

In cooperation with the Lockheed Martin Corporation

Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek at Air Force Plant 4, Fort Worth, Texas, 2003–08



Scientific Investigations Report 2010–5076

Front cover:

Top left, Pumping two suspended-sediment samples during filtration for organic analyses, 2006.

Top right, Churning and pumping a suspended-sediment sample during filtration for organic analyses, 2003.

Bottom, Filtering a suspended-sediment sample to isolate sediments for organics analyses, 2006.

Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek at Air Force Plant 4, Fort Worth, Texas, 2003–08

By Christopher L. Braun and Jennifer T. Wilson

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Contents

Abstract	1
Introduction	1
Purpose and Scope	3
Site Background and Description of Study Area	3
Polychlorinated Biphenyls	5
Description of Previous Studies	5
Engineering Controls Used to Alleviate Polychlorinated Biphenyl Contamination at Air Force Plant 4	7
Approach	7
Collection and Processing of Suspended-Sediment Samples	7
Analytical Methods	7
Quality Control	8
Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek	8
Summary	11
References Cited	12
Appendixes	
1. Concentrations of selected polychlorinated biphenyl congeners in suspended- sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2003–07	17
2. Concentrations of antibacterial, antifungal, pesticide, and flame retardant compounds in suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2008	18

Figures

1–2. Maps showing:	
1. Location of Meandering Road Creek, Woods Inlet of Lake Worth, and Air Force Plant 4, Fort Worth, Texas	2
2. Suspended-sediment sampling sites, storm drainage areas for outfalls 4 and 5, areas of known or suspected polychlorinated biphenyl (PCB) releases, former landfills, and areas where engineering controls (asphalt cap areas and sweeping) were implemented to potentially alleviate PCB contamination at Air Force Plant 4, Fort Worth, Texas, 2003–08	4
3–4. Graphs showing:	
3. Ratios of total polychlorinated biphenyl (PCB) concentrations (sum of 18 reported congeners [$\sum PCB_i$]) to threshold effect concentration, a consensus- based sediment-quality guideline for PCBs, for suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2003–08	9
4. Ratio of individual polychlorinated biphenyl (PCB) congener concentrations to sum of 10 selected PCB congeners for suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2003–08	10

Table

1. Concentrations of polychlorinated biphenyls in suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 20086

Conversion Factors, Datum, and Sediment-Quality Units

SI to Inch/Pound

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
kilometer (km)	0.6214	mile (mi)
meter (m)	3.281	foot (ft)
Area		
square meter (m ²)	10.76	square foot (ft ²)
Volume		
liter (L)	33.82	ounce, fluid (fl. oz)
Mass		
gram (g)	0.03527	ounce, avoirdupois (oz)
Pressure		
kilopascal (kPa)	0.1450	pound per square inch (lb/in ²)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

Datum

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

Sediment-Quality Units

Chemical compound concentrations are reported in micrograms per kilogram ($\mu\text{g}/\text{kg}$), a unit expressing the concentration of a chemical compound as weight (micrograms) per unit volume (kilogram) of sediment.

Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek at Air Force Plant 4, Fort Worth, Texas, 2003–08

By Christopher L. Braun and Jennifer T. Wilson

Abstract

Meandering Road Creek is an intermittent stream and tributary to Lake Worth, a reservoir on the West Fork Trinity River on the western edge of Fort Worth, Texas. U.S. Air Force Plant 4 (AFP4) is on the eastern shore of Woods Inlet, an arm of Lake Worth. Meandering Road Creek gains inflow from several stormwater outfalls as it flows across AFP4. Several studies have characterized polychlorinated biphenyls (PCBs) in the water and sediments of Lake Worth and Meandering Road Creek; sources of PCBs are believed to originate primarily from AFP4. Two previous U.S. Geological Survey (USGS) reports documented elevated PCB concentrations in surficial sediment samples from Woods Inlet relative to concentrations in surficial sediment samples from other parts of Lake Worth. The second of these two previous reports also identified some of the sources of PCBs to Lake Worth. These reports were followed by a third USGS report that documented the extent of PCB contamination in Meandering Road Creek and Woods Inlet and identified runoff from outfalls 4 and 5 at AFP4 as prominent sources of these PCBs.

