts and others, 1992)	14.0	135	98.6	47.5	555	44.1	161.0	12.0	130	95.0	438
Relative Percent Difference	**.7**	**7.1**	**3.7**	**1.1**	**6.3**	**4.9**	**6.4**	**4.9**	**3.0**	**2.7**	**1.6**
Percent Recovery	**99.3**	**107.4**	**96.3**	**98.9**	**106.5**	**95.2**	**93.8**	**105.0**	**103.1**	**102.7**	**98.4**
SCO-1 found	11.8	79.4	29.1	47.2	420	25.9	31.4	13.1	173	144	109
SCO-1 true (Potts and others, 1992)	10.5	68.0	28.7	45.0	410	27.0	31.0	10.8	174	131	103
Relative Percent Difference	**11.7**	**15.5**	**1.4**	**4.8**	**2.4**	**4.2**	**1.3**	**19.2**	**.6**	**9.5**	**5.7**
Percent Recovery	**112.4**	**116.8**	**101.4**	**104.9**	**102.4**	**95.9**	**101.3**	**121.3**	**99.4**	**109.9**	**105.8**
GSD-8 found	3.51	5.98	4.59	13.8	353	1.41	21.2	5.49	49.3	24.8	49.9
GSD-8 true (Potts and others, 1992)	3.6	7.60	4.1	13.2	310	2.7	21.0	5.7	52.0	26	43.0
Relative Percent Difference	**2.5**	**23.9**	**11.3**	**4.4**	**13.0**	**62.8**	**.9**	**3.8**	**5.3**	**4.7**	**14.9**
Percent Recovery	**97.5**	**78.7**	**112.0**	**104.5**	**113.9**	**52.2**	**101.0**	**96.3**	**94.8**	**95.4**	**116.0**
MAG-1 found	22.2	111	29.3	82.7	769	48.4	23.9	19.0	146	150	136
MAG-1 true (Potts and others, 1992)	20.4	97	30.0	79.0	760	53.0	24.0	17.2	146	140	130
Relative Percent Difference	**8.5**	**13.5**	**2.4**	**4.6**	**1.2**	**9.1**	**.4**	**9.9**	**0**	**6.9**	**4.5**
Percent Recovery	**108.8**	**114.4**	**97.7**	**104.7**	**101.2**	**91.3**	**99.6**	**110.5**	**100.0**	**107.1**	**104.6**
Median % Difference	**5.5**	**14.5**	**3.0**	**4.5**	**4.3**	**7.0**	**1.1**	**7.4**	**1.8**	**5.8**	**5.1**
Mean % Recovery	**104.5**	**104.3**	**101.8**	**103.3**	**106.0**	**83.7**	**98.9**	**108.3**	**99.3**	**103.8**	**106.2**

Appendix 2.7. Major and trace element quality-control samples—Continued

Sample ID	Co-balt	Chro-mium	Cop-per	Lith-ium	Manga-nese	Nick-el	Lead	Scan-dium	Stron-tium	Vana-dium	Zinc
Batch No. 3784											
MAG-1 found	22.6	114	29.2	78.8	798	50.2	17.6	19.1	144	152	138
MAG-1 true (Potts and others, 1992)	20.4	97	30.0	79.0	760	53.0	24.0	17.2	146	140	130
Relative Percent Difference	**10.2**	**16.1**	**2.7**	**.3**	**4.9**	**5.4**	**30.8**	**10.5**	**1.4**	**8.2**	**6.0**
Percent Recovery	**110.8**	**117.5**	**97.3**	**99.7**	**105.0**	**94.7**	**73.3**	**111.0**	**98.6**	**108.6**	**106.2**
NIST 2704 found	13.6	144	97.5	45.7	600	42.3	156	12.5	132	94.6	438
NIST 2704 true (Potts and others, 1992)	14.0	135	98.6	47.5	555	44.1	161.0	12.0	130	95.0	438
Relative Percent Difference	**2.9**	**6.5**	**1.1**	**3.9**	**7.8**	**4.2**	**3.2**	**4.1**	**1.5**	**.4**	**0**
Percent Recovery	**97.1**	**106.7**	**98.9**	**96.2**	**108.1**	**95.9**	**96.9**	**104.2**	**101.5**	**99.6**	**100.0**
SCO-1 found	11.9	79.1	37.9	47.0	431	26.5	31.7	13.0	176	145	111
SCO-1 true (Potts and others, 1992)	10.5	68.0	28.7	45.0	410	27.0	31.0	10.8	174	131	103
Relative Percent Difference	**12.5**	**15.1**	**27.6**	**4.3**	**5.0**	**1.9**	**2.2**	**18.5**	**1.1**	**10.1**	**7.5**
Percent Recovery	**113.3**	**116.3**	**132.1**	**104.4**	**105.1**	**98.1**	**102.3**	**120.4**	**101.1**	**110.7**	**107.8**
GSD-8 found	3.48	6.28	5.07	13.5	367	1.04	21.1	5.54	47.1	25.2	47.8
GSD-8 true (Potts and others, 1992)	3.6	7.60	4.1	13.2	310	2.7	21.0	5.7	52.0	26	43.0
Relative Percent Difference	**3.4**	**19.0**	**21.2**	**2.2**	**16.8**	**88.8**	**.5**	**2.8**	**9.9**	**3.1**	**10.6**
Percent Recovery	**96.7**	**82.6**	**123.7**	**102.3**	**118.4**	**38.5**	**100.5**	**97.2**	**90.6**	**96.9**	**111.2**
Median % Difference	**6.8**	**15.6**	**11.9**	**3.1**	**6.4**	**4.8**	**2.7**	**7.3**	**1.5**	**5.7**	**6.7**
Mean % Recovery	**104.5**	**105.8**	**113.0**	**100.7**	**109.2**	**81.8**	**93.2**	**108.2**	**98.0**	**103.9**	**106.3**

Appendix 2.8. Major and trace element duplicate and triplicate samples

[In micrograms per gram except as noted; na, not applicable; isa, insufficient sediment for analyses]

Sample ID	Batch number	Organic carbon (percent)	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium	Phosphorus
CMO.5 40–50	3427	0.98	8,470	273,000	11,900	1,900	2,440	823	436
CMO.5 40–50 rep. 1	3427	na	8,420	268,000	11,800	1,790	2,390	807	437
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.0			**.6**	**1.8**	**.8**	**6.0**	**2.1**	**2.0**	**.2**
CMO.5 40–50	3427	.98	8,470	273,000	11,900	1,900	2,440	823	436
CMO.5 40–50 rep. 2	3427	na	8,430	263,000	11,500	1,830	2,360	806	434
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 3.0			**.5**	**3.7**	**3.4**	**3.8**	**3.3**	**2.1**	**.5**
CMO.5 40–50 rep. 1	3427	na	8,420	268,000	11,800	1,790	2,390	807	437
CMO.5 40–50 rep. 2	3427	na	8,430	263,000	11,500	1,830	2,360	806	434
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.2			**.1**	**1.9**	**2.6**	**2.2**	**1.3**	**.1**	**.7**
ECO.1 0–5	3202	3.50	57,800	103,000	31,900	8,910	7,590	1,070	1,010
ECO.1 0–5 rep. 1	3202	na	57,000	98,600	31,800	8,640	8,160	1,180	1,030
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.9			**1.4**	**4.4**	**.3**	**3.1**	**7.2**	**9.8**	**2.0**
ECO.1 0–5	3202	3.50	57,800	103,000	31,900	8,910	7,590	1,070	1,010
ECO.1 0–5 rep. 2	3202	na	55,600	96,800	31,100	8,440	7,970	1,160	1,010
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 3.0			**3.9**	**6.2**	**2.5**	**5.4**	**4.9**	**8.1**	**0**
ECO.1 0–5 rep. 1	3202	na	57,000	98,600	31,800	8,640	8,160	1,180	1,030
ECO.1 0–5 rep. 2	3202	na	55,600	96,800	31,100	8,440	7,970	1,160	1,010
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.0			**2.5**	**1.8**	**2.2**	**2.3**	**2.4**	**1.7**	**2.0**
FOS.4 0–5	3186	2.67	51,000	94,600	29,900	7,670	4,430	1,050	1,620
FOS.4 0–5 rep. 1	3186	na	48,900	86,300	27,900	6,660	4,570	1,060	1,480
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 6.5			**4.2**	**9.2**	**6.9**	**14.1**	**3.1**	**.9**	**9.0**
FOS.4 0–5	3186	2.67	51,000	94,600	29,900	7,670	4,430	1,050	1,620
FOS.4 0–5 rep. 2	3186	na	48,200	83,900	27,300	6,490	4,630	1,060	1,450
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 8.4			**5.6**	**12.0**	**9.1**	**16.7**	**4.4**	**.9**	**11.1**

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Batch number	Organic carbon (percent)	Alumi-num	Cal-cium	Iron	Potas-sium	Mag-nesium	Sodi-um	Phos-phorus
FOS.4 0–5 rep. 1	3186	na	48,900	86,300	27,900	6,660	4,570	1,060	1,480
FOS.4 0–5 rep. 2	3186	na	48,200	83,900	27,300	6,490	4,630	1,060	1,450
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.0			**1.4**	**2.8**	**2.2**	**2.6**	**1.3**	**0**	**2.0**
FOS.4 55–60	3188	2.97	60,200	93,400	31,000	8,150	5,140	1,070	781
FOS.4 55–60 rep. 1	3188	na	60,900	93,000	31,300	8,150	5,090	1,060	784
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.0			**1.2**	**.4**	**1.0**	**0**	**1.0**	**.9**	**.4**
FOS.4 55–60	3188	2.97	60,200	93,400	31,000	8,150	5,140	1,070	781
FOS.4 55–60 rep. 2	3188	na	60,500	92,900	31,000	8,140	5,080	1,060	775
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 0.9			**.5**	**.5**	**0**	**.1**	**1.2**	**.9**	**.8**
FOS.4 55–60 rep. 1	3188	na	60,900	93,000	31,300	8,150	5,090	1,060	784
FOS.4 55–60 rep. 2	3188	na	60,500	92,900	31,000	8,140	5,080	1,060	775
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 0.8			**.7**	**.1**	**1.0**	**.1**	**.2**	**0**	**1.2**
Boggy Creek 05/25/01 @ 0205	3209	2.28	51,800	166,000	20,700	12,200	8,210	1,130	800
Boggy Creek 05/25/01 @ 0205 rep. 1	3209	na	51,500	164,000	20,600	12,200	7,610	1,190	796
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.8			**.6**	**1.2**	**.5**	**0**	**7.6**	**5.2**	**.5**
Boggy Creek 05/25/01 @ 0205	3209	2.28	51,800	166,000	20,700	12,200	8,210	1,130	800
Boggy Creek 05/25/01 @ 0205 rep. 2	3209	na	52,200	165,000	20,600	12,200	7,630	1,180	808
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.3			**.8**	**.6**	**.5**	**0**	**7.3**	**4.3**	**1.0**
Boggy Creek 05/25/01 @ 0205 rep. 1	3209	na	51,500	164,000	20,600	12,200	7,610	1,190	796
Boggy Creek 05/25/01 @ 0205 rep. 2	3209	na	52,200	165,000	20,600	12,200	7,630	1,180	808
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 0.9			**1.4**	**.6**	**0**	**0**	**.3**	**.8**	**1.5**
Barton Springs Sed. Trap 05/10–05/17/01	3210	1.22	34,100	141,000	16,300	6,460	62,000	820	721
Barton Springs Sed. Trap 05/10–05/17/01 rep. 1	3210	na	34,000	142,000	16,400	6,370	65,500	866	701
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.4			**.3**	**.7**	**.6**	**1.4**	**5.5**	**5.5**	**2.8**

