Prepared in cooperation with Little Rock Air Force Base

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Scientific Investigations Report 2015–5112

U.S. Department of the Interior
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Contents

Figure

Tables

Conversion Factors

International System of Units to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)
	Weight	
gram (gm)	0.03527	ounce (oz)

Datum

Horizontal coordinate information is referenced to North American Datum of 1983 (NAD 83).

Supplemental Information

Concentrations of chemical constituents in sediment are given as micrograms per kilogram (µg/kg).

Abbreviations

^{137}Cs	cesium-137
^{214}Pb	lead-214
^{226}Ra	radium-226
^{222}Rn	radon-222
As	arsenic
Ba	barium
Be	beryllium
Ca	calcium
Cd	cadmium
CIC	constant initial concentration
Co	cobalt
Cr	chromium
CRS	constant rate of supply
Cu	copper
DDT	dichlorodiphenyltrichloroethane
EPA	U.S. Environmental Protection Agency
Hg	mercury
K	potassium
LRAFB	Little Rock Air Force Base
Mg	magnesium
Mn	manganese
Mo	molybdenum
Na	sodium
Ni	nickel
OC	organochlorine pesticide
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PCB	polychlorinated biphenyl
PEC	probable effect concentration
PEC-Q	probable effect concentration-quotient
p,p’-DDE	dichlorodiphenyldichloroethylene
Sb	antimony
Se	selenium
SQG	sediment-quality guideline
TEC	threshold effect concentration
USGS	U.S. Geological Survey
V	vanadium
Zn	zinc

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Abstract

This report compares concentrations for a wide range of inorganic and organic constituents in bed sediment from Big Base Lake and Little Base Lake, which are located on Little Rock Air Force Base, Arkansas, to sediment-quality guidelines. This report also compares trace-metal concentrations in a bed-sediment core sample to sediment age to determine when the highest concentrations of trace metals were deposited in Big Base Lake.

Trace-metal results often were higher than background concentrations in the surrounding Pulaski County area, and concentrations of arsenic, cadmium, cobalt, copper, lead, manganese, mercury, nickel, and zinc at one or more of three study sites were higher than median concentrations for a study involving 98 urban streams in seven metropolitan areas of the United States. Concentrations for most polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and organochlorine pesticides in all three bed-sediment samples were less than the laboratory reporting limit or were detected at low concentrations.

Some contaminants were detected at concentrations that are potentially toxic to sediment-dwelling biota; however, in general, the analyses suggest that the risk of sediment toxicity may be relatively low. Threshold effect concentrations were exceeded for 14 constituents—arsenic, copper, lead, nickel, and zinc, five polycyclic aromatic hydrocarbons compounds, chlordane, and all three dichlorodiphenyltrichloroethane (DDT) congeners—which suggests potential toxicity to some sediment-dwelling biota. Only two constituents had concentrations that exceeded published probable effect concentrations—arsenic (at the deepest site in Big Base Lake, NS6) and p,p’-dichlorodiphenyldichloroethylene (p,p’-DDE; at both sites in Big Base Lake, NS5 and NS6).

Regarding highest concentrations and associated timing of exposure, trace metals analyzed in the sediment core seem to indicate three fairly distinct exposure patterns. For 11 trace metals that had the highest concentration measured in the shallowest and most recently deposited sediment, the most likely explanation is recent exposure by anthropogenic activities. Most of the 11 trace metals with highest concentrations in shallow sediment are relatively innocuous; however, arsenic, copper, selenium, and zinc are among the U.S. Environmental Protection Agency’s 126 priority pollutants. For three trace metals (cadmium, lead, and mercury), for which concentrations were highest in sediments that were 16–20 centimeters down the core, it is likely that a source associated with those contaminants during the period when those sediments were deposited, was reduced or eliminated. The eight remaining trace metals, for which concentrations were highest in sediments that were just below the prereservoir surface, likely had sources that were eliminated soon after lake construction or occurred at relatively high background concentrations in soils in the area around Little Rock Air Force Base.

Introduction

The U.S. Geological Survey (USGS) first analyzed trace metals in soil and bed-sediment samples collected at Little Rock Air Force Base (LRAFB) in the late 1980s and early 1990s as part of a broad screening of inorganic and organic constituents in soils and groundwater (Freiwald and others, 1991). In 2005, a study was conducted by the USGS to evaluate water quality in the Big Base and Little Base Lakes located on LRAFB (Justus, 2005).

This is the third report provided to LRAFB by the USGS in a 4-year period. The first two reports were administrative reports that addressed trace-metal concentrations, primarily in bed-sediment samples, from Big Base and Little Base Lakes. In 2011, bed-sediment and fish-tissue sampling was conducted at Big Base and Little Base Lakes, and the analytical results were provided to LRAFB. Results from the bed-sediment sampling in 2011 indicated that trace-metal concentrations at LRAFB were higher than expected background concentrations.

In 2012, additional bed-sediment samples were collected near inflows to Big Base and Little Base Lakes to determine if trace-metal concentrations could be linked to a particular area in the watershed. Concentrations for some trace metals in bed-sediment samples collected in 2012 exceeded sediment-quality guidelines (SQGs; MacDonald and others, 2000) that are protective of sediment-dwelling biota; however, trace-metal concentrations could not be linked to specific areas in the watershed. Later in 2012, more bed-sediment samples were collected from a range of lake depths. Results from that study indicated that trace-metal concentrations were higher in deeper parts of Big Base Lake compared to Little Base Lake and shallower parts of Big Base Lake.

In December 2013, as part of this study, more bed-sediment sampling was conducted at two sites previously sampled by the USGS in deep areas of Big Base Lake. At the deeper of those two sites, the USGS collected sediments with a core sampler in addition to surficial sediments (defined as bed-sediment samples collected with a grab sampler from the top 2.5 centimeters [cm] of substrate). Samples throughout the core were analyzed for trace-metal concentrations to determine distribution as a function of depth. Sediment ages were determined to facilitate determinations for the most likely time of input for the trace metals. Because of concerns about the overall sediment toxicity, bed-sediment samples also were analyzed for organic compounds (including polycyclic aromatic hydrocarbons [PAHs], polychlorinated biphenyls [PCBs], and organochlorine pesticides [OCs]) in addition to trace metals. As a consequence of discrepancies associated with some laboratory analyses, it was necessary to repeat the surficial sediment sampling in May 2014, which was previously completed in December 2013, and a surficial sediment sample also was collected at Little Base Lake.

Purpose and Scope

The purpose of this report is to compare concentrations for a wide range of inorganic and organic constituents in surficial sediment at two sampling locations in Big Base Lake and at one location in Little Base Lake to SQGs. This report also examines trace-metal concentrations for a bed-sediment core sample in relation to sediment age to determine when the highest concentrations of trace metals were deposited in Big Base Lake. The samples were collected in December 2013 and May 2014.