This report describes the results of a fourth study by the USGS, in cooperation with the Lockheed Martin Corporation, to investigate PCBs in suspended-sediment samples in storm runoff from outfalls 4 and 5 at AFP4 following the implementation of engineering controls designed to potentially alleviate PCB contamination in the drainage areas of these outfalls. Suspended-sediment samples collected from outfalls 4 and 5 during storms on March 2 and November 10, 2008, were analyzed for selected PCBs. Sums of concentrations of 18 reported PCB congeners (ΣPCB_c) in suspended-sediment samples collected before and after implementation of engineering controls are compared. At both outfalls, the ΣPCB_c before engineering controls was higher than the ΣPCB_c after engineering controls. The ΣPCB_c in suspended-sediment samples collected at AFP4 before and after implementation of engineering controls also is compared to the threshold effect concentration (TEC), the concentration below which adverse effects to benthic biota rarely occur. ΣPCB_c exceeded the TEC for 75 percent of the samples collected at outfall 4 and 67 percent of the samples collected at outfall 5 before

the implementation of engineering controls. ΣPCB_c did not exceed the TEC in samples collected at either outfall 4 or outfall 5 after the implementation of engineering controls.

The relative prominence of 10 selected PCB congeners was evaluated by graphical analysis of ratios of individual concentrations of the 10 PCB congeners to the sum of these PCB congeners. An overall decrease in concentrations of PCB congeners at outfalls 4 and 5 after implementation of engineering controls, as well as a shift in prominence from lighter, less chlorinated congeners to a heavier, more chlorinated congener might have resulted from the implementation of engineering controls. Because of the small number of samples collected and lack of runoff and precipitation data to evaluate comparability of sampling conditions before and after implementation of engineering controls, all conclusions are preliminary.

Introduction

Meandering Road Creek is an intermittent stream and tributary to Lake Worth, a reservoir on the West Fork Trinity River on the western edge of Fort Worth, Tex. U.S. Air Force Plant 4 (AFP4) is on the eastern shore of Woods Inlet, an arm of Lake Worth that extends south from the main body of the lake, east of Interstate Highway 820 (fig. 1). Meandering Road Creek gains inflow from several stormwater outfalls on AFP4 as the creek flows to its terminus at Woods Inlet. Because of groundwater contamination, AFP4 was placed on the National Priorities List of hazardous waste sites in 1990 (U.S. Environmental Protection Agency, 1990). In spring 2000, the Texas Department of Health issued a fish consumption advisory for Lake Worth because of elevated concentrations of polychlorinated biphenyls (PCBs) in the edible tissues of selected species of fish (Texas Department of State Health Services, 2010). PCBs are hydrophobic organic contaminants that sorb strongly to organic matter and particulates; detection of PCBs is common in urban lake and reservoir sediments (Van Metre, Callender, and Fuller, 1997; Van Metre and others, 1998; Long and others, 2003). The occurrence of PCBs in fish led to several investigations by the U.S. Geological Survey (USGS) in cooperation with the U.S. Air Force to