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Batch number	Organic carbon (percent)	Alumi-num	Cal-cium	Iron	Potas-sium	Mag-nesium	Sodi-um	Phos-phorus
Barton Springs Sed. Trap 05/10–05/17/01	3210	1.22	34,100	141,000	16,300	6,460	62,000	820	721
Barton Springs Sed. Trap 05/10–05/17/01 rep. 2	3210	na	33,300	138,000	16,100	6,240	65,200	772	700
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.2			**2.4**	**2.2**	**1.2**	**3.5**	**5.0**	**6.0**	**3.0**
Barton Springs Sed. Trap 05/10–05/17/01 rep. 1	3210	na	34,000	142,000	16,400	6,370	65,500	866	701
Barton Springs Sed. Trap 05/10–05/17/01 rep. 2	3210	na	33,300	138,000	16,100	6,240	65,200	772	700
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.4			**2.1**	**2.9**	**1.8**	**2.1**	**.5**	**11.5**	**.1**
Site 5, Downtown 08/16/01 @ 0846	3711	7.99	43,200	150,000	27,300	8,230	6,050	1,160	2,020
Site 5, Downtown 08/16/01 @ 0846 dup.	3711	na	39,600	150,000	26,500	7,970	5,940	1,190	1,900
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.7			**8.7**	**0**	**3.0**	**3.2**	**1.8**	**2.6**	**6.1**
Site 5, Downtown 08/16/01 @ 0846 Dup.	3711	7.99	39,600	150,000	26,500	7,970	5,940	1,190	1,900
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 1	3711	na	41,000	151,000	26,800	7,990	6,200	1,260	1,900
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.8			**3.5**	**.7**	**1.1**	**.3**	**4.3**	**5.7**	**0**
Site 5, Downtown 08/16/01 @ 0846 Dup.	3711	7.99	39,600	150,000	26,500	7,970	5,940	1,190	1,900
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 2	3711	na	38,600	147,000	26,400	7,770	5,750	1,160	1,900
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.0			**2.6**	**2.0**	**.4**	**2.5**	**3.3**	**2.6**	**0**
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 1	3711	na	41,000	151,000	26,800	7,990	6,200	1,260	1,900
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 2	3711	na	38,600	147,000	26,400	7,770	5,750	1,160	1,900
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 3.8			**6.0**	**2.7**	**1.5**	**2.8**	**7.5**	**8.3**	**0**
Site 1, Benbrook 03/08/01 @ 1300	3201	4.97	34,300	143,000	15,900	6,450	5,660	1,270	610
Site 1, Benbrook 03/08/01 @ 1300 rep. 1	3201	na	34,200	140,000	15,600	6,280	5,940	1,310	586
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.9			**.3**	**2.1**	**1.9**	**2.7**	**4.8**	**3.1**	**4.0**
Site 1, Benbrook 03/08/01 @ 1300	3201	4.97	34,300	143,000	15,900	6,450	5,660	1,270	610
Site 1, Benbrook 03/08/01 @ 1300 rep. 2	3201	na	33,500	137,000	15,300	6,180	5,920	1,300	582
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 3.8			**2.4**	**4.3**	**3.8**	**4.3**	**4.5**	**2.3**	**4.7**

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Batch number	Organic carbon (percent)	Alumi-num	Cal-cium	Iron	Potas-sium	Mag-nesium	Sodi-um	Phos-phorus
Site 1, Benbrook 03/08/01 @ 1300 rep. 1	3201	na	34,200	140,000	15,600	6,280	5,940	1,310	586
Site 1, Benbrook 03/08/01 @ 1300 rep. 2	3201	na	33,500	137,000	15,300	6,180	5,920	1,300	582
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.1			**2.1**	**2.2**	**1.9**	**1.6**	**.3**	**.8**	**.7**
Site 5, Downtown 05/04/01 @ 2100	3342	isa	27,900	125,000	17,000	6,270	3,880	1,150	1,650
Site 5, Downtown 05/04/01 @ 2100 dup.	3342	7.3	32,900	144,000	20,700	7,150	4,780	1,390	1,890
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 16.3			**16.4**	**14.1**	**19.6**	**13.1**	**20.8**	**18.9**	**13.6**
Sycamore Creek #1 08/30/01 @ 0829	3744	4.13	62,300	139,000	32,800	12,500	7,790	1,420	974
Sycamore Creek #1 08/30/01 @ 0829 dup.	3744	na	55,600	125,000	29,500	11,300	6,620	1,280	885
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 11.8			**11.4**	**10.6**	**10.6**	**10.1**	**16.2**	**10.4**	**9.6**
Old Mill Springs 11/16/01 @ 1655	3784	isa	107,000	32,300	48,800	13,400	17,800	2,520	1,090
Old Mill Springs 11/16/01 @ 1655 dup.	3784	na	106,000	32,000	48,300	13,300	17,700	2,530	1,060
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.0			**.9**	**.9**	**1.0**	**.7**	**.6**	**.4**	**2.8**
Lake Como Inflow 01/23/02 @ 1750	3818	isa	39,800	185,000	24,000	7,660	5,950	1,100	1,350
Lake Como Inflow 01/23/02 @ 1750 dup.	3818	na	39,200	183,000	23,700	7,560	5,890	1,080	1,370
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.3			**1.5**	**1.1**	**1.3**	**1.3**	**1.0**	**1.8**	**1.5**

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Titanium	Arsenic	Barium	Beryllium	Cadmium	Cobalt	Chromium	Copper
CMO.5 40–50	472	5.80	97.7	0.401	0.455	3.75	28.7	9.27
CMO.5 40–50 rep. 1	484	6.61	99.7	.456	.472	3.66	27.0	9.08
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 2.0**	**2.5**	**13.1**	**2.0**	**12.8**	**3.7**	**2.4**	**6.1**	**2.1**
CMO.5 40–50	472	5.80	97.7	.401	.455	3.75	28.7	9.27
CMO.5 40–50 rep. 2	460	6.50	102	.394	.466	3.62	27.8	9.00
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 3.0**	**2.6**	**11.4**	**4.3**	**1.8**	**2.4**	**3.5**	**3.2**	**3.0**
CMO.5 40–50 rep. 1	484	6.61	99.7	.456	.472	3.66	27.0	9.08
CMO.5 40–50 rep. 2	460	6.50	102	.394	.466	3.62	27.8	9.00
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 2.2**	**5.1**	**1.7**	**2.3**	**14.6**	**1.3**	**1.1**	**2.9**	**.9**
ECO.1 0–5	3,220	15.9	413	2.42	3.18	10.6	72.1	39.9
ECO.1 0–5 rep. 1	3,380	16.5	434	2.24	3.30	10.3	71.7	39.8
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 2.9**	**4.8**	**3.7**	**5.0**	**7.7**	**3.7**	**2.9**	**.6**	**.3**
ECO.1 0–5	3,220	15.9	413	2.42	3.18	10.6	72.1	39.9
ECO.1 0–5 rep. 2	3,220	16.1	422	2.20	3.27	10.1	70.5	38.6
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 3.0**	**0**	**1.3**	**2.2**	**9.5**	**2.8**	**4.8**	**2.2**	**3.3**
ECO.1 0–5 rep. 1	3,380	16.5	434	2.24	3.30	10.3	71.7	39.8
ECO.1 0–5 rep. 2	3,220	16.1	422	2.20	3.27	10.1	70.5	38.6
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 2.0**	**4.8**	**2.5**	**2.8**	**1.8**	**.9**	**2.0**	**1.7**	**3.1**
FOS.4 0–5	2,990	13.0	260	1.51	1.70	10.4	87.0	38.5
FOS.4 0–5 rep. 1	2,500	12.2	248	1.75	1.72	9.60	70.2	35.9
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 6.5**	**17.9**	**6.3**	**4.7**	**14.7**	**1.2**	**8.0**	**21.4**	**7.0**
FOS.4 0–5	2,990	13.0	260	1.51	1.70	10.4	87.0	38.5
FOS.4 0–5 rep. 2	2,900	12.1	246	1.70	1.68	9.30	71.2	35.2
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 8.4**	**3.1**	**7.2**	**5.5**	**11.8**	**1.2**	**11.2**	**20.0**	**9.0**

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Titanium	Arsenic	Barium	Beryllium	Cadmium	Cobalt	Chromium	Copper
FOS.4 0–5 rep. 1	2,500	12.2	248	1.75	1.72	9.60	70.2	35.9
FOS.4 0–5 rep. 2	2,900	12.1	246	1.70	1.68	9.30	71.2	35.2
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.0	**14.8**	**.8**	**.8**	**2.9**	**2.4**	**3.2**	**1.4**	**2.0**
FOS.4 55–60	3,060	220	253	2.16	.902	10.6	66.4	21.8
FOS.4 55–60 rep. 1	2,990	223	257	2.11	.905	10.6	65.0	21.4
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.0	**2.3**	**1.4**	**1.6**	**2.3**	**.3**	**0**	**2.1**	**1.9**
FOS.4 55–60	3,060	220	253	2.16	.902	10.6	66.4	21.8
FOS.4 55–60 rep. 2	3,010	218	255	2.07	.932	10.6	65.4	21.1
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 0.9	**1.6**	**.9**	**.8**	**4.3**	**3.3**	**0**	**1.5**	**3.3**
FOS.4 55–60 rep. 1	2,990	223	257	2.11	.905	10.6	65.0	21.4
FOS.4 55–60 rep. 2	3,010	218	255	2.07	.932	10.6	65.4	21.1
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 0.8	**.7**	**2.3**	**.8**	**1.9**	**2.9**	**0**	**.6**	**1.4**
Boggy Creek 05/25/01 @ 0205	3,070	11.4	239	1.21	.526	8.43	54.8	20.5
Boggy Creek 05/25/01 @ 0205 rep. 1	2,860	11.2	244	1.26	.548	8.20	54.7	19.6
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.8	**7.1**	**1.8**	**2.1**	**4.0**	**4.1**	**2.8**	**.2**	**4.5**
Boggy Creek 05/25/01 @ 0205	3,070	11.4	239	1.21	.526	8.43	54.8	20.5
Boggy Creek 05/25/01 @ 0205 rep. 2	3,110	11.5	246	1.30	.549	8.10	56.3	20.5
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.3	**1.3**	**.9**	**2.9**	**7.2**	**4.3**	**4.0**	**2.7**	**0**
Boggy Creek 05/25/01 @ 0205 rep. 1	2,860	11.2	244	1.26	.548	8.20	54.7	19.6
Boggy Creek 05/25/01 @ 0205 rep. 2	3,110	11.5	246	1.30	.549	8.10	56.3	20.5
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 0.9	**8.4**	**2.6**	**.8**	**3.1**	**.2**	**1.2**	**2.9**	**4.5**
Barton Springs Sed. Trap 05/10–05/17/01	2,220	12.6	144	1.17	.272	8.99	40.7	18.3
Barton Springs Sed. Trap 05/10–05/17/01 rep. 1	2,580	12.9	146	1.20	.296	8.85	43.0	18.4
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.4	**15.0**	**2.4**	**1.4**	**2.5**	**8.5**	**1.6**	**5.5**	**.5**

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Titanium	Arsenic	Barium	Beryllium	Cadmium	Cobalt	Chromium	Copper
Barton Springs Sed. Trap 05/10–05/17/01	2,220	12.6	144	1.17	.272	8.99	40.7	18.3
Barton Springs Sed. Trap 05/10–05/17/01 rep. 2	2,210	12.6	142	1.30	.287	8.64	40.0	17.6
Relative Percent Difference (RPD) for each compound:	**.5**	**0**	**1.4**	**10.5**	**5.4**	**4.0**	**1.7**	**3.9**
Median RPD of sample = 2.2								
Barton Springs Sed. Trap 05/10–05/17/01 rep. 1	2,580	12.9	146	1.20	.296	8.85	43.0	18.4
Barton Springs Sed. Trap 05/10–05/17/01 rep. 2	2,210	12.6	142	1.30	.287	8.64	40.0	17.6
Relative Percent Difference (RPD) for each compound:	**15.4**	**2.4**	**2.8**	**8.0**	**3.1**	**2.4**	**7.2**	**4.4**
Median RPD of sample = 2.4								
Site 5, Downtown 08/16/01 @ 0846	2,390	11.7	383	1.52	2.73	11.4	77.0	281
Site 5, Downtown 08/16/01 @ 0846 dup.	2,480	11.5	370	1.49	2.52	11.0	72.4	257
Relative Percent Difference (RPD) for each compound:	**3.7**	**1.7**	**3.5**	**2.0**	**8.0**	**3.6**	**6.2**	**8.9**
Median RPD of sample = 2.7								
Site 5, Downtown 08/16/01 @ 0846 Dup.	2,480	11.5	370	1.49	2.52	11.0	72.4	257
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 1	2,520	12.2	380	1.51	2.59	11.2	71.9	265
Relative Percent Difference (RPD) for each compound:	**1.6**	**5.9**	**2.7**	**1.3**	**2.7**	**1.8**	**.7**	**3.1**
Median RPD of sample = 1.8								
Site 5, Downtown 08/16/01 @ 0846 Dup.	2,480	11.5	370	1.49	2.52	11.0	72.4	257
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 2	2,480	11.4	370	1.41	2.47	10.9	70.2	253
Relative Percent Difference (RPD) for each compound:	**0**	**.9**	**0**	**5.5**	**2.0**	**.9**	**3.1**	**1.6**
Median RPD of sample = 2.0								
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 1	2,520	12.2	380	1.51	2.59	11.2	71.9	265
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 2	2,480	11.4	370	1.41	2.47	10.9	70.2	253
Relative Percent Difference (RPD) for each compound:	**1.6**	**6.8**	**2.7**	**6.8**	**4.7**	**2.7**	**2.4**	**4.6**
Median RPD of sample = 3.8								
Site 1, Benbrook 03/08/01 @ 1300	1,950	9.30	230	1.50	.333	6.57	39.4	13.0
Site 1, Benbrook 03/08/01 @ 1300 rep. 1	2,060	8.93	232	1.50	.365	6.39	39.8	12.8
Relative Percent Difference (RPD) for each compound:	**5.5**	**4.1**	**.9**	**0**	**9.2**	**2.8**	**1.0**	**1.6**
Median RPD of sample = 1.9								
Site 1, Benbrook 03/08/01 @ 1300	1,950	9.30	230	1.50	.333	6.57	39.4	13.0
Site 1, Benbrook 03/08/01 @ 1300 rep. 2	1,930	8.92	232	1.38	.349	6.23	38.6	12.5
Relative Percent Difference (RPD) for each compound:	**1.0**	**4.2**	**.9**	**8.3**	**4.7**	**5.3**	**2.1**	**3.9**
Median RPD of sample = 3.8								