Study Area Description

More detailed descriptions of the study area can be found in an earlier USGS report (Justus, 2005). Big Base Lake and Little Base Lake are connected beneath Arnold Drive by a culvert, and Big Base Lake has a much larger surface area and is much deeper than Little Base Lake (fig. 1). Under normal (rainfall) conditions, Big Base Lake has a surface area of approximately 15.8 hectares, whereas the surface area of Little Base Lake is approximately 1.2 hectares. Big Base Lake was constructed from 1954 to 1956 as dirt was removed during the construction phase of adjacent residential areas (James Popham, Little Rock Air Force Base, written commun., June 2014).

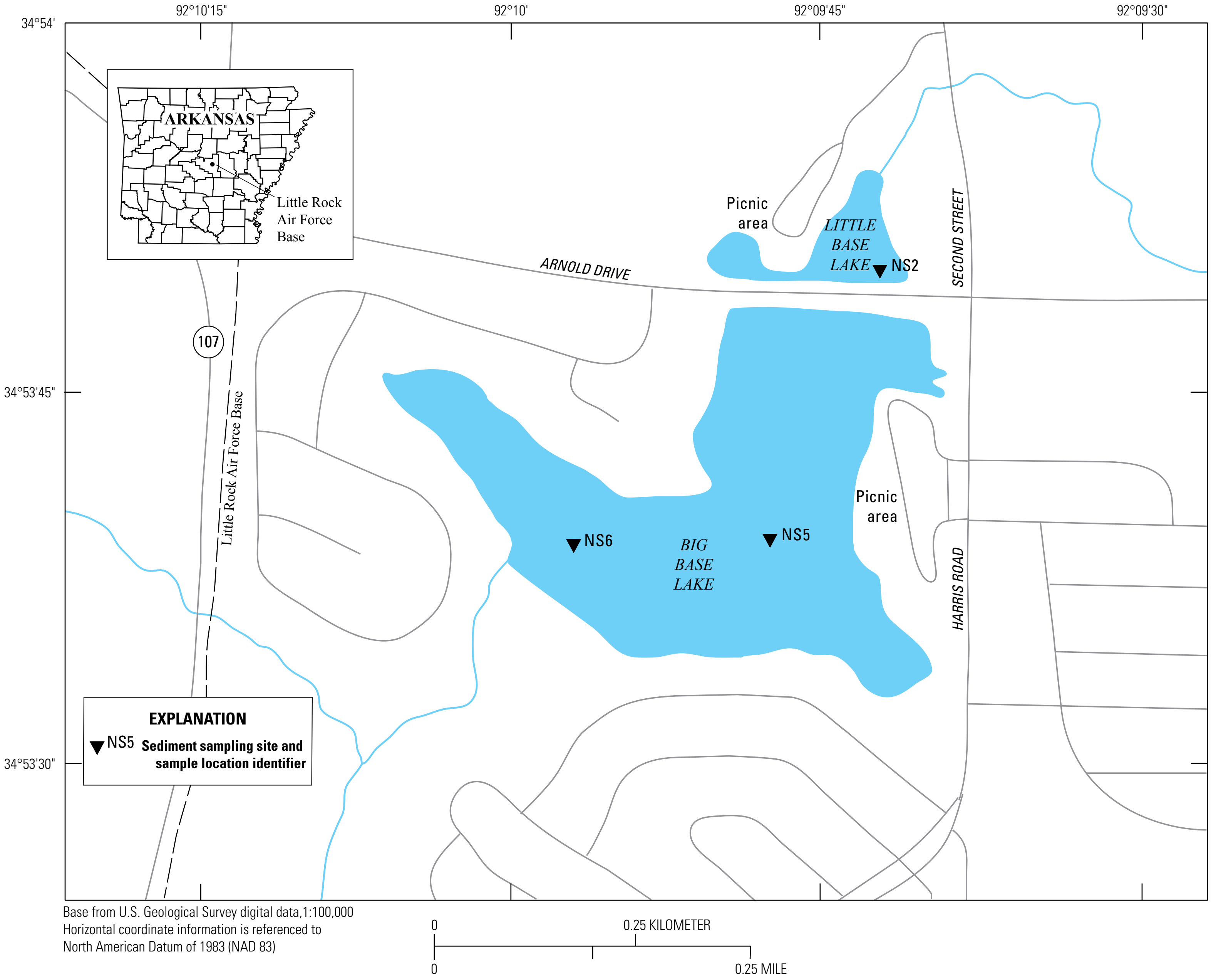
Field and Laboratory Methods

Field Sampling

On December 4, 2013, the USGS collected two bed-sediment samples for trace-metal analyses at two sites (NS5 and NS6) on Big Base Lake that had previously been sampled (fig. 1, table 1). Both samples were collected from the water/sediment interface using a Young grab sampler. The Young grab sampler was cleaned and samples were processed according to USGS protocols (Shelton and Capel, 1994; Justus, 2013). The top 2.5 cm of the surficial sediment from three grabs was composited into a prewashed glass bowl. After being thoroughly mixed, bed sediment was transferred into appropriate sample containers with a Teflon spoon.

A bed-sediment core sample also was collected on December 4, 2013, at NS6, which was the deeper of the two sampling sites. The bed-sediment core sample was collected using a percussion gravity corer with a diameter of 89 millimeters (mm). The depth of Big Base Lake at NS6 was approximately 6.5 meters. The corer was gently lowered from an anchored boat until it reached the substrate, and a slide hammer was used to drive the sampling tube into the bed sediment to refusal, which is the depth below the bottom of the lake at the time of construction. The corer and the sample material were gently lifted up through the water column and back onto the boat, and the bottom of the tube was quickly capped to prevent sample loss. Approximately 20 cm of water above the sediment surface in the collected core was carefully poured off.

Sediment samples from the core were processed in a manner to provide information about when trace metals were deposited and whether concentrations increased or decreased through time (with depth from the top of the sediment core). The core was sectioned at 1-cm intervals from top to bottom, and sections were split to make two subsamples—one subsample for trace-metal analysis and one subsample for sediment-density and age models. A half of each 1-cm section was placed into a glass sample jar with a Teflon spoon for eventual trace-metals analysis. The remaining individual section halves were each placed into a plastic zip-top bag, labeled by depth, and used later for developing the sediment-density and age-dating models. Trace-metal samples submitted to the laboratory were typically a composite of five sequential subsamples; however, only 4 cm of core were available for the last sample. Samples were collected from approximately 74 cm of core, with 15 composite samples retained for trace-metal analysis. Initially, 16 samples that were composites of 4–6 cm were evaluated for the sediment-density and age-dating model (which involved analysis of isotopes of lead-210 [^{210}Pb], radium-226 [^{226}Ra] and cesium-137 [^{137}Cs]).



Base from U.S. Geological Survey digital data,1:100,000
Horizontal coordinate information is referenced to
North American Datum of 1983 (NAD 83)

Figure 1. Bed-sediment sampling sites on Big Base Lake and Little Base Lake, Little Rock Air Force Base, Arkansas, December 4, 2013, and May 8, 2014.