2 Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek

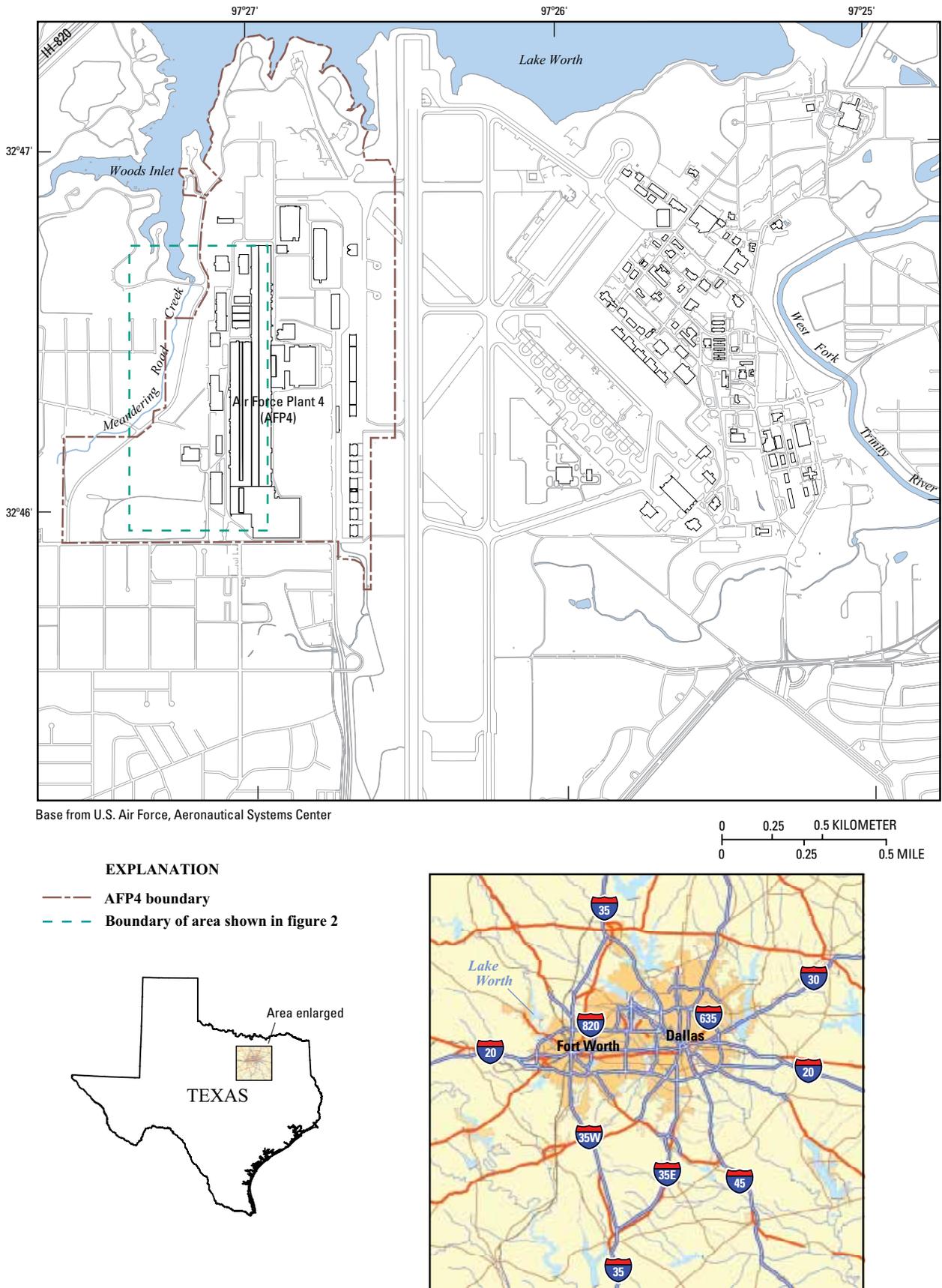


Figure 1. Location of Meandering Road Creek, Woods Inlet of Lake Worth, and Air Force Plant 4, Fort Worth, Texas.

characterize sediment-associated contaminants, including PCBs, in the lake-bottom, streambed, and suspended sediments of Lake Worth, Woods Inlet, Meandering Road Creek, and the stormwater outfalls at AFP4 that drain to Meandering Road Creek (Harwell and others, 2003; Besse and others, 2005; Braun and others, 2008). Lighter, more volatile PCBs have fewer chlorine atoms attached and are less chlorinated, whereas heavier, less volatile PCBs have more chlorine atoms attached and are more chlorinated (Ockenden and others, 1998). Selected PCBs were analyzed in lake-bottom sediment samples collected from Lake Worth and in streambed and suspended-sediment samples collected from Meandering Road Creek (a tributary to Lake Worth) at AFP4 and from outfalls that drain to Meandering Road Creek. On the basis of PCB concentrations measured in suspended-sediment samples, outfalls 4 and 5 at AFP4 were identified as two prominent sources of PCBs in Meandering Road Creek (Braun and others, 2008). Engineering controls were implemented in late 2007 and early 2008, from about November 2007 through February 2008, to potentially alleviate PCB contamination in the drainage areas of outfalls 4 and 5. This report, the fourth USGS study, was done in cooperation with the Lockheed Martin Corporation. The study investigated the concentration of PCBs in suspended-sediment samples in storm runoff from outfalls 4 and 5 at AFP4 following the implementation of engineering controls in the drainage areas of these outfalls and compared the measured concentrations to results from previous USGS studies at the site and to applicable threshold effect concentration (TEC) guidelines.

Purpose and Scope

This report describes concentrations of PCB congeners measured in suspended-sediment samples collected from outfalls 4 and 5 at AFP4 during 2003–08. PCB concentrations measured in suspended-sediment samples collected from outfalls 4 and 5 during 2003–07 for previous USGS studies at AFP4, before implementation of engineering controls designed to potentially alleviate PCB contamination in the drainage areas of outfalls 4 and 5, are compared to PCB concentrations measured in suspended-sediment samples collected from outfalls 4 and 5 during periods of runoff on March 2 and November 10, 2008, after implementation of engineering controls.