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Titanium	Arsenic	Barium	Beryllium	Cadmium	Cobalt	Chromium	Copper
Site 1, Benbrook 03/08/01 @ 1300 rep. 1	2,060	8.93	232	1.50	.365	6.39	39.8	12.8
Site 1, Benbrook 03/08/01 @ 1300 rep. 2	1,930	8.92	232	1.38	.349	6.23	38.6	12.5
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.1	**6.5**	**.1**	**0**	**8.3**	**4.5**	**2.5**	**3.1**	**2.4**
Site 5, Downtown 05/04/01 @ 2100	1,890	7.01	240	.911	1.33	6.12	46.6	61.3
Site 5, Downtown 05/04/01 @ 2100 dup.	1,830	8.18	279	1.17	1.68	7.41	55.1	72.1
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 16.3	**3.2**	**15.4**	**15.0**	**24.9**	**23.3**	**19.1**	**16.7**	**16.2**
Sycamore Creek #1 08/30/01 @ 0829	3,710	13.9	365	2.25	.924	13.9	73.2	41.4
Sycamore Creek #1 08/30/01 @ 0829 dup.	3,360	12.0	324	1.96	.811	12.1	66.4	36.6
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 11.8	**9.9**	**14.7**	**11.9**	**13.8**	**13.0**	**13.8**	**9.7**	**12.3**
Old Mill Springs 11/16/01 @ 1655	6,620	24.2	257	3.30	.619	17.2	94.8	45.0
Old Mill Springs 11/16/01 @ 1655 dup.	6,580	23.8	253	3.10	.614	17.1	91.5	44.7
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.0	**.6**	**1.7**	**1.6**	**6.2**	**.8**	**.6**	**3.5**	**.7**
Lake Como Inflow 01/23/02 @ 1750	1,920	10.4	300	1.48	1.46	8.95	56.7	63.6
Lake Como Inflow 01/23/02 @ 1750 dup.	1,960	10.6	296	1.54	1.42	8.88	55.7	64.1
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.3	**2.1**	**1.9**	**1.3**	**4.0**	**2.8**	**.8**	**1.8**	**.8**

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Mercury	Lithium	Manganese	Nickel	Lead	Scandium	Strontium	Vanadium	Zinc	Total carbon (percent)	Inorganic carbon as CO^3 (percent)
CMO.5 40–50	0.05	5.67	367	18.0	112	2.09	379	28.0	52.4	8.63	7.65
CMO.5 40–50 rep. 1	na	5.50	362	17.9	108	2.12	386	28.1	53.2	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.0		**3.0**	**1.4**	**.6**	**3.6**	**1.4**	**1.8**	**.4**	**1.5**		
CMO.5 40–50	.05	5.67	367	18.0	112	2.09	379	28.0	52.4	8.63	7.65
CMO.5 40–50 rep. 2	na	5.38	354	17.9	111	2.06	379	26.9	51.3	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 3.0		**5.2**	**3.6**	**.6**	**.9**	**1.4**	**0**	**4.0**	**2.1**		
CMO.5 40–50 rep. 1	na	5.50	362	17.9	108	2.12	386	28.1	53.2	na	na
CMO.5 40–50 rep. 2	na	5.38	354	17.9	111	2.06	379	26.9	51.3	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.2		**2.2**	**2.2**	**0**	**2.7**	**2.9**	**1.8**	**4.4**	**3.6**		
ECO.1 0–5	.11	42.5	731	30.7	124	9.86	238	87.6	297	4.99	8.49
ECO.1 0–5 rep. 1	na	43.1	734	29.6	126	9.66	237	90.2	292	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.9		**1.4**	**.4**	**3.6**	**1.6**	**2.0**	**.4**	**2.9**	**1.7**		
ECO.1 0–5	.11	42.5	731	30.7	124	9.86	238	87.6	297	4.99	8.49
ECO.1 0–5 rep. 2	na	42.3	720	28.6	124	9.47	231	88.0	287	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 3.0		**.5**	**1.5**	**7.1**	**0**	**4.0**	**3.0**	**.5**	**3.4**		
ECO.1 0–5 rep. 1	na	43.1	734	29.6	126	9.66	237	90.2	292	na	na
ECO.1 0–5 rep. 2	na	42.3	720	28.6	124	9.47	231	88.0	287	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.0		**1.9**	**1.9**	**3.4**	**1.6**	**2.0**	**2.6**	**2.5**	**1.7**		
FOS.4 0–5	.24	36.9	869	26.3	108	9.19	222	78.5	223	9.85	7.18
FOS.4 0–5 rep. 1	na	36.8	823	23.8	108	8.90	208	73.9	208	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 6.5		**.3**	**5.4**	**10.0**	**0**	**3.2**	**6.5**	**6.0**	**7.0**		
FOS.4 0–5	.24	36.9	869	26.3	108	9.19	222	78.5	223	9.85	7.18
FOS.4 0–5 rep. 2	na	37.0	799	23.2	111	8.72	204	74.5	203	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 8.4		**.3**	**8.4**	**12.5**	**2.7**	**5.2**	**8.5**	**5.2**	**9.4**		

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Mer-cury	Lith-ium	Manga-nese	Nick-el	Lead	Scan-dium	Stron-tium	Vana-dium	Zinc	Total carbon (percent)	Inorganic carbon as CO^3 (percent)
FOS.4 0–5 rep. 1	na	36.8	823	23.8	108	8.90	208	73.9	208	na	na
FOS.4 0–5 rep. 2	na	37.0	799	23.2	111	8.72	204	74.5	203	na	na
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 2.0**		**.5**	**3.0**	**2.6**	**2.7**	**2.0**	**1.9**	**.8**	**2.4**		
FOS.4 55–60	.16	48.3	572	25.9	243	10.5	154	89.8	130	6.05	3.08
FOS.4 55–60 rep. 1	na	48.6	576	25.6	244	10.5	156	88.9	130	na	na
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 1.0**		**.6**	**.7**	**1.2**	**.4**	**0**	**1.3**	**1.0**	**0**		
FOS.4 55–60	.16	48.3	572	25.9	243	10.5	154	89.8	130	6.05	3.08
FOS.4 55–60 rep. 2	na	48.5	571	25.4	240	10.6	156	89.7	130	na	na
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 0.9**		**.4**	**.2**	**1.9**	**1.2**	**.9**	**1.3**	**.1**	**0**		
FOS.4 55–60 rep. 1	na	48.6	576	25.6	244	10.5	156	88.9	130	na	na
FOS.4 55–60 rep. 2	na	48.5	571	25.4	240	10.6	156	89.7	130	na	na
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 0.8**		**.2**	**.9**	**.8**	**1.7**	**.9**	**0**	**.9**	**0**		
Boggy Creek 05/25/01 @ 0205	.04	28.9	540	22.7	35.5	9.08	390	87.3	136	7.02	4.74
Boggy Creek 05/25/01 @ 0205 rep. 1	na	29.8	541	22.3	35.4	8.80	381	88.5	137	na	na
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 1.8**		**3.1**	**.2**	**1.8**	**.3**	**3.1**	**2.3**	**1.4**	**.7**		
Boggy Creek 05/25/01 @ 0205	.04	28.9	540	22.7	35.5	9.08	390	87.3	136	7.02	4.74
Boggy Creek 05/25/01 @ 0205 rep. 2	na	29.2	546	22.1	35.4	8.96	381	89.3	136	na	na
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 1.3**		**1.0**	**1.1**	**2.7**	**.3**	**1.3**	**2.3**	**2.3**	**0**		
Boggy Creek 05/25/01 @ 0205 rep. 1	na	29.8	541	22.3	35.4	8.80	381	88.5	137	na	na
Boggy Creek 05/25/01 @ 0205 rep. 2	na	29.2	546	22.1	35.4	8.96	381	89.3	136	na	na
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 0.9**		**2.0**	**.9**	**.9**	**0**	**1.8**	**0**	**.9**	**.7**		
Barton Springs Sed. Trap 05/10–05/17/01	.06	29.3	1,190	25.5	13.9	6.30	105	70.0	53.2	7.86	6.64
Barton Springs Sed. Trap 05/10–05/17/01 rep. 1	na	29.4	1,200	25.2	14.1	6.50	104	71.0	54.3	na	na
Relative Percent Difference (RPD) for each compound: **Median RPD of sample = 1.4**		**.3**	**.8**	**1.2**	**1.4**	**3.1**	**1.0**	**1.4**	**2.0**		

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Mercury	Lithium	Manganese	Nickel	Lead	Scandium	Strontium	Vanadium	Zinc	Total carbon (percent)	Inorganic carbon as CO^3 (percent)
Barton Springs Sed. Trap 05/10–05/17/01	0.06	29.3	1,190	25.5	13.9	6.30	105	70.0	53.2	7.86	6.64
Barton Springs Sed. Trap 05/10–05/17/01 rep. 2	na	29.4	1,190	24.7	13.9	6.19	101	69.6	52.8	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.2		**.3**	**0**	**3.2**	**0**	**1.8**	**3.9**	**.6**	**.8**		
Barton Springs Sed. Trap 05/10–05/17/01 rep. 1	na	29.4	1,200	25.2	14.1	6.50	104	71.0	54.3	na	na
Barton Springs Sed. Trap 05/10–05/17/01 rep. 2	na	29.4	1,190	24.7	13.9	6.19	101	69.6	52.8	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.4		**0**	**.8**	**2.0**	**1.4**	**4.9**	**2.9**	**2.0**	**2.8**		
Site 5, Downtown 08/16/01 @ 0846	.31	27.3	588	32.2	237	7.85	335	68.6	1,600	12.2	4.21
Site 5, Downtown 08/16/01 @ 0846 dup.	.32	26.7	585	31.9	236	7.49	319	66.8	1,560	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.7	**3.2**	**2.2**	**.5**	**.9**	**.4**	**4.7**	**4.9**	**2.7**	**2.5**		
Site 5, Downtown 08/16/01 @ 0846 Dup.	.32	26.7	585	31.9	236	7.49	319	66.8	1,560	12.2	4.21
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 1	na	27.0	595	32.0	249	7.71	330	67.2	1,600	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.8		**1.1**	**1.7**	**.3**	**5.4**	**2.9**	**3.4**	**.6**	**2.5**		
Site 5, Downtown 08/16/01 @ 0846 Dup.	.32	26.7	585	31.9	236	7.49	319	66.8	1,560	12.2	4.21
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 2	na	25.9	580	30.8	237	7.48	315	65.4	1,440	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 2.0		**3.0**	**.9**	**3.5**	**.4**	**.1**	**1.3**	**2.1**	**8.0**		
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 1	na	27.0	595	32.0	249	7.71	330	67.2	1,600	na	na
Site 5, Downtown 08/16/01 @ 0846 Dup. rep. 2	na	25.9	580	30.8	237	7.48	315	65.4	1,440	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 3.8		**4.2**	**2.6**	**3.8**	**4.9**	**3.0**	**4.7**	**2.7**	**10.5**		
Site 1, Benbrook 03/08/01 @ 1300	.03	23.7	566	18.0	15.3	6.35	232	52.5	78.9	2.98	7.95
Site 1, Benbrook 03/08/01 @ 1300 rep. 1	na	24.8	556	17.3	15.1	6.27	228	52.9	78.5	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 1.9		**4.5**	**1.8**	**4.0**	**1.3**	**1.3**	**1.7**	**.8**	**.5**		
Site 1, Benbrook 03/08/01 @ 1300	.03	23.7	566	18.0	15.3	6.35	232	52.5	78.9	2.98	7.95
Site 1, Benbrook 03/08/01 @ 1300 rep. 2	na	24.2	544	16.6	15.0	6.19	224	52.1	76.4	na	na
Relative Percent Difference (RPD) for each compound: Median RPD of sample = 3.8		**2.1**	**4.0**	**8.1**	**2.0**	**2.6**	**3.5**	**.8**	**3.2**		