Table 1. Approximate locations and depths for trace-metal samples collected in Big Base and Little Base Lakes on Little Rock Air Force Base, Arkansas, December 4, 2013, and May 8, 2014.

Lake	Sample location identifier (see fig. 1)	Latitude	Longitude	Depth (meter)	Dates sampled	Types of bed-sediment samples collected
Little Base	NS2	34°53′47″	92°09′44″	1.0	5/8/2014	Surficial
Big Base	[1]NS5	34°53′34″	92°09′41″	3.0	12/4/2013; 5/8/2014	Surficial and core
Big Base	[1]NS6	34°53′45″	92°10′06″	6.5	12/4/2013; 5/8/2014	Surficial and core

[1] Global Positioning System battery failure. Locations estimated from map coordinates from Google Earth.

Based on results of the sediment-density model, sample material remaining after sediment-density measurements was eventually analyzed from other depths for the age-dating model. As a result of some quality-assurance issues at the laboratory (described below), the two sites on Big Base Lake were resampled on May 8, 2014, and an additional bed-sediment sample also was collected from a site on Little Base Lake (NS2) at that time (fig. 1, table 1).

Laboratory Analysis

Trace metals from the December 2013 bed-sediment samples were analyzed using the same methods that had been used for previous studies conducted by the USGS on LRAFB; however, analyses were conducted by a different laboratory than in previous years. The U.S. Environmental Protection Agency (EPA) Solid Waste Method 6010B was used for all trace-metals but mercury, which was analyzed using method 7174A (U.S. Environmental Protection Agency, 2002). The USGS National Water Quality Laboratory conducted analyses for PAHs, PCBs, and OCs. The PAH samples were analyzed using schedule 5506 (Zaugg and others, 2006) and PCBs and OCs were analyzed using a custom analysis (laboratory code 8093; U.S. Geological Survey, 2015). Isotope analysis of the core sample was conducted at the University of Florida, Land Use and Environmental Change Institute, Radioisotope Laboratory for the ^{137}Cs, ^{210}Pb, and ^{226}Ra isotopes. Sediment data were stored in the USGS National Water Information System water-quality database (http://waterdata.usgs.gov/nwis/qw/).

Quality-assurance samples collected in December 2013 indicated the trace-metal analyses for the bed-sediment samples and the core sample were compromised at the laboratory; consequently, a second set of analyses was necessary. Bed-sediment samples collected at the water/sediment interface had to be resampled; fortunately, some sediment from all samples taken throughout the core had been archived and was available for the second analysis. As another quality-assurance step, trace-metal analyses for the samples collected in May 2014 were analyzed by two contract laboratories—Test America, the laboratory that had conducted previous analysis for the ongoing LRAFB project, and RTI, a new contract laboratory that analyzed the samples collected in December 2013. Unfortunately, even though material remained from the original core, those subsamples were not analyzed a second time for trace metals until June 2014, and holding times were exceeded for all trace-metal constituents.

Trace-Metal Comparisons

Trace-metal concentrations in Big Base and Little Base Lakes were compared to those of bed-sediment samples analyzed across different spatial and temporal scales. Results were provided along with results of previous samples collected at the two lakes in 2012, background concentrations for soils in the surrounding Pulaski County area (U.S. Geological Survey, 2004), concentrations measured in 198 stream sites across the United States (Gilliom and others, 1998), concentrations measured in 98 urban streams in the United States (Moran and others, 2012), and threshold effect concentrations (MacDonald and others, 2000) (table 2). Concentrations measured in 98 urban streams and threshold effect concentrations typically had the highest median trace-metal concentrations of the four reference concentrations, and direct comparisons were made only between 2014 samples and these two selected references (table 2).

Sources and Methods Used to Determine Sediment-Quality Guidelines

Consensus-based SQGs such as threshold effect concentrations (TEC; below which adverse effects are not expected to occur), probable effect concentrations (PEC; above which adverse effects are expected to occur more often than not), and guidelines for probable effect concentration quotients (PEC-Qs; the combined toxicity of different chemical constituent groups) that were used in this study to evaluate sediment quality were determined by MacDonald and others (2000) by matching sediment chemistry and toxicity data. The PEC values for multiple constituents were combined to calculate mean PEC-Qs for each of the four chemical constituent groups—trace-metals, PAHs, (total) PCBs, and OCs. The PEC-Q values were calculated by dividing the

Table 2. Concentrations of 12 trace metals (in micrograms per kilogram) that were detected at high concentrations or are considered to be priority contaminants in 3 surficial bed-sediment samples collected in Big Base and Little Base Lakes on Little Rock Air Force Base, Arkansas, in May 2014 compared to results from October 2012.

[Data also are compared to four criteria: (1) median concentrations measured in 23 bed-sediment samples collected in Pulaski County, Arkansas (which includes LRAFB), for a National Geochemical Survey (U.S. Geological Survey, 2004); (2) median values for a national study of 198 stream sampling sites from across the United States (Gilliom and others, 1998); (3) median concentrations for a study involving 98 urban streams in seven metropolitan areas of the U.S. (Moran and others, 2012); and (4) Threshold Effect Concentrations (TECs, MacDonald and others, 2000). Red font color indicates that values exceeded the median concentration measured at 98 urban stream sampling sites; **bold** font indicates values that exceeded TECs; ***bold italic*** font indicates values that exceeded the median concentration measured at 98 urban stream sampling sites and TECs; NA, not determined; J, value was less than the reporting limit but greater than or equal to the method detection level; B, constituent concentrations were detected in the blank and in the sample; H, sample holding time exceeded; --, reference concentration not available]

Sample location identifier (fig. 1) and sampling year	Lake	Percent moisture	Aluminum	Arsenic	Cadmium	Chromium	Cobalt	Copper	Lead	Manganese	Mercury	Nickel	Vanadium	Zinc
NS2 2014	Little Base	NA	12,000	6.8	0.22J	16.0	17.0	15.0	29.0	1,100B	0.82H	16.0	21.0B	110
NS5 2014	Big Base	82	21,000	8.3J	0.53J	26.0B	21.0	28.0	***68.0***	2,100	0.10H	**24.0**	39.0	**130**
NS6 2014	Big Base	86	29,000	***44.0***	0.80J	37.0B	25.0	***47.0***	***84.0***	1,800	0.11H	***33.0***	58.0	***180***
NS2 2012	Little Base	75	15,000	6.3J	0.38JB	18.0	16.0	17.0	34.0	960B	0.068	18.0	27.0	120
NS5 2012	Big Base	78	24,000	8.5J	0.39JB	28.0	21.0	30.0	***69.0***	930B	0.090	**27.0**	44.0	**130**
NS6 2012	Big Base	81	27,000	8.5J	0.61JB	31.0	23.0	**36.0**	***79.0***	1,700B	0.110	***29.0***	51.0	**160**
Reference (median) concentrations														
Pulaski County, Arkansas[1]			29,700	6.35	--	33.0	7.0	8.0	20.5	339	0.032	12.0	46.0	46
198 stream sites across the United States			--	6.35	0.40	62.0	--	26.0	24.3	--	0.060	25.0	--	110
98 urban stream samples across the United States			58,000	8.60	0.48	65.3	12.7	38.7	35.2	852	0.089	27.8	86.8	163
Threshold Effect Concentration			--	9.79	0.99	43.4	--	31.6	35.8	--	0.182	22.7	--	121

[1] Data were accessed from U.S. Geological Survey at http://mrdata.usgs.gov/geochem/county.php?place=f05119&el=Hg&rf=south-central.

concentration for the constituent of interest at a site by the PEC value assigned to that constituent by MacDonald and others (2000). A total mean PEC-Q was calculated for all 23 constituents measured, which indicated the overall toxicity of the four chemical constituent groups (trace-metal, PAH, PCB, and OC) in bed sediment by site.