Concentrations of PCB congeners are compared to TECs described in consensus-based sediment-quality guidelines. Concentrations of PCB congeners were normalized to compare relative distributions of PCB congeners from the different samples. In this report, a subset of 18 of the 27 PCB congeners that were analyzed in samples collected from outfalls 4 and 5 in previous USGS studies at AFP4 were quantified and compared to the same 18 PCB congeners quantified in samples collected in 2008. The relative prominence of lighter and heavier (more and less volatile, respectively) PCB congeners before and after implementation of engineering controls are also described. No discharge measurements were made at the

outfalls in Meandering Road Creek during the periods of runoff when samples were collected, and no precipitation data were collected to quantify the concentrations of PCB congeners in the suspended-sediment samples on the basis of discharge amounts or storm intensity. Because of the small number of samples collected and lack of runoff and precipitation data to evaluate comparability of sampling conditions before and after implementation of engineering controls, all conclusions are preliminary.

Site Background and Description of Study Area

AFP4 has manufactured military aircraft since 1942 on land adjacent to Woods Inlet of Lake Worth in Fort Worth and is currently (2009) in the remedial action phase of the Superfund process (U.S. Environmental Protection Agency, 2009). Waste materials containing PCBs were generated at the plant and likely placed in on-site landfills or burned in fire-training exercises prior to 1973 (Texas Department of Health, 1998). Areas of known and suspected PCB releases are described in detail in Braun and others (2008), including a transformer failure in March 1984 in an electrical substation, which resulted in the leakage of PCBs adjacent to building 14 (fig. 2; area 014PCBLK3). Surface-water runoff from the area near the PCB leak at building 14 either discharges to Meandering Road Creek at outfall 4 or collects in a storm-sewer line that ultimately discharges to Meandering Road Creek at outfall 4 (fig. 2). In March 1989, PCBs were discovered to have leaked beneath a concrete slab inside building 5 (fig. 2; area 005PCBLK1). Storm-sewer lines intersecting the PCB leak at building 5 discharge to outfalls 4 and 5 (fig. 2). PCBs also might have been released from Fire Department Training Area 2 (FDTA2), a 15-meter-diameter earthen ring (RUST Geotech, 1995) west of building 15 used for semiannual fire training exercises between 1955 and 1965; FDTA2 might have been used for disposal of waste oils and fuels containing PCBs (CH2M Hill, 1984). FDTA2 is next to a storm-sewer line that discharges to Meandering Road Creek at outfall 4. Some of the surface-water runoff from FDTA2 collects in a storm-sewer line that eventually discharges to Meandering Road Creek at outfall 4. Because FDTA2 is in the drainage area of outfall 5, the rest of the runoff from FDTA2 discharges to Meandering Road Creek at outfall 5.

Historical landfills 1 and 3 on opposite sides of Bomber Road (fig. 2) are another suspected source of PCB releases. These landfills were used to dispose of potentially hazardous wastes including used oils, solvents, thinners, paint, and unspecified liquid waste (International Technology Corporation, 2001). In 1966, landfill 1 was closed, and the area was graded and paved to make the west parking lot (fig. 2). Landfill 3 is on the east bank of Meandering Road Creek on the west side of Bomber Road (fig. 2). Landfills 1 and 3 provide surface-water runoff and groundwater seepage to Meandering Road Creek; remediation work to curtail runoff and groundwater seepage from these landfills began in the 1980s