Appendix 2.8. Major and trace element duplicate and triplicate samples—Continued

Sample ID	Mercury	Lithium	Manganese	Nickel	Lead	Scandium	Strontium	Vanadium	Zinc	Total carbon (percent)	Inorganic carbon as CO^3 (percent)
Site 1, Benbrook 03/08/01 @ 1300 rep. 1	na	24.8	556	17.3	15.1	6.27	228	52.9	78.5	na	na
Site 1, Benbrook 03/08/01 @ 1300 rep. 2	na	24.2	544	16.6	15.0	6.19	224	52.1	76.4	na	na
Relative Percent Difference (RPD) for each compound:		**2.4**	**2.2**	**4.1**	**.7**	**1.3**	**1.8**	**1.5**	**2.7**		
Median RPD of sample = 2.1											
Site 5, Downtown 05/04/01 @ 2100	isa	16.6	324	21.1	114	4.80	252	43.6	536	11.5	isa
Site 5, Downtown 05/04/01 @ 2100 dup.	.22	19.7	386	26.5	134	5.46	296	50.8	636	11.5	4.21
Relative Percent Difference (RPD) for each compound:		**17.1**	**17.5**	**22.7**	**16.1**	**12.9**	**16.1**	**15.3**	**17.1**	**0**	
Median RPD of sample = 16.3											
Sycamore Creek #1 08/30/01 @ 0829	.10	46.0	1,050	34.2	107	11.6	311	92.6	258	7.93	3.80
Sycamore Creek #1 08/30/01 @ 0829 dup.	na	39.1	945	30.4	93.7	10.6	276	84.2	223	na	na
Relative Percent Difference (RPD) for each compound:		**16.2**	**10.5**	**11.8**	**13.3**	**9.0**	**11.9**	**9.5**	**14.6**		
Median RPD of sample = 11.8											
Old Mill Springs 11/16/01 @ 1655	na	71.2	1380	47.1	35.3	16.8	201	144	160	isa	isa
Old Mill Springs 11/16/01 @ 1655 dup.	na	71.1	1360	46.2	34.9	16.8	199	142	158	na	na
Relative Percent Difference (RPD) for each compound:		**.1**	**1.5**	**1.9**	**1.1**	**0**	**1.0**	**1.4**	**1.3**		
Median RPD of sample = 1.0											
Lake Como Inflow 01/23/02 @ 1750	.13	23.3	820	29.4	121	6.70	327	67.9	421	isa	isa
Lake Como Inflow 01/23/02 @ 1750 dup.	na	22.7	816	28.9	121	6.62	326	68.4	412	na	na
Relative Percent Difference (RPD) for each compound:		**2.6**	**.5**	**1.7**	**0**	**1.2**	**.3**	**.7**	**2.2**		
Median RPD of sample = 1.3											

Appendix 2.9. Cesium-137 quality control and duplicate samples

[RPD, relative percent difference; pCi/g, picocuries per gram]

Sample set	RPD of duplicate sample	Blank concentration (pCi/g)	Laboratory control sample recovery
Lake Como samples	CMO.1 60–65: 15.3%	-0.00274 ± 0.0321	101.79%
Echo Lake samples	ECO.1 10–15: 28.0%	0.0157 ± 0.0327	98.71%
Fosdic Lake samples	FOS.2 0–10: 64.6%	-0.00184 ± 0.0343	102.89%

APPENDIX 3—
Loads and Yields

Appendix 3.1. Loads and yields of chlorinated hydrocarbons on suspended-sediment samples

[km^2, square kilometers; m^3, cubic meters; SSC, suspended-sediment concentration; mg/L, milligrams per liter; kg, kilograms; g, grams; isa, insufficient sediment for analysis; $\mu g/m^2$, micrograms per square meter]

Site	Date	Watershed area (km^2)	Storm volume (m^3)	Average SSC (mg/L)	Sediment load (kg)	Contaminant load (g)									
						Technical chlordane	Dieldrin	DDE	DDD	DDT	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260	Total PCBs	Total DDT
Lake Como Inflow	8/30/2001	1.86	15,400	55	850	0.3	0.05	0.02	0	0	0.1	0.1	0.1	0.2	0.02
Lake Como Inflow	9/20/2001		1,770	91.5	162	.1	.02	0	0	0	.02	.01	.01	.05	0
Lake Como Inflow	11/9/2001		2,210	133	293	.2	.02	.01	0	0	0	0	0	0	.01
Lake Como Inflow	1/23/2002		6,250	212	1,330	.1	.01	.01	0	0	.03	.02	.02	.1	.01
Lake Fosdic Inflow	8/11/2001	.84	940	188	177	0	0	0	0	0	0	0	0	0	0
Lake Fosdic Inflow	9/18/2001		2,650	844	2,240	.9	.1	.03	0	.04	0	0	0	.4	.1
Lake Fosdic Inflow	10/10/2001		695	323	225	.1	0	.1	.1	2.9	0	0	0	.1	3.2
Lake Fosdic Inflow	12/6/2001		3,630	125	454	.1	.01	.01	0	0	0	0	0	0	.01
Lake Echo Inflow	5/28/2001	2.13	27,000	2200	59,400	4.7	.4	.4	0	.6	.9	1.5	1.2	3.6	1.0
Lake Echo Inflow	8/17/2001		34,000	389	13,200	2.9	.1	.4	.1	1.7	.4	1.5	.8	2.6	2.2
Lake Echo Inflow	9/20/2001		11,200	200	2,240	.6	.1	.04	0	.1	0	.1	.1	.3	.1
Lake Echo Inflow	10/11/2001		6,770	501	3,390	.7	.1	.1	0	.3	.1	.2	.2	.5	.4
Big Fossil Creek	5/4/2001	136.76	478,000	445	213,000	0	0	.3	0	0	0	0	0	0	.3
Big Fossil Creek	8/11/2001		47,600	308	14,600	.8	0	.1	0	.1	0	.6	.8	1.5	.1
Big Fossil Creek	9/18/2001		292,000	561	164,000	1.8	0	.1	0	0	0	0	0	0	.1
Big Fossil Creek	10/11/2001		254,000	380	96,500	4.9	0	.2	0	.6	0	0	0	0	.7
Sycamore Creek # 1	5/4/2001	77.94	3,000	40	120	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	5/4/2001		122,000	1130	138,000	19.3	1.1	2.5	0	1.2	4.0	4.4	4.7	13.1	3.7
Sycamore Creek # 3	5/4/2001		120,000	381	45,500	7.7	.9	1.1	0	0	0	0	0	0	1.1
Sycamore Creek # 4&5	5/5/2001		161,000	463	74,700	12.7	.4	.8	0	0	0	1.7	1.9	3.7	.8
Sycamore Creek # 6&7	5/5/2001		162,000	95	15,400	0	0	.1	0	0	0	0	1.4	1.4	.1
TOTAL			**568,000**		**274,000**	**39.8**	**2.4**	**4.6**	**0**	**1.2**	**4.0**	**6.1**	**8.1**	**18.2**	**5.8**
Sycamore Creek # 1	8/16/2001	77.94	887	48	43	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	8/16/2001		546	37.5	20	0	0	0	0	0	0	0	0	0	0
Sycamore Creek # 3	8/16/2001		1,000	112	114	0	0	0	0	0	0	0	0	0	0
Sycamore Creek # 4	8/16/2001		240	98.5	24	0	0	0	0	0	0	0	0	0	0
TOTAL			2,690		200	0	0	0	0	0	0	0	0	0	0
Sycamore Creek # 1	8/30/2001	77.94	74,900	410	30,700	2.8	.2	.5	0	.6	.3	.6	.9	1.7	1.0
Sycamore Creek # 2	8/30/2001		193,000	846	163,000	11.8	.7	2.0	0	2.0	1.1	2.3	4.1	7.5	3.9
Sycamore Creek # 3	8/30/2001		580,000	911	528,000	41.2	2.9	6.9	0	7.9	4.7	6.3	12.2	23.2	14.8
Sycamore Creek # 4	8/30/2001		153,000	123	18,800	.8	0	.2	0	.2	0	0	.7	.7	.3
Sycamore Creek # 5	8/30/2001		103,000	41	4,200	0	0	.03	0	.1	0	0	0	0	.1
TOTAL			**1,100,000**		**745,000**	**56.5**	**3.7**	**9.5**	**0**	**10.7**	**6.1**	**9.2**	**17.9**	**33.1**	**20.2**

Appendix 3.1. Loads and yields of chlorinated hydrocarbons on suspended-sediment samples—Continued

Site	Contaminant yield ($\mu g/m^2$)									
	Technical chlordane	Dieldrin	DDE	DDD	DDT	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260	Total PCBs	Total DDT
Lake Como Inflow	0.2	0.03	0.01	0	0	0.04	0.03	0.03	0.1	0.01
Lake Como Inflow	.1	.01	0	0	0	.01	.01	.01	.03	0
Lake Como Inflow	.1	.01	0	0	0	0	0	0	0	0
Lake Como Inflow	.1	0	0	0	0	.01	.01	.01	.04	0
Lake Fosdic Inflow	0	0	0	0	0	0	0	0	0	0
Lake Fosdic Inflow	1.0	.1	.03	0	.05	0	0	0	.5	.1
Lake Fosdic Inflow	.1	0	.2	.1	3.5	0	0	0	.1	3.8
Lake Fosdic Inflow	.2	.01	.01	0	0	0	0	0	0	.01
Lake Echo Inflow	2.2	.2	.2	0	.3	.4	.7	.6	1.7	.5
Lake Echo Inflow	1.4	.1	.2	.03	.8	.2	.7	.4	1.2	1.0
Lake Echo Inflow	.3	.03	.02	0	.04	0	.1	.1	.1	.1
Lake Echo Inflow	.3	.04	.05	0	.1	.03	.1	.1	.2	.2
Big Fossil Creek	0	0	0	0	0	0	0	0	0	0
Big Fossil Creek	.01	0	0	0	0	0	0	.01	.01	0
Big Fossil Creek	.01	0	0	0	0	0	0	0	0	0
Big Fossil Creek	.04	0	0	0	0	0	0	0	0	.01
Sycamore Creek # 1	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	.2	.01	.03	0	.02	.1	.1	.1	.2	.05
Sycamore Creek # 3	.1	.01	.01	0	0	0	0	0	0	.01
Sycamore Creek # 4&5	.2	.01	.01	0	0	0	.02	.02	.05	.01
Sycamore Creek # 6&7	0	0	0	0	0	0	0	.02	.02	0
TOTAL	**.5**	**0**	**.1**	**0**	**0**	**.1**	**.1**	**.1**	**.2**	**.1**
Sycamore Creek # 1	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	0	0	0	0	0	0	0	0	0	0
Sycamore Creek # 3	0	0	0	0	0	0	0	0	0	0
Sycamore Creek # 4	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0
Sycamore Creek # 1	.04	0	.01	0	.01	0	.01	.01	.02	.01
Sycamore Creek # 2	.2	.01	.03	0	.03	.01	.03	.1	.1	.1
Sycamore Creek # 3	.5	.04	.1	0	.1	.1	.1	.2	.3	.2
Sycamore Creek # 4	.01	0	0	0	0	0	0	.01	.01	0
Sycamore Creek # 5	0	0	0	0	0	0	0	0	0	0
TOTAL	**.7**	**.05**	**.1**	**0**	**.1**	**.1**	**.1**	**.2**	**.4**	**.3**