Aging and Density Models

Sediment-age data were compared to trace-metal analyses for the core sample to estimate the year when the highest concentrations of several trace metals were deposited. Sediment densities were determined for 1-cm interval subsamples from the core, and a sediment-density model—entailing detailed core density measurements and empirical estimation of sedimentation rates—was developed at the University of Arkansas Stable Isotope Laboratory. Sediment density was used to determine the base of the lake sediment and whether the sediment had been disturbed in the past. Any sediment disturbance or mixing would invalidate some of the assumptions applied for development of the age-dating model. Using sediment density, the accumulated mass through the core was calculated, the accumulation was compared to age, and a sedimentation rate was determined. A linear relation between excess ^{210}Pb and accumulated mass was expected for undisturbed sediment.

A sediment deposition chronology was determined by measuring ^{210}Pb, ^{226}Ra, and ^{137}Cs (throughout the core) at the University of Florida, Land Use and Environmental Change Institute, Radioisotope Laboratory. Sixteen sample depths were counted for ^{210}Pb and ^{137}Cs. Five to 15 grams of sediment were sealed in petri dishes and aged for approximately 30 days to enable ^{226}Ra to equilibrate with daughters lead-214 (^{214}Pb) and bismuth-214. After aging, samples in the sealed dishes were counted on a gamma spectrometer (HyperpureGe detector) to determine ^{210}Pb, ^{226}Ra, and ^{137}Cs activities. Sediment dating used the ^{210}Pb uranium-thorium series disequilibrium method. This method is based on the process of radon-222 (^{222}Rn) gas that escapes from sediments to the atmosphere where it then decays to ^{210}Pb. The ^{210}Pb attaches to particles and is deposited on land or water and can be used to date sediments as much as 150 years in age. This atmospheric ^{210}Pb is not the only source of ^{210}Pb in sediments. Most sediments contain uranium and ^{226}Ra, which also produce ^{210}Pb. This in situ ^{210}Pb is termed supported ^{210}Pb. The amount of supported ^{210}Pb is related to the amount of ^{214}Pb (determined by gamma spectroscopy). The difference between total ^{210}Pb and ^{214}Pb gives the unsupported ^{210}Pb used for dating.

The sediment deposition chronology was calculated using the constant rate of supply (CRS) model (Appleby and Oldfield, 1978; Oldfield and Appleby, 1984) and checked for accuracy using the constant initial concentration (CIC) model (Robbins, 1978). Age errors for the CRS model were propagated using first-order approximations and calculated according to Binford (1990). Because the reservoir was only a little more than 50 years old at the time of core collection and reservoir sediments had accumulated for less than six half-lives of ^{210}Pb, total integrated, unsupported ^{210}Pb (megabecquerel) that should have accumulated at the core site could not be directly calculated. Instead, the amount of expected, unsupported ^{210}Pb was calculated by stipulating that sediment had been accumulating before the date of reservoir construction. This calculation approach can add error but is the standard approach used for sediments that are near the younger end of the sediment ^{210}Pb dating range (Robbins, 1978; Oldfield and Appleby, 1984). Final results were feasible and reasonable solutions with good comparability using CRS and CIC models, indicating effective application of the method.

Trace-Metal and Organic Constituent Concentrations in Bed Sediment

Some trace-metal concentrations in surficial sediment samples were comparable to results from recent sampling efforts at Big and Little Base Lakes; however, other concentrations were higher than previous results (table 2). Trace-metal concentrations measured in bed sediment in the Big Base Lake NS5 and Little Base Lake NS2 samples in May 2014 were comparable to concentrations measured at those two sites in October 2012 (table 2). Trace-metal concentrations measured in bed sediment in the Big Base Lake NS6 sample in May 2014, however, were higher for 11 of 12 trace metals of concern compared to concentrations measured in October 2012. Higher concentrations in 2014 were likely the result of small-scale spatial variability that is commonly associated with trace-metal analysis (Rice, 1999; Justus, 2013) rather than temporal changes in concentration during the 19-month period between samples.

Trace-metal concentrations were higher than local- and national-scale background concentrations. On a local scale, trace-metal concentrations collected in 2014 at the three sampling sites often were higher than background concentrations for soils in the surrounding Pulaski County area. This was true for arsenic (As), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), and zinc (Zn) (table 2; U.S. Geological Survey, 2004). On a national scale, concentrations of As, cadmium (Cd), Co, Cu, Pb, Mn, Hg, Ni, and Zn at one or more of the three sites sampled in May 2014 were higher than median concentrations for a study involving 98 urban streams in seven metropolitan areas of the United States (table 2; Moran and others, 2012).

Concentrations for most PAH, PCB, and OC pesticide constituents in all three bed-sediment samples were less than the laboratory reporting limit or were detected at low concentrations (app. 1). Unlike trace metals, substantially higher concentrations were not observed at one site compared to the remaining two sites.

Comparisons of Constituent Concentrations to Sediment-Quality Guidelines

Available SQGs suggest that some contaminants were detected at concentrations that are potentially toxic to sediment-dwelling biota. Detected concentrations were above TECs for 14 of the 23 trace-metal, PAH, PCB, and OC constituents evaluated. Trace-metal concentrations of As, Cu, Pb, Ni, and Zn exceeded established TECs, as did five PAH compounds (benz[a]anthracene, benzo[a]pyrene, chrysene, fluoranthene, and pyrene), chlordane, and all three DDT congeners (table 3). Trace metal TECs were exceeded most frequently and to the greatest degree at the deepest site in Big Base Lake, NS6. The PAH TECs were only exceeded at NS2, whereas OC TECs were exceeded at all sites. Only two constituents had concentrations that exceeded published PECs—As (NS6) and the p,p’-DDE (NS5 and NS6, table 3).