4 Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek

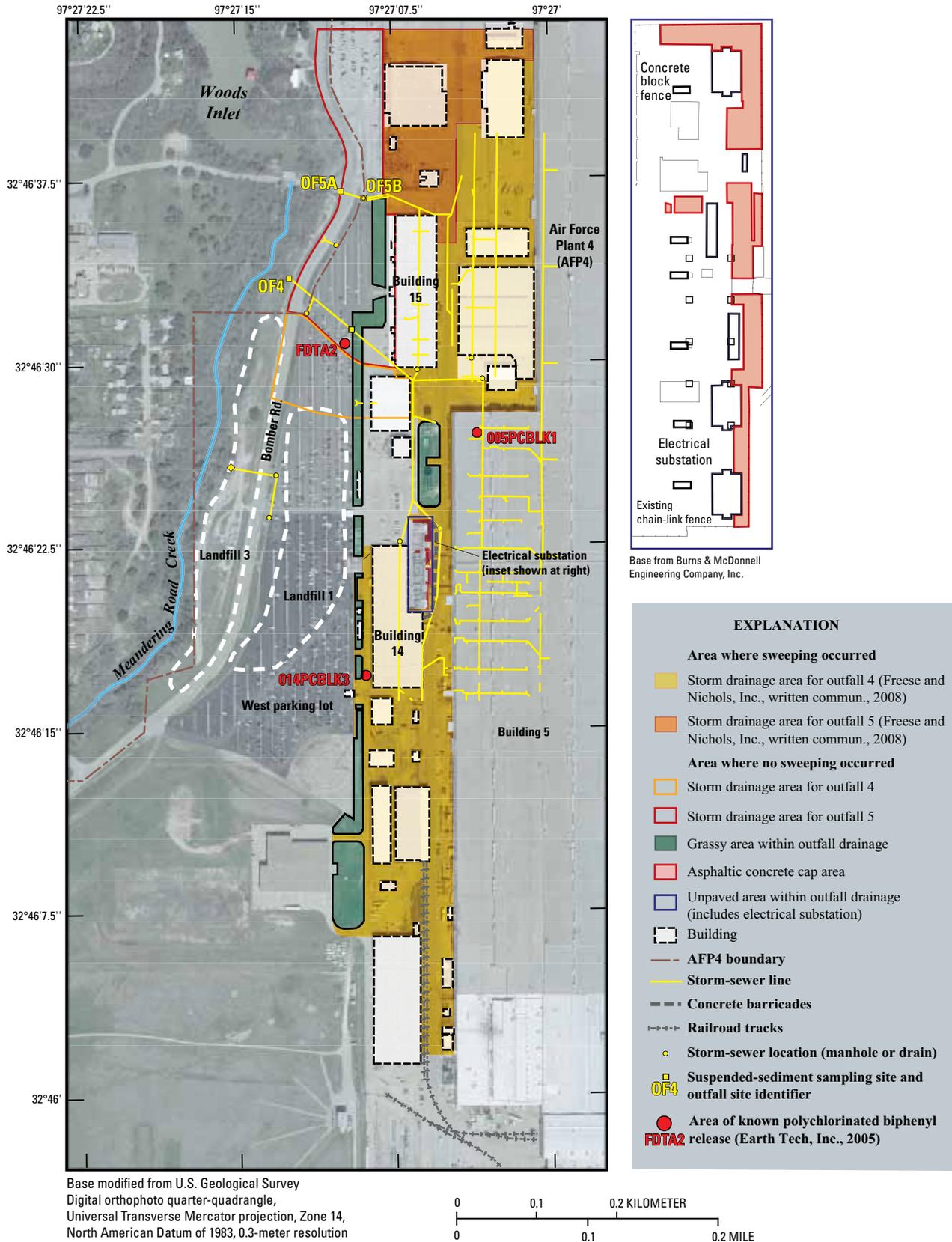


Figure 2. Suspended-sediment sampling sites, storm drainage areas for outfalls 4 and 5, areas of known or suspected polychlorinated biphenyl (PCB) releases, former landfills, and areas where engineering controls (asphalt cap areas and sweeping) were implemented to potentially alleviate PCB contamination at Air Force Plant 4, Fort Worth, Texas, 2003–08.

and is described in detail in Braun and others (2008). Further details about the known or suspected areas of PCB releases are included in Braun and others (2008). Meandering Road Creek borders AFP4 to the west and flows north to the Woods Inlet of Lake Worth. Historically, Meandering Road Creek received contaminated runoff from stormwater outfalls 4 and 5 (Besse and others, 2005; Braun and others, 2008). Outfall 4 receives runoff from several buildings and parking areas, including some of the area over landfill 1, and drains into Meandering Road Creek about 200 meters upstream from the point where Meandering Road Creek enters Woods Inlet. Outfall 5 receives runoff from building 15 and parking areas and drains into Meandering Road Creek about 25 meters upstream from the point where Meandering Road Creek enters Woods Inlet (fig. 2). Additional site background information, including a more detailed history of PCB contamination studies at AFP4, is provided in Braun and others (2008).

Polychlorinated Biphenyls

PCBs are comprised of as many as 209 theoretically possible chlorinated compounds, called congeners, with various numbers and positions of chlorine atoms attached to the biphenyl structure. Each congener has been assigned a congener number; congener number increases generally with increasing chlorination of the biphenyl structure. Of the 209 theoretically possible congeners, about 130 were widely used in commercial PCB mixtures (Erickson, 2001). Braun and others (2008) summarizes the development and use of PCBs and their adverse human health effects and association with cancer in humans and animals.