Appendix 3.2. Loads and yields of major and trace elements on suspended sediment-samples

[km^2, square kilometers; m^3, cubic meters; SSC, suspended-sediment concentration; mg/L, milligrams per liter; kg, kilograms; g, grams; isa, insufficient sediment for analysis; $\mu g/m^2$, micrograms per square meter]

Site	Date	Watershed area (km^2)	Storm volume (m^3)	Average SSC (mg/L)	Sediment load (kg)	Contaminant load (g)							
						Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
Lake Como Inflow	8/30/2001	1.86	15,400	55	850	8.4	2.3	62.5	88.4	isa	25.3	125	541
Lake Como Inflow	9/20/2001		1,770	91.5	162	2.0	.3	10.3	13.9	isa	4.5	21.5	106
Lake Como Inflow	11/9/2001		2,210	133	293	3.3	.6	19.2	27.8	isa	8.2	50.5	173
Lake Como Inflow	1/23/2002		6,250	212	1,330	13.8	1.9	75.2	84.3	.2	39.0	160	558
Lake Fosdic Inflow	8/11/2001	.84	940	188	177	2.3	.4	15.8	34.8	isa	4.2	22.4	105
Lake Fosdic Inflow	9/18/2001		2,650	844	2,240	30.0	1.4	182	59.8	.2	68.0	161	412
Lake Fosdic Inflow	10/10/2001		695	323	225	2.8	.2	17.4	8.9	.03	7.9	18.0	84.0
Lake Fosdic Inflow	12/6/2001		3,630	125	454	5.9	.6	42.3	23.3	na	15.7	38.4	154
Lake Echo Inflow	5/28/2001	2.13	27,000	2,200	59,400	454	79.0	3,240	2,410	4.2	1,440	4,730	16,000
Lake Echo Inflow	8/17/2001		34,000	389	13,200	153	32.0	901	566	1.5	474	1,930	4,950
Lake Echo Inflow	9/20/2001		11,200	200	2,240	23.5	6.0	134	140	isa	77.6	371	1,360
Lake Echo Inflow	10/11/2001		6,770	501	3,390	35	8.3	234	205	isa	115.2	718	1,880
Big Fossil Creek	5/4/2001	136.76	478,000	445	213,000	2,850	75.5	17,400	4,270	8.5	6,820	8,060	25,100
Big Fossil Creek	8/11/2001		47,600	308	14,600	164	11.8	1,000	391	isa	433	991	3,370
Big Fossil Creek	9/18/2001		292,000	561	164,000	2,130	61.0	12,700	3,200	6.6	5,670	4,690	18,000
Big Fossil Creek	10/11/2001		254,000	380	96,500	1,280	26.2	7,100	1,950	4.8	3,200	3,550	11,500
Sycamore Creek # 1	5/4/2001	77.94	3,000	40	120	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	5/4/2001		122,000	1,130	138,000	1,570	123	8,880	5,480	16.6	3,840	15,100	36,000
Sycamore Creek # 3	5/4/2001		120,000	381	45,500	450	48.3	2,480	1,730	2.3	1,170	4,340	11,200
Sycamore Creek # 4&5	5/5/2001		161,000	463	74,700	896	69.5	5,670	2,800	4.5	2,450	5,690	21,500
Sycamore Creek # 6&7	5/5/2001		162,000	95	15,400	209	13.9	1,340	674	isa	565	1,180	5,290
TOTAL			568,000		274,000	3,130	255	18,400	10,700	23.3	8,020	26,300	73,900
Sycamore Creek # 1	8/16/2001	77.94	887	48	43	.58	.07	3.37	3.54	isa	1.5	5.9	23.5
Sycamore Creek # 2	8/16/2001		546	37.5	20	.21	.03	1.67	1.33	isa	.2	3.9	7.2
Sycamore Creek # 3	8/16/2001		1,000	112	114	1.52	.08	8.94	6.66	isa	3.9	21.2	32.5
Sycamore Creek # 4	8/16/2001		240	98.5	24	.38	.02	2.61	1.30	isa	1.0	2.8	7.3
TOTAL			**2,690**		**200**	**2.7**	**.20**	**16.6**	**12.8**	**0**	**6.6**	**33.8**	**70.5**
Sycamore Creek # 1	8/30/2001	77.94	74,900	410	30,700	426	28.3	2,240	1,270	3.1	1,050	3,280	7,910
Sycamore Creek # 2	8/30/2001		193,000	846	163,000	1,990	126	11,200	5,860	11.4	5,340	11,900	31,800
Sycamore Creek # 3	8/30/2001		580,000	911	528,000	5,048	256	33,000	14,300	26.4	15,500	30,000	77,200
Sycamore Creek # 4	8/30/2001		153,000	123	18,800	264	13.3	1,400	537	isa	639	1,160	3,540
Sycamore Creek # 5	8/30/2001		103,000	41	4,200	67.7	3.2	344	154	isa	153	313	925
TOTAL			**1,100,000**		**745,000**	**9,200**	**427**	**48,200**	**22,100**	**40.9**	**22,700**	**46,610**	**121,380**

Appendix 3.2. Loads and yields of major and trace elements on suspended-sediment samples—Continued

Site	Contaminant yield ($\mu g/m^2$)							
	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
Lake Como Inflow	4.5	1.2	33.6	47.5	isa	13.6	67.1	291
Lake Como Inflow	1.1	.2	5.6	7.5	isa	2.4	11.6	57.2
Lake Como Inflow	1.8	.3	10.3	14.9	isa	4.4	27.1	93.1
Lake Como Inflow	7.4	1.0	40.4	45.3	.1	21.0	86.2	300
Lake Fosdic Inflow	2.7	.5	18.8	41.5	isa	5.0	26.8	126
Lake Fosdic Inflow	35.8	1.7	217	71.3	.3	81.2	192	491
Lake Fosdic Inflow	3.3	.3	20.8	10.6	0	9.4	21.4	100
Lake Fosdic Inflow	7.1	.7	50.5	27.8	na	18.7	45.8	184
Lake Echo Inflow	213	37.0	1,520	1,130	1.9	674	2,220	7,490
Lake Echo Inflow	71.8	15.0	422	265	.7	222	904	2,320
Lake Echo Inflow	11.0	2.8	62.7	65.4	isa	36.4	174	636
Lake Echo Inflow	16.5	3.9	109.6	96.1	isa	54.0	337	880
Big Fossil Creek	20.8	.6	127	31.2	.1	49.9	58.9	183
Big Fossil Creek	1.2	.1	7.3	2.9	isa	3.2	7.2	24.6
Big Fossil Creek	15.6	.4	93.0	23.4	.05	41.5	34.3	132
Big Fossil Creek	9.4	.2	52.0	14.3	.04	23.4	26.0	84.0
Sycamore Creek # 1	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	20.2	1.6	114	70.4	.2	49.3	193	461
Sycamore Creek # 3	5.8	.6	32	22.1	0	15.0	55.7	144
Sycamore Creek # 4&5	11.5	.9	73	35.9	.1	31.4	73.0	276
Sycamore Creek # 6&7	2.7	.2	17.2	8.6	isa	7.2	15.2	67.9
TOTAL	40.2	3.3	236	137	0	103	337	948
Sycamore Creek # 1	.01	0	.04	.05	isa	.02	.08	.30
Sycamore Creek # 2	0	0	.02	.02	isa	0	.05	.09
Sycamore Creek # 3	.02	0	.11	.09	isa	.05	.27	.42
Sycamore Creek # 4	0	0	.03	.02	isa	.01	.04	.09
TOTAL	**0**	**0**	**.2**	**.2**	**0**	**.1**	**.4**	**.9**
Sycamore Creek # 1	5.5	.4	28.8	16.3	0	13.5	42.1	101
Sycamore Creek # 2	25.6	1.6	143	75.2	.1	68.5	152	408
Sycamore Creek # 3	82.7	3.3	424	184	.3	199	385	990
Sycamore Creek # 4	3.4	.2	18.0	6.9	isa	8.2	14.9	45.5
Sycamore Creek # 5	.9	0	4.4	2.0	isa	2.0	4.0	11.9
TOTAL	**118**	**5.5**	**618**	**284**	**.5**	**291**	**598**	**1,560**

Appendix 3.3. Loads and yields of polycyclic aromatic hydrocarbons on suspended-sediment samples

[km^2, square kilometers; m^3, cubic meters; SSC, suspended-sediment concentration; mg/L, milligrams per liter; kg, kilograms; g, grams; isa, insufficient sediment for analysis; $\mu g/m^2$, micrograms per square meter]

Site	Date	Watershed area (km^2)	Storm volume (m^3)	Average SSC (mg/L)	Sediment load (kg)	Contaminant load (g)									
						Naphthalene	9H-Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Dibenzo(a,h)anthracene
Lake Como Inflow	8/30/2001	1.86	15,400	55	850	0.1	0.1	2.5	0.5	8.8	7.0	3.1	5.7	4.3	0.9
Lake Como Inflow	9/20/2001		1,770	91.5	162	.03	.03	.4	.1	1.5	1.2	.4	1.0	.6	.2
Lake Como Inflow	11/9/2001		2,210	133	293	.1	0	.7	.1	2.2	1.8	.7	1.4	1.0	.2
Lake Como Inflow	1/23/2002		6,250	212	1,330	.1	.1	2.4	.3	7.5	5.7	2.3	4.4	3.5	.8
Lake Fosdic Inflow	8/11/2001	.84	940	188	177	.01	.02	.1	.05	.2	.2	.1	.1	.1	.04
Lake Fosdic Inflow	9/18/2001		2,650	844	2,240	.03	.1	.9	.2	2.5	2.1	.9	1.7	1.3	.3
Lake Fosdic Inflow	10/10/2001		695	323	225	.01	.01	.1	.03	.4	.3	.1	.2	.2	.04
Lake Fosdic Inflow	12/6/2001		3,630	125	454	.02	.1	.4	.1	1.4	1.1	.5	.9	.8	.2
Lake Echo Inflow	5/28/2001	2.13	27,000	2,200	59,400	.5	1.3	3.8	3.1	47.6	5.5	0	0	0	0
Lake Echo Inflow	8/17/2001		34,000	389	13,200	.9	1.5	24.0	5.1	83.4	61.4	30.4	51.5	38.6	8.5
Lake Echo Inflow	9/20/2001		11,200	200	2,240	.3	.2	4.2	.8	13.5	10.2	4.1	8.9	5.1	1.1
Lake Echo Inflow	10/11/2001		6,770	501	3,390	.4	.4	6.8	1.4	27.6	21.5	9.8	18.5	11.5	2.2
Big Fossil Creek	5/4/2001	136.76	478,000	445	213,000	1.3	2.3	20.3	5.3	51.4	40.6	16.4	29.8	26.4	6.5
Big Fossil Creek	8/11/2001		47,600	308	14,600	.2	.2	3.5	.9	11.1	8.4	3.6	8.1	5.8	1.3
Big Fossil Creek	9/18/2001		292,000	561	164,000	.7	1.3	5.7	2.7	18.5	15.4	7.3	12.4	11.0	2.7
Big Fossil Creek	10/11/2001		254,000	380	96,500	.5	1.1	7.3	2.8	24.7	19.1	9.0	15.3	13.7	3.1
Sycamore Creek # 1	5/4/2001	77.94	3,000	40	120	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	5/4/2001		122,000	1,130	138,000	1.4	4.1	0	8.3	174	0	0	87.3	0	0
Sycamore Creek # 3	5/4/2001		120,000	381	45,500	1.2	1.8	0	4.0	55.1	0	0	27.1	0	0
Sycamore Creek # 4&5	5/5/2001		161,000	463	74,700	.6	1.4	0	3.6	58.5	0	0	46.5	0	0
Sycamore Creek # 6&7	5/5/2001		162,000	95	15,400	1.9	1.0	17.5	3.5	47.5	36.9	15.2	27.4	20.3	3.2
TOTAL			**568,000**		**274,000**	**5.2**	**8.3**	**17.5**	**19.4**	**335**	**36.9**	**15.2**	**188**	**20.3**	**3.2**
Sycamore Creek # 1	8/16/2001	77.94	887	48	43	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	8/16/2001		546	37.5	20	0	.01	.02	.01	.1	.04	.03	.03	.04	.01
Sycamore Creek # 3	8/16/2001		1,000	112	114	0	.01	.04	.02	.1	.1	.05	.1	.1	.02
Sycamore Creek # 4	8/16/2001		240	98.5	24	0	0	.01	0	.02	.01	.01	.01	.01	0
TOTAL			**2,690**		**200**	**0**	**0**	**.1**	**0**	**.2**	**.1**	**.1**	**.1**	**.1**	**0**
Sycamore Creek # 1	8/30/2001	77.94	74,900	410	30,700	1.1	1.3	21.7	5.7	69.3	53.3	26.1	39.6	31.3	6.0
Sycamore Creek # 2	8/30/2001		193,000	846	163,000	7.2	3.0	47.8	11.5	152	122	58.4	97.1	72.0	16.0
Sycamore Creek # 3	8/30/2001		580,000	911	528,000	14.5	11.8	165	42.3	555	444	211	320	256	51.3
Sycamore Creek # 4	8/30/2001		153,000	123	18,800	.5	.8	4.9	2.1	15.8	23.7	7.7	11.3	20.4	2.3
Sycamore Creek # 5	8/30/2001		103,000	41	4,200	0	0	.5	.4	1.6	1.3	.7	1.0	1.1	.3
TOTAL			**1,100,000**		**745,000**	**23.3**	**16.9**	**239.9**	**61.9**	**794**	**645**	**304**	**469**	**381**	**75.9**