The consensus-based SQGs also can provide a basis for predicting sediment toxicity when sediments contain mixtures of contaminants. MacDonald and others (2000) reported that based on various freshwater toxicity analyses, mean PEC-Qs greater than 0.5 (calculated in their case using the PECs for eight trace metals, the PEC for total PAHs [rather than the PECs for individual PAHs], the PEC for PCBs, and the PEC for p,p’-DDE), were toxic to sediment-dwelling organisms about 85 percent of the time. Of the 12 mean PEC-Qs calculated for the LRAFB samples (for trace metals, PAHs, PCBs, and OC pesticides at each of the three sites), only 1 equaled 0.50 (a level that is toxic to sediment-dwelling organisms about 85 percent of the time)—the mean trace-metal PEC-Q calculated for the Big Base Lake NS6 sample (table 4). The overall mean PEC-Qs for the 23 trace metal, PAH, PCB, and OC pesticide constituents evaluated (for example, 0.30 at NS6, table 4) suggest that the risk of toxicity may be relatively low.

Sediment Deposition, Constituent Concentrations, and Indications for Timing of Exposure

Results of the density model and sediment chronology in Big Base Lake at NS6 indicate that lake-sediment deposition was initiated at a depth between 23 and 28 cm (table 5). However, sediment at a depth of 28 cm is estimated to have been deposited in approximately 1947, which would have been prior to construction of the reservoir (circa 1954). Sediment at a depth of 23 cm is estimated to have been deposited in approximately 1968.

Regarding the highest concentrations and associated timing of exposure, trace metals analyzed in the bed-sediment core sample seem to indicate three fairly distinct exposure patterns. For 11 trace metals—antimony (Sb), As, barium (Ba), calcium (Ca), Cu, iron (Fe), Mn, molybdenum (Mo), selenium (Se), sodium (Na), and Zn—concentrations were highest in sediments nearest to the water/sediment interface (table 6). For three trace metals—Cd, Pb, and Hg—concentrations were highest in sediments that were 16–20 cm deep. For eight trace metals—Al, beryllium (Be), chromium (Cr), Co, magnesium (Mg), Ni, potassium (K), and vanadium (V)—concentrations were highest in sediments that were just below the prereservoir surface at the time of construction or at a current sediment depth of about 30 cm (table 6).

For the 11 trace metals that had the highest concentration measured in the shallowest and most recently deposited sediment, the most likely explanation is recent exposure to anthropogenic activities (such as general urbanization, vehicular wear and tear, and parking lot runoff; Justus, 2013). Most of the 11 trace metals with the highest concentrations in shallow sediment are relatively innocuous; however, As, Cu, Se, and Zn are listed by the EPA as being in the top 126 priority pollutants (U.S. Environmental Protection Agency, 2014).

For Cd, Pb, and Hg, three trace metals for which concentrations were highest in sediments that were 16–20 cm down the bed-sediment core, it is likely that a source associated with those priority contaminants (and that period) was reduced or eliminated. This pattern has been noted in numerous other studies (Mahler and others, 2006) and likely reflects a strong, atmospherically derived, anthropogenic input that occurred through the 1970s. For example, the discontinued use of leaded fuels in the 1970s has resulted in decreases in anthropogenic lead from 30 to 79 percent (Mahler and others, 2006), whereas lower concentrations of Hg and other trace metals during that same period may be associated with industrial advances in the reduction of air emissions. Higher concentrations of some constituents in the surficial sample from site NS6 compared to median concentrations from the 98 urban stream samples could be related more to differences in the physical properties of lake sediment compared to stream sediment than to sources of contamination. For instance, given the same source exposure, the higher the sand:silt ratio, the lower the trace metal concentration that might be expected.

Two scenarios could apply to the remaining eight trace metals that had the highest concentrations near the bottom of the lake at the time of construction. It is possible that sources for some trace metals were eliminated after lake construction; however, concentrations in soils sampled in the Pulaski County area also suggest that background concentrations in soils in the LRAFB area can be relatively high (table 2).

Table 3. Concentrations of selected contaminants in three surficial bed-sediment samples collected in Big Base and Little Base Lakes on Little Rock Air Force Base, Arkansas, compared to consensus-based threshold and probable effect concentrations (TECs and PECs).

[Bold values indicate threshold effect concentration (TEC) values were exceeded]

Chemical constituent	TEC[1]	PEC[1]	Sampling lake and site		
			Little Base NS2	Big Base NS5	Big Base NS6
Metals, in milligrams per kilograms					
Arsenic	9.79	33.00	6.80	8.30	**44.00**
Cadmium	0.99	4.98	0.22	0.53	0.80
Chromium	43.40	111.00	16.00	26.00	37.00
Copper	31.60	149.00	15.00	28.00	**47.00**
Lead	35.80	128.00	29.00	**68.00**	**84.00**
Mercury	0.18	1.06	0.08	0.10	0.11
Nickel	22.70	48.60	16.00	**24.00**	**33.00**
Zinc	121.00	459.00	110.00	**130.00**	**180.00**
Polycyclic aromatic hydrocarbons (PAHs), in micrograms per kilograms					
Anthracene	57.2	845	33	6.14	18
Fluorene	77.4	536	50	[2]44.5	60
Naphthalene	176	561	40	[2]44.5	41
Phenanthrene	204	1,170	160	31	84
Benz[*a*]anthracene	108	1,050	[2]**160**	21.2	57
Benzo[*a*]pyrene	150	1,450	[2]**280**	[2]44.5	110
Chrysene	166	1,290	[2]**360**	60	150
Fluoranthene	423	2,230	**520**	83.2	240
Pyrene	195	1,520	**420**	61	190
Total Polycyclic aromatic hydrocarbons	1,610	22,800	1,223	263	950
Polychlorinated biphenyls (PCBs), in micrograms per kilograms					
Total polychlorinated biphenyls	59.8	676	0.0	25.5	30.2
Organochlorine pesticides (OCs), in micrograms per kilograms					
Chlordane (including *cis*-Chlordane and *cis*-Nonachlor)	3.24	17.6	1.278	**4.66**	**7.74**
Dieldrin	1.9	61.8	1.03	1.32	1.78
p,p′-dichlorodiphenyldichloroethane (DDD)	4.88	28	2.63	[2]**6**	[2]**6**
p,p′-dichlorodiphenyldichloroethylene (DDE)	3.16	31.3	**9.13**	**33.7**	**33.1**
p,p′-dichlorodiphenyltrichloroethane (DDT)	4.16	62.9	[2]**10**	[2]**12**	[2]**23**
Total DDD, DDE, and DDTs	5.28	572	**21.76**	**51.7**	**62.1**

[1] MacDonald and others, 2000.

[2] Values were below the detection limit and estimated by the laboratory but were considered to be actual values in the calculation of sediment-quality guidelines for these PAH, DDD, and DDT constituents.

Table 4. Mean probable effect concentration-quotients (PEC-Qs) for four contaminant groups and three surficial bed-sediment sampling locations in Big Base and Little Base Lakes on Little Rock Air Force Base, Arkansas, May 2013.

[0.50, mean PEC-Qs greater than 0.50 are toxic to sediment-dwelling organisms about 85 percent of the time; NA, not applicable]

Chemical constituent	PEC[1]	Sampling lake and site concentration			Sampling lake and site PEC-Q		
		Little Base NS2	Big Base NS5	Big Base NS6	Little Base NS2	Big Base NS5	Big Base NS6
Metals, in milligrams per kilograms							
Arsenic	33.00	6.80	8.30	44.00	0.21	0.25	1.33
Cadmium	4.98	0.22	0.53	0.80	0.04	0.11	0.16
Chromium	111.00	16.00	26.00	37.00	0.14	0.23	0.33
Copper	149.00	15.00	28.00	47.00	0.10	0.19	0.32
Lead	128.00	29.00	68.00	84.00	0.23	0.53	0.66
Mercury	1.06	0.08	0.10	0.11	0.08	0.09	0.10
Nickel	48.60	16.00	24.00	33.00	0.33	0.49	0.68
Zinc	459.00	110.00	130.00	180.00	0.24	0.28	0.39
Mean metal PEC-Q	NA	NA	NA	NA	**0.17**	**0.27**	**0.50**
Polycyclic aromatic hydrocarbons (PAHs), in micrograms per kilograms							
Anthracene	845	33	6.14	18	0.04	0.01	0.02
Fluorene	536	50	44.5	60	0.09	0.08	0.11
Naphthalene	561	40	44.5	41	0.07	0.08	0.07
Phenanthrene	1,170	160	31	84	0.14	0.03	0.07
Benz[*a*]anthracene	1,050	160	21.2	57	0.15	0.02	0.05
Benzo[*a*]pyrene	1,450	280	44.5	110	0.19	0.03	0.08
Chrysene	1,290	360	60	150	0.28	0.05	0.12
Fluoranthene	2,230	520	83.2	240	0.23	0.04	0.11
Pyrene	1,520	420	61	190	0.28	0.04	0.13
Mean PAH PEC-Q	NA	NA	NA	NA	**0.16**	**0.04**	**0.08**
Total polychlorinated biphenyls (PCBs), in micrograms per kilogram							
Mean total PCB PEC-Q	676	0.0	25.5	30.2	**0.00**	**0.04**	**0.04**
Organochlorine pesticides (OCs), in micrograms per kilograms							
Chlordane	17.6	1.278	**4.66**	**7.74**	0.07	0.26	0.44
Dieldrin	61.8	1.03	1.32	1.78	0.02	0.02	0.03
p,p′-dichlorodiphenyldichloroethane (DDD)	28	2.63	6	6	0.09	0.21	0.21
p,p′-dichlorodiphenyldichloroethylene (DDE)	31.3	9.13	33.7	33.1	0.29	1.08	1.06
p,p′-dichlorodiphenyltrichloroethane (DDT)	62.9	10	12	23	0.16	0.19	0.37
Mean OC PEC-Q	NA	NA	NA	NA	**0.13**	**0.35**	**0.42**
Total mean PEC-Q for the 23 constituents (listed above)	NA	NA	NA	NA	**0.15**	**0.19**	**0.30**

[1] MacDonald and others, 2000.

Table 5. Lead-210 (^{210}Pb), radium-226 (^{226}Ra), and cesium-137 (^{137}Cs) isotope concentrations at various depths in a bed-sediment core sample collected from Big Base Lake on Little Rock Air Force Base, Arkansas, December 4, 2013.

[cm, centimeter; dpm/g, disintegrations per minute per gram; MDA, minimum detection activity; ^{210}Pb, ^{226}Ra, and ^{137}Cs, are isotopes of lead, radium, and cesium; gray line indicates the approximate time of lake construction]

Approximate sample depth (cm)	Density corrected ^{210}Pb activity (dpm/g)	^{210}Pb MDA (dpm/g)	Mean ^{226}Ra activity (dpm/g)	Mean ^{226}Ra MDA (dpm/g)	^{137}Cs activity (dpm/g)	^{137}Cs MDA (dpm/g)	Approximate deposition date
4–6	16.804	0.482	4.250	0.433	1.460	0.046	2008.5
10–11	15.621	0.417	3.899	0.374	1.102	0.040	2000.2
14–15	10.060	0.373	4.171	0.334	2.141	0.036	1992.5
19–20	6.203	0.269	4.208	0.242	4.088	0.026	1977.7
22–23	6.001	0.256	4.303	0.230	4.629	0.025	1968.2
28–29	4.630	0.262	4.287	0.236	5.766	0.025	1946.8
34–35	3.709	0.234	4.529	0.210	5.399	0.022	1922.7
38–39	3.984	0.237	4.488	0.213	4.452	0.023	1904.6
39–40	2.866	0.192	4.037	0.173	2.028	0.018	1899.3
44–45	2.444	0.110	3.198	0.100	0.455	0.010	1865.6
49–50	2.247	0.112	3.199	0.101	0.334	0.010	1833.1
54–55	1.848	0.109	3.018	0.099	0.325	0.010	1802.1
59–60	2.654	0.106	3.507	0.096	0.262	0.009	1773.2
65–66	2.061	0.104	3.096	0.095	0.234	0.009	1737.5
69–70	1.573	0.106	2.868	0.096	0.337	0.009	1713.9
71–72	2.377	0.128	3.606	0.116	0.306	0.011	1702.4

Table 6. Concentrations of selected trace metals detected at different depths in a bed-sediment core sample from Big Base Lake (site NS6) on Little Rock Air Force Base, Arkansas, December 2013.

[All results are in milligrams per kilogram except for mercury which is reported in micrograms per kilogram; **bold** font indicates highest constituent concentration detected; cm, centimeter; J, value was less than the reporting limit but greater than or equal to the method detection level; B, constituent concentrations were detected in the blank and in the sample; ND, not detected; laboratory issues associated with the first analysis necessitated a rerun and all constituents were analyzed past the recommented holding time]

Sample depth (cm)	Approximate sediment age	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
0–5	2010	20,000	**0.67J**	**29**	**220B**	1.1	0.15J	**1,100**	25	17	**33**	**49,000B**	55
6–10	2002	13,000	ND	22	120B	0.67	0.062J	600	16	11	24	32,000B	36
11–15	1992	18,000	0.47J	21	160B	0.93	0.19J	680	22	16	21	37,000B	64
16–20	1978	21,000	0.56J	15	190J	1.1	**0.26J**	690	24	20	20	34,000B	**110**
21–25	1966	23,000	0.4J	14	190B	**1.2**	0.24J	720	24	**22**	20	33,000B	93
26–30	1948	**26,000**	0.47J	12	190B	**1.2**	0.23J	760	**26**	**22**	20	32,000B	83
31–35	1926	21,000	ND	11	170B	1.1	0.17J	680	22	20	17	27,000B	52
36–40	1900	21,000	ND	9.9	160B	1.1	0.1J	680	21	20	16	26,000B	43
41–45	1865	17,000	ND	6.9	120B	0.83	ND	680	18	13	13	23,000B	27
46–50	1834	13,000	ND	6.2	82B	0.62	ND	700	16	12	10	21,000B	20
51–55	1802	12,000	ND	6.2	79B	0.58	ND	620	15	11	9.3	18,000B	18
56–60	1774	14,000	ND	6.6	97B	0.7	ND	690	17	12	11	20,000B	20
61–65	1740	12,000	ND	6.3	85B	0.66	ND	610	15	10	9.3	17,000B	17
66–70	1714	13,000	ND	5.7	96B	0.072	ND	770	14	13	9.4	19,000B	18
71–75	1700	16,000	ND	6.6	130B	0.86	ND	770	17	16	12	21,000B	21