Appendix 3.3. Loads and yields of polycyclic aromatic hydrocarbons on suspended-sediment samples—Continued

Site	Contaminant load (g)			Contaminant yield ($\mu g/m^2$)												
	Coronene	Total PAH	Combustion PAH	Naphthalene	9H-Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)-anthracene	Chrysene	Benzo(a)-pyrene	Dibenzo-(a,h)-anthracene	Coronene	Total PAH	Combustion PAH
Lake Como Inflow	1.3	80.5	54.0	0.1	0.1	1.4	0.2	4.7	3.8	1.7	3.1	2.3	0.5	0.7	43.3	29.0
Lake Como Inflow	.2	14.2	8.9	.02	.02	.2	.04	.8	.6	.2	.5	.3	.1	.1	7.6	4.8
Lake Como Inflow	.5	21.3	13.5	.03	.03	.4	.1	1.2	1.0	.4	.8	.6	.1	.3	11.5	7.2
Lake Como Inflow	.7	60.8	42.5	.1	.1	1.3	.2	4.0	3.1	1.3	2.4	1.9	.4	.4	32.7	22.9
Lake Fosdic Inflow	.1	2.1	1.2	.01	.03	.1	.1	.2	.2	.1	.1	.2	.04	.1	2.5	1.4
Lake Fosdic Inflow	.2	26.6	16.0	.03	.1	1.1	.2	3.0	2.5	1.1	2.0	1.6	.4	.3	31.7	19.1
Lake Fosdic Inflow	.05	4.0	2.2	.01	.01	.2	.04	.5	.3	.1	.3	.2	.05	.1	4.7	2.7
Lake Fosdic Inflow	.2	13.5	8.8	.02	.1	.5	.1	1.6	1.3	.6	1.0	.9	.3	.3	16.1	10.5
Lake Echo Inflow	4.6	1,400	272	.2	.6	1.8	1.4	22.3	2.6	0	0	0	0	2.2	654	127.7
Lake Echo Inflow	11.0	719	467	.4	.7	11.3	2.4	39.1	28.8	14.2	24.1	18.1	4.0	5.2	337	219
Lake Echo Inflow	1.2	114.0	73.7	.2	.1	2.0	.4	6.3	4.8	1.9	4.2	2.4	.5	.6	53.4	34.6
Lake Echo Inflow	1.6	229	155	.2	.2	3.2	.6	12.9	10.1	4.6	8.7	5.4	1.1	.8	107.5	72.4
Big Fossil Creek	4.5	599	288	.01	.02	.1	.04	.4	.3	.1	.2	.2	.05	0	4.4	2.1
Big Fossil Creek	1.3	92.3	68.0	0	0	.03	.01	.1	.1	.03	.1	.04	.01	0	.7	.5
Big Fossil Creek	2.9	212	119	.01	.01	.04	.02	.1	.1	.1	.1	.1	.02	0	1.6	.9
Big Fossil Creek	1.8	263	148	0	.01	.1	.02	.2	.1	.1	.1	.1	.02	0	1.9	1.1
Sycamore Creek # 1	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	10.1	2,050	536	.02	.1	0	.1	2.2	0	0	1.1	0	0	.1	26	6.9
Sycamore Creek # 3	3.1	800	209	.02	.02	0	.1	.7	0	0	.3	0	0	.04	10.3	2.7
Sycamore Creek # 4&5	4.8	1,250	302	.01	.02	0	.05	.8	0	0	.6	0	0	.1	16.1	3.9
Sycamore Creek # 6&7	1.5	421	251	.02	.01	.2	.05	.6	.5	.2	.4	.3	.04	.02	5.4	3.2
TOTAL	**19.6**	**4,530**	**1,300**	**.1**	**.1**	**.2**	**.2**	**4.3**	**.5**	**.2**	**2.4**	**.3**	**0**	**.3**	**58.1**	**16.7**
Sycamore Creek # 1	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa	isa
Sycamore Creek # 2	.02	.5	.4	0	0	0	0	0	0	0	0	0	0	0	.01	0
Sycamore Creek # 3	.02	1.5	.8	0	0	0	0	0	0	0	0	0	0	0	.02	.01
Sycamore Creek # 4	0	.2	.1	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**0**	**2.2**	**1.3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**.03**	**.02**
Sycamore Creek # 1	5.8	621	376	.01	.02	.3	.1	.9	.7	.3	.5	.4	.1	.1	8.0	4.8
Sycamore Creek # 2	17.0	1,480	904	.1	.04	.6	.1	2.0	1.6	.7	1.2	.9	.2	.2	19.0	11.6
Sycamore Creek # 3	49.1	4,850	3,060	.2	.2	2.1	.5	7.1	5.7	2.7	4.1	3.3	.7	.6	62	39
Sycamore Creek # 4	16.4	250	167	.01	.01	.1	.03	.2	.3	.1	.1	.3	.03	.2	3.2	2.1
Sycamore Creek # 5	.4	20.3	11.5	0	0	.01	0	.02	.02	.01	.01	.01	0	.01	.3	.1
TOTAL	**88.7**	**7,220**	**4,510**	**.3**	**.2**	**3.1**	**.8**	**10.2**	**8.3**	**3.9**	**6.0**	**4.9**	**1.0**	**1.1**	**92.6**	**57.9**

APPENDIX 4—
Fish-Tissue Data

Appendix 4.1. Trinity River fish samples

[µg/kg, micrograms per kilogram; <, nondetection at indicated value]

Date source	Date	Lab number	Site	Sample	Whole or fillet	Remark	PCBs (µg/kg)	Remark	DDE (*o,p*'+ *p,p*') (µg/kg)	Remark	DDD (µg/kg)	Remark	DDT (µg/kg)	Remark	Dieldrin (µg/kg)	Remark	Technical chlordane (µg/kg)
TDH Seafood Safety Division	11/3/1998	TRR-1	Trinity River downstream of Beach Street	Largemouth bass	Unknown		86		8.5	<	10	<	10	<	6	<	10
TDH Seafood Safety Division	11/3/1998	TRR-2	Trinity River downstream of Beach Street	Smallmouth buffalo	Unknown		260		170	<	10	<	10		28	<	10
TDH Seafood Safety Division	11/3/1998	TRR-3	Trinity River downstream of Beach Street	Smallmouth buffalo	Unknown		220		55	<	10	<	10		40		370
TDH Seafood Safety Division	11/3/1998	TRR-4	Trinity River downstream of Beach Street	Channel catfish	Unknown		400		43	<	10	<	10		7.4		260
TDH Seafood Safety Division	11/3/1998	TRR-5	Trinity River downstream of Beach Street	Smallmouth buffalo	Unknown		69		15	<	10	<	10	<	6	<	10
TDH Seafood Safety Division	11/3/1998	TRR-6	Trinity River downstream of Beach Street	Common carp	Unknown		370		66	<	10	<	10	<	6		170
TDH Seafood Safety Division	11/3/1998	TRR-7	Trinity River downstream of Beach Street	Common carp	Unknown		73		14	<	10	<	10	<	6		43
TDH Seafood Safety Division	11/3/1998	TRR-8	Trinity River downstream of Beach Street	Common carp	Unknown		150		17	<	10	<	10	<	6		91
TDH Seafood Safety Division	11/3/1998	TRR-9	Trinity River downstream of Beach Street	Longnose gar	Unknown		2700		320	<	10	<	10	<	6		160
TDH Seafood Safety Division	11/3/1998	TRR-10	Trinity River downstream of Beach Street	Longnose gar	Unknown		670		60		17	<	10	<	6		200
TDH Seafood Safety Division	6/13/2000	TRR-1	Trinity River at Beach Street	Common carp	Unknown		200		9	<	10	<	10	<	6		48
TDH Seafood Safety Division	6/13/2000	TRR-2	Trinity River at Beach Street	Smallmouth buffalo	Unknown		290		21	<	10	<	10		6.9		290
TDH Seafood Safety Division	6/13/2000	TRR-3	Trinity River at Beach Street	Smallmouth buffalo	Unknown		150		17	<	10	<	10	<	6		72
TDH Seafood Safety Division	6/13/2000	TRR-4	Trinity River at Beach Street	Spotted gar	Unknown		645		140		21	<	10	<	6		258
TDH Seafood Safety Division	6/13/2000	TRR-5	Trinity River at Beach Street	Longnose gar	Unknown		3,270		260		77	<	10		15		944
TDH Seafood Safety Division	6/29/2000	TRR-6	Trinity River downstream of Benbrook Dam	Common carp	Unknown	<	40	<	5	<	10	<	10	<	6		100
TDH Seafood Safety Division	6/29/2000	TRR-7	Trinity River downstream of Benbrook Dam	Common carp	Unknown	<	40		6.5	<	10	<	10	<	6		110
TDH Seafood Safety Division	6/29/2000	TRR-8	Trinity River downstream of Benbrook Dam	Common carp	Unknown	<	40	<	5	<	10	<	10	<	6		25
TDH Seafood Safety Division	6/29/2000	TRR-9	Trinity River downstream of Benbrook Dam	Common carp	Unknown	<	40	<	5	<	10	<	10		8		160
TDH Seafood Safety Division	6/29/2000	TRR-10	Trinity River downstream of Benbrook Dam	Common carp	Unknown	<	40		12	<	10	<	10		10		397

Appendix 4.2. Lake Como fish samples

[µg/kg, micrograms per kilogram; NA, not available; <, nondetection at indicated value; bdl, below detection limit]