Table 6. Concentrations of selected trace metals detected at different depths in a bed-sediment core sample from Big Base Lake (site NS6) on Little Rock Air Force Base, Arkansas, December 2013.—Continued

[All results are in milligrams per kilogram except for mercury which is reported in micrograms per kilogram; **bold** font indicates highest constituent concentration detected; cm, centimeter; J, value was less than the reporting limit but greater than or equal to the method detection level; B, constituent concentrations were detected in the blank and in the sample; ND, not detected; laboratory issues associated with the first analysis necessitated a rerun and all constituents were analyzed past the recommented holding time]

Sample depth (cm)	Approximate sediment age	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Potassium	Selenium	Silver	Sodium	Vanadium	Zinc
0–5	2010	1,300B	**1,100B**	100	**1.4J**	22	1,200	**0.95J**	ND	**140J**	38B	**130**
6–10	2002	890B	540B	100	0.8J	14	810	ND	ND	80J	25B	77
11–15	1992	1,100B	650B	100	1.2J	20	1,100	ND	ND	84J	34B	100
16–20	1978	1,300B	560B	**110**	0.76J	22	1,200	ND	ND	82J	38B	110
21–25	1966	1,300B	650B	99	0.86J	**23**	1,200	ND	ND	84J	40B	97
26–30	1948	**1,400B**	630B	86	0.69J	**24**	**1,400**	ND	ND	91J	**43B**	96
31–35	1926	1,200B	550B	77	0.65J	20	1,100	ND	ND	73J	37B	74
36–40	1900	1,200B	440B	73	0.87J	20	1,100	ND	ND	73J	36B	69
41–45	1865	990B	700B	56	0.44J	16	880	ND	ND	60J	29B	52
46–50	1834	760B	860B	39	0.31J	12	680	ND	ND	ND	37B	39
51–55	1802	720B	570B	39	0.3J	11	650	ND	ND	ND	23B	35
56–60	1774	830B	520B	49	0.36J	13	750	ND	ND	58J	26B	45
61–65	1740	690B	400B	49	0.29J	12	630	ND	ND	ND	22B	41
66–70	1714	720B	1,000B	51	0.23	12	650	ND	ND	ND	23B	38
71–75	1700	890B	920B	68	0.4J	15	790	ND	ND	62J	28B	42

Summary

This report compares concentrations for a wide range of inorganic and organic constituents in surficial bed sediment at two sampling locations in Big Base Lake and at one location in Little Base Lake, which are located on Little Rock Air Force Base, Arkansas, to sediment-quality guidelines. This report also compares trace-metal concentrations in a bed-sediment core sample to sediment age to determine when the highest concentrations of trace metals were deposited in Big Base Lake.

Trace-metal concentrations were higher than background concentrations at the local and national scale. On a local scale, trace-metal concentrations from samples collected in 2014 often were higher than background concentrations for the surrounding Pulaski County area. On a national scale, concentrations of arsenic, cadmium, cobalt, copper, lead, manganese, mercury, nickel, and zinc at one or more of the three sites sampled in May 2014 were higher than median concentrations for a study involving 98 urban streams in seven metropolitan areas of the United States. Concentrations for most polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and organochlorine (OC) pesticide constituents in all three bed-sediment samples were less than the laboratory reporting limit or were detected at low concentrations.

Some contaminants were detected at concentrations that are potentially toxic to sediment-dwelling biota; however, in general, the analyses suggest that the risk of sediment toxicity may be relatively low. Detected concentrations were above threshold effect concentrations (TECs) for 14 of the 23 trace-metal, PAH, PCB, and OC constituents evaluated. Trace-metal concentrations for arsenic, copper, lead, nickel, and zinc exceeded established TECs, as did five PAH compounds (benz[a]anthracene, benzo[a]pyrene, chrysene, fluoranthene, and pyrene), chlordane, and all three dichlorodiphenyltrichloroethane (DDT) congeners. Trace metal TECs were exceeded most frequently and to the greatest degree at the deepest site in Big Base Lake, NS6. The PAH TECs were only exceeded at the site in Little Base Lake, but all sites had OC TECs that were exceeded. Only two constituents had concentrations that exceeded published probable effect concentrations (PECs)—arsenic (at the deepest site in Big Base Lake, NS6) and dichlorodiphenyldichloroethylene (p,p’-DDE, at both sites in Big Base Lake, NS5 and NS6). Of the 12 mean probable effect concentration-quotients (PEC-Qs) calculated (for trace metals, PAHs, PCBs, and OC pesticides at each of the three sites), only the sample from Big Base Lake, NS6 exceeded 0.50. The overall mean PEC-Qs for the 23 trace metal, PAH, PCB, and OC pesticide constituents evaluated, suggest that the risk of toxicity may be relatively low.

Regarding the highest concentrations and associated timing of exposure, trace metals analyzed in the bed-sediment core sample seem to indicate three fairly distinct exposure patterns. For the 11 trace metals that had the highest concentration measured in the shallowest and most recently deposited sediment, the most likely explanation is recent exposure to anthropogenic activities (such as general urbanization, vehicular wear and tear, parking lot runoff). Most of the 11 trace metals with the highest concentrations in shallow sediment are relatively innocuous; however, arsenic, copper, selenium, and zinc are listed by the U.S. Environmental Protection Agency as being in the top 126 priority pollutants.

For three trace metals for which concentrations were highest in sediments that were 16–20 cm down the bed-sediment core, it is likely that a source associated with those contaminants (and that period), was reduced or eliminated. The discontinued use of leaded fuels in the 1970s has resulted in decreases in anthropogenic lead from 30 to 79 percent, whereas lower concentrations of mercury and other trace metals during that same period may be associated with industrial advances in the reduction of air emissions.

Two scenarios could apply to the remaining eight trace metals that had the highest concentrations near the bottom of the lake at the time of construction. It is possible that sources for some trace metals were eliminated after lake construction or it is possible that background concentrations in soils in the LRAFB area are relatively high.

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Appendix 1. Concentrations of organic constituents in three surficial bed-sediment samples analyzed for a lake study conducted on Little Rock Air Force Base, Arkansas, May 2014.

[Results are in micrograms per kilogram; <, less than the specified laboratory reporting limit; bold values were estimated at the laboratory; M, missing data; all results were used as absolute values when calculating probable effect concentrations]

Organic group or constituent	Sampling lake and site		
	Little Base NS2	Big Base NS5	Big Base NS6
Polycyclic aromatic hydrocarbons			
1,2,4-Trichlorobenzene	<50	<44.5	<60
1,2-Dimethylnaphthalene	<50	<44.5	<60
1,6-Dimethylnaphthalene	<50	<44.5	29
1-Methyl-9*H*-fluorene	<50	<44.5	<60
1-Methylphenanthrene	14	<44.5	12
1-Methylpyrene	<50	<44.5	<60
2,3,6-Trimethylnaphthalene	<50	<44.5	<60
2,6-Dimethylnaphthalene	105	49.3	411
2-Ethylnaphthalene	<50	<44.5	<60
2-Methylanthracene	<50	<44.5	<60
4*H*-Cyclopenta[*def*]phenanthrene	30	7.814	21
9*H*-Fluorene	<50	<44.5	<60
Acenaphthene	<50	<44.5	M
Acenaphthylene	<50	<44.5	<60
Anthracene	33	6.14	18
Benzo[*a*]anthracene	**160**	21.2	**57**
Benzo[*a*]pyrene	**280**	<44.5	**110**
Benzo[*b*]fluoranthene	**600**	101	**260**
Benzo[*e*]pyrene	328	51.9	147
Benzo[*ghi*]perylene	320	<44.5	<120
Benzo[*k*]fluoranthene	**200**	32.6	**80**
Chrysene	**360**	60	**150**
Dibenzo[*a,h*]anthracene	<50	<44.5	<60
Dibenzothiophene	<50	<44.5	<60
Fluoranthene	520	83.2	240
Indeno[1,2,3-*cd*]pyrene	**280**	<44.5	**120**
Naphthalene	40	<44.5	41
Octachlorostyrene	<2.5	<3.0	<3.0
Pentabromotoluene	<2.5	<3.0	<3.0
Perylene	446	474	1,180
Phenanthrene	160	31	84
Pyrene	420	61	190

Appendix 1. Concentrations of organic constituents in three surficial bed-sediment samples analyzed for a lake study conducted on Little Rock Air Force Base, Arkansas, May 2014.—Continued

[Results are in micrograms per kilogram; <, less than the specified laboratory reporting limit; bold values were estimated at the laboratory; M, missing data; all results were used as absolute values when calculating probable effect concentrations]

Organic group or constituent	Sampling lake and site		
	Little Base NS2	Big Base NS5	Big Base NS6
Miscellaneous organic constituents			
1,2-Bis(2,4,6-tribromophenoxy)ethane	4.62	3.58	3.95
9,10-Anthraquinone	100	21.4	65
BDE congener 100	0.35	0.365	0.464
BDE congener 138	<2.5	<3.0	<3.0
BDE congener 153	0.103	0.3	0.3
BDE congener 154	**0.122**	**0.188**	**0.272**
BDE congener 183	0.25	0.3	0.35
BDE congener 47	**2.58**	**1.73**	**1.89**
BDE congener 66	<2.5	<3.0	<3.0
BDE congener 71	<2.5	<3.0	<3.0
BDE congener 85	0.28	**0.224**	**0.283**
BDE congener 99	1.11	0.901	1.18
Bis(2-ethylhexyl) phthalate	1,200	86.1	480
Bis(hexachlorocyclopentadieno) cyclooctane	**0.198**	**0.307**	**0.378**
Diethyl phthalate	<50	<44.5	<60
Phenanthridine	<50	<44.5	<60
Methyl triclosan	M	<18	<18
Triclosan	**3.62**	**6.07**	**6.14**
Polychlorinated biphenyls			
PCB congener 101	<2.5	<3.0	**1.2**
PCB congener 110	<2.5	<3.0	7.85
PCB congener 118	0.342	1.09	0.956
PCB congener 138	0.25	0.6	2.05
PCB congener 146	**0.107**	**0.268**	**0.284**
PCB congener 149	<2.5	**0.705**	**0.766**
PCB congener 151	<0.25	**0.078**	**0.111**
PCB congener 170	0.202	0.415	0.442
PCB congener 174	<0.1	**0.108**	**0.17**
PCB congener 177	**0.0849**	**0.194**	**0.238**
PCB congener 180	0.15	0.487	0.516
PCB congener 183	<0.25	**0.0752**	**0.0353**
PCB congener 187	**0.0488**	**0.236**	**0.296**
PCB congener 194	**0.0729**	**0.145**	**0.178**
PCB congener 206	**0.0435**	**0.119**	**0.142**
PCB congener 49	<5.0	<6.0	<6.0
PCB congener 52	<2.5	<3.0	<3.0
PCB congener 70	<5.0	<6.0	<6.0

Appendix 1. Concentrations of organic constituents in three surficial bed-sediment samples analyzed for a lake study conducted on Little Rock Air Force Base, Arkansas, May 2014.—Continued

[Results are in micrograms per kilogram; <, less than the specified laboratory reporting limit; bold values were estimated at the laboratory; M, missing data; all results were used as absolute values when calculating probable effect concentrations]

Organic group or constituent	Sampling lake and site		
	Little Base NS2	Big Base NS5	Big Base NS6
Organochlorine pesticides			
alpha-Endosulfan	<0.5	<0.6	<0.6
Benfluralin	<0.5	<0.6	<0.6
beta-Endosulfan	<0.5	<0.6	<0.6
Carbazole	**66**	10.4	**39.9**
Chlorpyrifos	**0.108**	<0.6	**0.393**
cis-Chlordane	0.844	2.48	3.84
cis-Nonachlor	0.434	2.18	3.9
Cyfluthrin	<0.5	<0.6	<0.6
DCPA	<0.5	<0.6	<0.6
Desulfinylfipronil	**0.17**	0.388	0.339
Dieldrin	1.03	1.32	1.78
Endosulfan sulfate	<1	<1.2	<1.2
Fipronil sulfide	**0.228**	<0.3	0.329
Fipronil	<0.25	<0.3	<0.3
lambda-Cyhalothrin	<0.5	<0.6	<0.6
Oxychlordane	<2.5	<3.0	<3.0
Oxyfluorfen	<10	<12	<12
p,p′-DDD	**2.63**	<6.0	<6.0
p,p′-DDE	9.13	33.7	33.1
p,p′-DDT	<10	<12	<23
Pendimethalin	<2.5	<3.0	<3.0
Pentachloroanisole	<50	<44.5	<60
Tefluthrin	<1.25	<1.5	<1.5
Tetradifon	M	<0.6	<0.6
trans-Chlordane	**0.474**	1.37	2.24
trans-Nonachlor	0.555	1.4	2.28
Trifluralin	<0.5	<0.6	<0.6
Hexachlorobenzene	<50	<44.5	<60
Pentachloronitrobenzene	<50	<44.5	<60

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