Data source	Date	Lab no.	Site	Sample	Whole or fillet	Remark	PCBs (µg/kg)	Remark	DDE (*o,p'+p,p'*) (µg/kg)
Texas Parks and Wildlife	12/11/1990	EC 809	Como Lake	Black bullhead (5 fish)	Whole (composite)		N/A	<	20.0
City of Ft. Worth	5/4/1994	1	Como - 1	Black bullhead	Whole		31.0	<	0
City of Ft. Worth	5/4/1994	2	Como - 2	Black bullhead	Whole		33.0		0
City of Ft. Worth	5/4/1994	3	Como - 3	Black bullhead	Whole		25.0		0
City of Ft. Worth	5/4/1994	4	Como - 4	Black bullhead	Whole		111.0		0
City of Ft. Worth	5/4/1994	5	Como - 5	Bluegill	Whole		18.0		0
City of Ft. Worth	5/4/1994	6	Como - 6	Bluegill	Whole		55.0		0
City of Ft. Worth	5/4/1994	7	Como - 7	Bluegill	Whole		102.0		0
City of Ft. Worth	5/4/1994	8	Como - 8	Bluegill	Whole		128.0		.1
City of Ft. Worth	5/4/1994	9	Como - 9	Bluegill	Fillet		73.0	<	0
City of Ft. Worth	5/4/1994	10	Como - 10	Bluegill	Fillet		78.0	<	.1
City of Ft. Worth	5/4/1994	11	Como - 11	Bluegill	Fillet	<	30.0	<	0
City of Ft. Worth	5/4/1994	12	Como - 12	Black bullhead	Fillet		26.0	<	0
City of Ft. Worth	5/4/1994	13	Como - 13	Black bullhead	Fillet	<	16.0	<	16.0
City of Ft. Worth	5/4/1994	14	Como - 14	Black bullhead	Fillet		22.0	<	12.0
City of Ft. Worth	5/4/1994	15	Como - 15	Channel catfish	Whole		61.0	<	20.0
City of Ft. Worth	5/4/1994	16	Como - 16	Channel catfish	Fillet		189.0		52.0
City of Ft. Worth	5/4/1994	17	Como - 17	Channel catfish	Fillet		289.0		102.0
City of Ft. Worth	5/4/1994	18	Como - 18	Channel catfish	Fillet		276.0		72.0
City of Ft. Worth	9/16/1997		Como - 1	Largemouth bass	Fillet			<	.4
City of Ft. Worth	9/16/1997		Como - 2	Largemouth bass	Fillet				10.9
City of Ft. Worth	9/16/1997		Como - 3	Largemouth bass	Fillet			<	.4
City of Ft. Worth	9/16/1997		Como - 4	Largemouth bass	Fillet			<	.4
City of Ft. Worth	9/16/1997		Como - 5	Largemouth bass	Fillet			<	.4
City of Ft. Worth	9/16/1997		Como - 6	Largemouth bass	Whole			<	.4
City of Ft. Worth	9/16/1997		Como - 7	Largemouth bass	Whole			<	.4
City of Ft. Worth	9/16/1997		Como - 8	Largemouth bass	Whole			<	.4
City of Ft. Worth	9/16/1997		Como - 9	Black bullhead (2 fish)	Whole (composite)				5.3
City of Ft. Worth	9/16/1997		Como - 10	Assorted sunfish (4 fish)	Whole (composite)			<	.4
Trinity River Authority	5/17/1999	33	Como - 1	Largemouth bass	Unknown		50.0		15.4
Trinity River Authority	5/17/1999	34	Como - 2	Largemouth bass	Unknown		50.0		10.0
Trinity River Authority	5/17/1999	35	Como - 3	Largemouth bass	Unknown	<	40.0		1.8
Trinity River Authority	5/17/1999	36	Como - 4	Largemouth bass	Unknown		60.0		20.5
Trinity River Authority	5/17/1999	37	Como - 5	Largemouth bass	Unknown		50.0		14.8
Trinity River Authority	5/17/1999	38	Como - 6	Largemouth bass	Unknown		80.0		23.7
Trinity River Authority	5/17/1999	39	Como - 7	Black bullhead	Unknown	<	40.0		2.1
City of Ft. Worth	10/26/2000		COMO-1 (FWEM)	Largemouth bass	Unknown	<	40.0	<	5.0
City of Ft. Worth	10/26/2000		COMO-2 (FWEM)	Largemouth bass	Unknown	<	40.0	<	5.0
City of Ft. Worth	10/26/2000		COMO-3 (FWEM)	Largemouth bass	Unknown	<	40.0	<	5.0
City of Ft. Worth	10/26/2000		COMO-4 (FWEM)	Largemouth bass	Unknown	<	40.0	<	5.0
City of Ft. Worth	10/26/2000		COMO-5 (FWEM)	Largemouth bass	Unknown	<	40.0	<	5.0
Texas Department of Health	3/6/2001		LCO-1 (TDH)	Largemouth bass	Unknown	<	40.0		22.0
Texas Department of Health	3/6/2001		LCO-2 (TDH)	Largemouth bass	Unknown	<	40.0	<	5.0
Texas Department of Health	6/13/2001		LCO-3 (TDH)	Largemouth bass	Unknown	<	40.0	<	5.0
Texas Department of Health	3/7/2001		LCO-4 (TDH)	Largemouth bass	Unknown	<	40.0	<	5.0
Texas Department of Health	3/7/2001		LCO-5 (TDH)	Largemouth bass	Unknown	<	40.0	<	5.0

Appendix 4.2. Lake Como fish samples—Continued

Data source	Re-mark	DDD (µg/kg)	Re-mark	DDT (µg/kg)	Re-mark	Diel-drin (µg/kg)	Re-mark	Technical chlordane (µg/kg)	Re-mark	*gamma*-Chlordane (µg/kg)	Re-mark	*alpha*-Chlordane (µg/kg)	Sum of *gamma*- and *alpha*-chlordane (µg/kg)
Texas Parks and Wildlife	<	50.0	<	50.0	<	100.0		N/A	<	40.0	<	40	
City of Ft. Worth		8.0	<	0		8.0				8.0		12	
City of Ft. Worth	<	12.0	<	7.0		19.0				20.0		22	
City of Ft. Worth		8.0	<	3.0	<	4.0				4.0		3	
City of Ft. Worth		19.0	<	5.0		22.0				37.0		36	
City of Ft. Worth		7.0	<	3.0		38.0				3.0		3	
City of Ft. Worth		9.0	<	3.0		16.0				8.0		6	
City of Ft. Worth		15.0	<	7.0		36.0				14.0		12	
City of Ft. Worth		24.0	<	7.0		95.0				15.0		14	
City of Ft. Worth	<	30.0	<	20.0		35.0			<	15.0	<	15	
City of Ft. Worth	<	72.0	<	40.0		116.0			<	36.0	<	36	
City of Ft. Worth	<	30.0	<	90.0	<	30.0			<	15.0	<	15	
City of Ft. Worth	<	8.0	<	5.0	<	8.0				6.0		7	13
City of Ft. Worth	<	16.0	<	10.0	<	16.0				12.0	<	8	
City of Ft. Worth	<	12.0	<	7.0	<	12.0				12.0		10	22
City of Ft. Worth	<	20.0	<	12.0		90.0				34.0	<	10	
City of Ft. Worth		35.0		13.0		144.0				78.0		60	138
City of Ft. Worth		62.0		12.0		100.0				173.0		148	321
City of Ft. Worth		43.0		74.0		99.0				154.0		180	334
City of Ft. Worth						17.1		849.0					
City of Ft. Worth						22.5		627.0					
City of Ft. Worth						129.0		739.0					
City of Ft. Worth						63.0		371.0					
City of Ft. Worth						19.0		738.0					
City of Ft. Worth					bdl	0		5,760.0					
City of Ft. Worth					bdl	0		3,650.0					
City of Ft. Worth					bdl	0		22.8					
City of Ft. Worth						5.7		494.0					
City of Ft. Worth						14.4		382.0					
Trinity River Authority						5.0		12.4		.8		4.8	
Trinity River Authority						2.0		6.9		.5		2.6	
Trinity River Authority						2.0		5.5		.7		1.8	
Trinity River Authority						13.0		23.7		2.5		8.2	
Trinity River Authority						9.0		19.7		2.0		6.9	
Trinity River Authority						14.0		36.1		3.6		12.7	
Trinity River Authority						2.0		6.0		.7		2	
City of Ft. Worth	<	10.0	<	10.0	<	6.0		18.0					
City of Ft. Worth	<	10.0	<	10.0	<	6.0	<	10.0					
City of Ft. Worth	<	10.0	<	10.0	<	6.0		30.0					
City of Ft. Worth	<	10.0	<	10.0	<	6.0		17.0					
City of Ft. Worth	<	10.0	<	10.0	<	6.0		17.0					
Texas Department of Health	<	10.0	<	10.0		11.0		406.0					
Texas Department of Health	<	10.0	<	10.0	<	6.0		67.0					
Texas Department of Health	<	10.0	<	10.0	<	6.0	<	10.0					
Texas Department of Health	<	10.0	<	10.0	<	6.0		37.0					
Texas Department of Health	<	10.0	<	10.0	<	6.0		17.0					

Appendix 4.3. Echo Lake fish samples

[µg/kg, micrograms per kilogram; <, nondetection at indicated value; bdl, below detection limit]

Data source	Date	Lab number	Site	Sample	Whole or fillet	Re-mark	PCBs (µg/kg)	Re-mark	DDE (*o,p'*+*p,p'*) (µg/kg)
Texas Parks and Wildlife	12/13/1990	EC 812	Echo Lake	Bluegill (5 fish)	Whole (composite)			<	200.0
Texas Department of Health	4/3/1995	ECO-1	Echo Lake	Common carp	Unknown		91.0		8.1
Texas Department of Health	4/3/1995	ECO-2	Echo Lake	Largemouth bass	Unknown		200.0		17.0
Texas Department of Health	4/3/1995	ECO-3	Echo Lake	Largemouth bass	Unknown		93.0		7.7
Texas Department of Health	4/3/1995	ECO-4	Echo Lake	Largemouth bass	Unknown		110.0		8.4
Texas Department of Health	4/3/1995	ECO-5	Echo Lake	White crappie	Unknown		50.0	<	5.0
Texas Department of Health	4/3/1995	ECO-6	Echo Lake	Channel catfish	Unknown		1,400.0		130.0
Texas Department of Health	4/3/1995	ECO-7	Echo Lake	Blue catfish	Unknown		170.0		23.0
Texas Department of Health	4/3/1995	ECO-8	Echo Lake	Blue catfish	Unknown		98.0		17.0
City of Ft. Worth	9/16/1997		Echo - 1	Largemouth bass	Fillet				
City of Ft. Worth	9/16/1997		Echo - 2	Largemouth bass	Fillet				
City of Ft. Worth	9/16/1997		Echo - 3	Largemouth bass	Fillet				
City of Ft. Worth	9/16/1997		Echo - 4	Largemouth bass	Fillet				
City of Ft. Worth	9/16/1997		Echo - 5	Largemouth bass	Fillet				
City of Ft. Worth	9/16/1997		Echo - 6	Largemouth bass	Whole				
City of Ft. Worth	9/16/1997		Echo - 7	Largemouth bass	Whole				
City of Ft. Worth	9/16/1997		Echo - 8	Largemouth bass	Whole				
City of Ft. Worth	9/16/1997		Echo - 9	Largemouth bass	Whole				
City of Ft. Worth	9/16/1997		Echo - 10	Largemouth bass	Whole				
Trinity River Authority	5/17/1999	19	Echo - 1	Largemouth bass	Unknown		210.0		69.7
Trinity River Authority	5/17/1999	20	Echo - 2	Largemouth bass	Unknown	<	40.0		19.3
Trinity River Authority	5/17/1999	21	Echo - 3	Largemouth bass	Unknown		60.0		29.3
Trinity River Authority	5/17/1999	22	Echo - 4	Largemouth bass	Unknown		60.0		4.5
Trinity River Authority	5/17/1999	23	Echo - 5	Largemouth bass	Unknown		80.0		19.3
Trinity River Authority	5/17/1999	24	Echo - 6	Largemouth bass	Unknown		40.0		21.3
Trinity River Authority	5/17/1999	25	Echo - 7	Largemouth bass	Unknown	<	40.0		13.9
Trinity River Authority	5/17/1999	26	Echo - 8	Largemouth bass	Unknown		50.0		19.9
Trinity River Authority	5/17/1999	27	Echo - 9	Channel catfish	Unknown		100.0		30.7
Trinity River Authority	5/17/1999	28	Echo - 10	Largemouth bass	Unknown	<	40.0		12.3
Trinity River Authority	5/17/1999	29	Echo - 11	Largemouth bass	Unknown	<	40.0		13.5
Trinity River Authority	5/17/1999	30	Echo - 12	Largemouth bass	Unknown		40.0		14.8
Trinity River Authority	5/17/1999	31	Echo - 13	Largemouth bass	Unknown	<	40.0		8.7
Trinity River Authority	5/17/1999	32	Echo - 14	Yellow bullhead	Unknown		70.0		14.3
TDH Seafood Safety Division	10/26/2000		ECHO-1 FWEM	Largemouth bass	Unknown	<	40.0		6.9
TDH Seafood Safety Division	10/26/2000		ECHO-2 FWEM	Largemouth bass	Unknown	<	40.0		8.0
TDH Seafood Safety Division	10/26/2000		ECHO-3 FWEM	Largemouth bass	Unknown	<	40.0	<	5.0
TDH Seafood Safety Division	10/26/2000		ECHO-4 FWEM	Largemouth bass	Unknown	<	40.0	<	5.0
TDH Seafood Safety Division	10/26/2000		ECHO-5 FWEM	Largemouth bass	Unknown	<	40.0	<	5.0
TDH Seafood Safety Division	3/6/2001		ECL-1	Largemouth bass	Unknown	<	40.0		20.0
TDH Seafood Safety Division	3/6/2001		ECL-2	Largemouth bass	Unknown	<	40.0	<	5.0
TDH Seafood Safety Division	3/6/2001		ECL-3	Largemouth bass	Unknown	<	40.0		12.0
TDH Seafood Safety Division	3/7/2001		ECL-4	Common carp	Unknown		431.0		116.0
TDH Seafood Safety Division	3/7/2001		ECL-5	Largemouth bass	Unknown	<	40.0	<	5.0

Appendix 4.3. Echo Lake fish samples—Continued

Data source	Remark	DDD (µg/kg)	Re-mark	DDT (µg/kg)	Re-mark	Dieldrin (µg/kg)	Re-mark	Technical chlordane (µg/kg)	Re-mark	*gamma*-Chlordane (µg/kg)	Re-mark	*alpha*-Chlordane (µg/kg)
Texas Parks and Wildlife	<	100.0	<	50	<	100.0				30.0	<	30.0
Texas Department of Health	<	10.0	<	10		8.2	<	20.0				
Texas Department of Health	<	10.0	<	10		7.8	<	20.0				
Texas Department of Health	<	10.0	<	10	<	6.0	<	20.0				
Texas Department of Health	<	10.0	<	10		4.4	<	20.0				
Texas Department of Health	<	10.0	<	10	<	6.0	<	20.0				
Texas Department of Health		26.0	<	10		44.0	<	20.0				
Texas Department of Health	<	10.0	<	10		46.0	<	20.0				
Texas Department of Health	<	10.0	<	10		46.0	<	20.0				
City of Ft. Worth	bdl					65.0		719.0				
City of Ft. Worth		50.8			bdl			1,440.0				
City of Ft. Worth	bdl				bdl			908.0				
City of Ft. Worth	bdl				bdl			4500.0				
City of Ft. Worth	bdl				bdl			1540.0				
City of Ft. Worth	bdl					36.0		358.0				
City of Ft. Worth	bdl				bdl			526.0				
City of Ft. Worth	bdl				bdl		bdl					
City of Ft. Worth	bdl					208.0		1,550.0				
City of Ft. Worth	bdl					52.1		2,630.0				
Trinity River Authority						17.0		55.9		5.6		19.6
Trinity River Authority						6.0		19.7		2.3		6.6
Trinity River Authority						7.0		23.7		2.1		8.6
Trinity River Authority						12.0		12.9		1.2		4.6
Trinity River Authority						5.0		15.3		2.1		4.8
Trinity River Authority						7.0		18.6		2.9		5.5
Trinity River Authority						4.0		10.4		.9		3.8
Trinity River Authority						5.0		16.4		1.3		6.1
Trinity River Authority						9.0		39.3		5.7		12.0
Trinity River Authority						21.0		10.6		1.2		3.6
Trinity River Authority						2.0		9.5		.6		3.7
Trinity River Authority						3.0		12.2		1.1		4.4
Trinity River Authority						3.0		9.3		1.1		3.1
Trinity River Authority						2.0		12.2		1.2		4.4
TDH Seafood Safety Division	<	10.0	<	10	<	6.0		35.0				
TDH Seafood Safety Division	<	10.0	<	10	<	6.0		31.0				
TDH Seafood Safety Division	<	10.0	<	10	<	6.0	<	10.0				
TDH Seafood Safety Division	<	10.0	<	10	<	6.0		21.0				
TDH Seafood Safety Division	<	10.0	<	10	<	6.0		17.0				
TDH Seafood Safety Division	<	10.0	<	10	<	6.0		128.0				
TDH Seafood Safety Division	<	10.0	<	10	<	6.0		30.0				
TDH Seafood Safety Division	<	10.0	<	10	<	6.0		109.0				
TDH Seafood Safety Division		24.0	<	10		11.0		499.0				
TDH Seafood Safety Division	<	10.0	<	10	<	6.0		25.0				

Appendix 4.4. Fosdic Lake fish samples

[µg/kg, micrograms per kilogram; <, nondetection at indicated value]

Date source	Date	Lab number	Site	Sample	Whole or fillet	Re-mark	PCBs (µg/kg)	Re-mark	DDE (*o,p′+p,p′*) (µg/kg)
Texas Department of Heath	8/28/1994	FSL-1	Fosdic - 1	Largemouth bass	Fillet		190		54.0
Texas Department of Heath	8/28/1994	FSL-2	Fosdic - 2	Largemouth bass	Fillet				
Texas Department of Heath	8/28/1994	FSL-3	Fosdic - 3	Largemouth bass	Fillet				
Texas Department of Heath	8/28/1994	FSL-4	Fosdic - 4	Largemouth bass	Fillet w/ skin				
Texas Department of Heath	8/28/1994	FSL-5	Fosdic - 5	White crappie	Fillet w/ skin				
Texas Department of Heath	8/28/1994	FSL-6	Fosdic - 6	White crappie	Fillet w/ skin				
Texas Department of Heath	8/28/1994	FSL-7	Fosdic - 7	Channel catfish	Fillet w/ skin				
City of Ft. Worth	9/16/1997		Fosdic - 1	Largemouth bass	Whole				6.4
City of Ft. Worth	9/16/1997		Fosdic - 2	White crappie (4 fish)	Whole (composite)			<	.4
City of Ft. Worth	9/16/1997		Fosdic - 3	Asst. sunfish (8 fish)	Whole (composite)				10.8
City of Ft. Worth	9/16/1997		Fosdic - 4	Largemouth bass (2 fish)	Whole (composite)			<	.4
City of Ft. Worth	9/16/1997		Fosdic - 5	Black bullhead	Whole (composite)				21.3
City of Ft. Worth	9/16/1997		Fosdic - 6	Largemouth bass	Fillet				31.0
City of Ft. Worth	9/16/1997		Fosdic - 7	White crappie	Fillet			<	.4
City of Ft. Worth	9/16/1997		Fosdic - 8	Black bullhead	Fillet			<	.4
City of Ft. Worth	9/16/1997		Fosdic - 9	Redear Sunfish	Fillet				8.3
City of Ft. Worth	9/16/1997		Fosdic - 10	Largemouth bass	Fillet				3.3
Trinity River Authority	5/17/1999	1	Fosdic - 1	Largemouth bass	Unknown	<	0		5.6
Trinity River Authority	5/17/1999	2	Fosdic - 2	Largemouth bass	Unknown	<	0		2.0
Trinity River Authority	5/17/1999	3	Fosdic - 3	Largemouth bass	Unknown	<	0		5.6
Trinity River Authority	5/17/1999	4	Fosdic - 4	Largemouth bass	Unknown	<	0		3.7
Trinity River Authority	5/17/1999	5	Fosdic - 5	Largemouth bass	Unknown	<	0		3.0
Trinity River Authority	5/17/1999	6	Fosdic - 6	Largemouth bass	Unknown	<	0		8.8
Trinity River Authority	5/17/1999	7	Fosdic - 7	Redear sunfish	Unknown	<	0	<	.4
Trinity River Authority	5/17/1999	8	Fosdic - 8	Redear sunfish	Unknown	<	0		1.0
Trinity River Authority	5/17/1999	9	Fosdic - 9	Redear sunfish	Unknown	<	0		1.9
Trinity River Authority	5/17/1999	10	Fosdic - 10	Redear sunfish	Unknown	<	0		1.7
Trinity River Authority	5/17/1999	11	Fosdic - 11	Black bullhead	Unknown	<	0		9.3
Trinity River Authority	5/17/1999	12	Fosdic - 12	Black bullhead	Unknown	<	0		4.9
Trinity River Authority	5/17/1999	13	Fosdic - 13	Black bullhead	Unknown	<	0		5.0
Trinity River Authority	5/17/1999	14	Fosdic - 14	Black bullhead	Unknown	<	0		4.6
Trinity River Authority	5/17/1999	15	Fosdic - 15	Black bullhead	Unknown	<	0		2.0
Trinity River Authority	5/17/1999	16	Fosdic - 16	Black bullhead	Unknown	<	0		1.4
Trinity River Authority	5/17/1999	17	Fosdic - 17	Black bullhead	Unknown	<	0		10.2
Trinity River Authority	5/17/1999	18	Fosdic - 18	Black bullhead	Unknown	<	0		12.6
City of Ft. Worth	10/26/2000		Fosdic-1 (FWEM)	Largemouth bass	Unknown	<	0		5.2
City of Ft. Worth	10/26/2000		Fosdic-2 (FWEM)	Largemouth bass	Unknown	<	0		5.6
City of Ft. Worth	10/26/2000		Fosdic-3 (FWEM)	Largemouth bass	Unknown	<	0	<	5.0
City of Ft. Worth	10/26/2000		Fosdic-4 (FWEM)	Largemouth bass	Unknown	<	0		6.2
City of Ft. Worth	10/26/2000		Fosdic-5 (FWEM)	Largemouth bass	Unknown	<	0	<	5.0
City of Ft. Worth	3/6/2001		FSL-1 (TDH)	Largemouth bass	Unknown	<	0	<	5.0
City of Ft. Worth	3/6/2001		FSL-2 (TDH)	Largemouth bass	Unknown	<	0		8.0
City of Ft. Worth	3/6/2001		FSL-3 (TDH)	Largemouth bass	Unknown	<	0	<	5.0
City of Ft. Worth	3/6/2001		FSL-4 (TDH)	Largemouth bass	Unknown	<	0	<	5.0
City of Ft. Worth	3/6/2001		FSL-5 (TDH)	Largemouth bass	Unknown	<	0	<	5.0

Appendix 4.4. Fosdic Lake fish samples—Continued

Date source	Re-mark	DDD (µg/kg)	Re-mark	DDT (mg/kg)	Re-mark	Dieldrin (µg/kg)	Re-mark	Technical chlordane (µg/kg)	Re-mark	*gamma*-Chlordane (µg/kg)	Re-mark	*alpha*-Chlordane (µg/kg)
Texas Department of Heath	<	10	<	10		13.0		35.0				
Texas Department of Heath												
Texas Department of Heath												
Texas Department of Heath												
Texas Department of Heath												
Texas Department of Heath												
Texas Department of Heath												
City of Ft. Worth						5.3		338.0				
City of Ft. Worth						2.8		68.8				
City of Ft. Worth						7.3		38.0				
City of Ft. Worth					<	1.0	<	.9				
City of Ft. Worth						13.7		780.0				
City of Ft. Worth						36.6		437.0				
City of Ft. Worth						3.0		32.3				
City of Ft. Worth						2.1		43.9				
City of Ft. Worth					<	1.0		53.8				
City of Ft. Worth					<	1.0		87.2				
Trinity River Authority					<	1.0		8.9		1.3		2.7
Trinity River Authority					<	1.0		.9		.4	<	.4
Trinity River Authority					<	1.0		6.4	<	.4		2.9
Trinity River Authority					<	1.0	<	.9	<	.4	<	.4
Trinity River Authority						2.0		5.8		1.0		1.6
Trinity River Authority						3.0		17.5		2.2		5.7
Trinity River Authority					<	1.0		.9	<	.4	<	.4
Trinity River Authority						2.0		4.2		1.0		.9
Trinity River Authority					<	1.0		5.1		1.0		1.9
Trinity River Authority						2.0		4.9		.6		1.6
Trinity River Authority						4.0		18.0		2.3		5.8
Trinity River Authority						2.0		10.6		1.6		3.2
Trinity River Authority						2.0		9.8		1.3		3.1
Trinity River Authority						2.0		9.8		1.4		3
Trinity River Authority						2.0		6.0		1.1		1.6
Trinity River Authority						1.0		1.3	<	.4		.6
Trinity River Authority					<	1.0		8.0		1.7		1.9
Trinity River Authority						6.0		21.5		4.3		5.4
City of Ft. Worth	<	10	<	10	<	6.0		41.0				
City of Ft. Worth	<	10	<	10	<	6.0		41.0				
City of Ft. Worth	<	10	<	10	<	6.0		24.0				
City of Ft. Worth	<	10	<	10	<	6.0		60.0				
City of Ft. Worth	<	10	<	10	<	6.0		18.0				
City of Ft. Worth	<	10	<	10	<	6.0		66.0				
City of Ft. Worth	<	10	<	10	<	6.0		83.0				
City of Ft. Worth	<	10	<	10	<	6.0		62.0				
City of Ft. Worth	<	10	<	10	<	6.0	<	10.0				
City of Ft. Worth	<	10	<	10	<	6.0		43.0				