In the samples collected for this study, the USGS National Water Quality Laboratory (NWQL), Denver, Colo., quantified 18 common PCB congeners of the 27 common PCB congeners quantified in Braun and others (2008). Total PCBs were calculated as the sum of the 18 quantified congeners ($\sum \text{PCB}_i$). Consistent with the treatment of nondetections of PCB congeners in previous USGS studies at AFP4 (Harwell and others, 2003; Besse and others, 2005; Braun and others, 2008), nondetections of PCB congeners were treated as zeros; estimated concentrations were used at their reported values. Detection frequencies for the 18 PCB congeners analyzed in this report varied by the degree of chlorination; in general, detection frequency increased with increasing degree of chlorination (table 1).

Concentrations of total PCBs in suspended-sediment samples are compared to a consensus-based sediment-quality guideline developed for freshwater ecosystems by MacDonald and others (2000) to provide a general indication of the degree of contamination. The TEC (table 1) is the concentration below which adverse effects to benthic biota rarely occur (MacDonald and others, 2000). This sediment-quality guideline was derived through various laboratory, field, and theoretical methods and is neither definitive for determining sediment toxicity to benthic biota nor to be extrapolated to assess adverse effects to fish, aquatic plants,

or humans (Long and others, 1995; MacDonald and others, 2000). Although this sediment-quality guideline provides a general indication of the degree of contamination, it does not provide a benchmark for concern for accumulation in fish or for human health risk associated with eating fish.

Description of Previous Studies

A Preliminary Assessment/Site Inspection (PA/SI) and a Remedial Investigation/Feasibility Study (RI/FS) of the AFP4 site began in October 1990 to characterize contamination of Lake Worth and its tributaries by PCBs and other organic contaminants (Braun and others, 2008), as well as to accomplish other objectives. Elevated concentrations of contaminants, such as PCBs, were detected in a small, inedible fish species (mosquito fish) during the PA/SI in July 1998. One conclusion of the PA/SI in July 1998 was that an indeterminate public health hazard existed in Lake Worth from exposure to contaminants through the food chain (Texas Department of Health, 1998). The Texas Department of Health (TDH) issued a fish-consumption advisory following fish sampling by the USGS (Moring, 2002) because the levels of PCBs detected in edible fish samples posed a “significant health risk” (Texas Department of State Health Services, 2010). A detailed description of the July 1998 TDH site evaluation and the Agency for Toxic Substances and Disease Registry (2001) site evaluation is provided in Moring (2002). The detection of PCBs and other organic contaminants in fish collected from Lake Worth and its tributaries led to three subsequent studies by the USGS in cooperation with the U.S. Air Force. In the first study, Lake Worth lake-bottom sediment samples were collected during 2000–2001 and analyzed for sediment-associated contaminants, including PCBs (Harwell and others, 2003). That study documented elevated PCB concentrations in surficial sediment in Woods Inlet relative to concentrations in surficial sediment in other parts of Lake Worth. This finding indicated that the Woods Inlet watershed likely contained a source, or sources, of PCBs. In 2003, a second USGS study to further characterize elevated PCB concentrations in sediment in Woods Inlet mapped the distribution of elevated PCB concentrations in Woods Inlet and identified possible source areas of PCBs in the watershed of Woods Inlet (Besse and others, 2005). The findings of that report indicated that the highest PCB concentrations were near the mouth of Meandering Road Creek and that PCBs originate in the Meandering Road Creek watershed. Furthermore, total PCB concentrations in suspended and streambed sediment indicated storm drain outfall 4, which receives runoff from AFP4, was a likely source of PCBs to Meandering Road Creek and ultimately Woods Inlet. However, the study did not determine whether outfall 4 was the only source of PCBs to Meandering Road Creek and Woods Inlet. Results from these studies (Harwell and others, 2003; Besse and others, 2005) prompted a third study by the USGS. During 2004–07, the USGS investigated the degree of PCB contamination of Meandering Road Creek and Woods Inlet and attempted to identify possible sources of PCBs to

6 Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek

Table 1. Concentrations of polychlorinated biphenyls in suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2008.

[In micrograms per kilogram except as noted; PCB, polychlorinated biphenyl (increasing congener number generally indicates increasing chlorination of biphenyl structure); OF4, outfall 4; <, nondetection less than minimum reporting level; E, estimated (quantitatively identified at less than minimum reporting level); OF5, outfall 5; --, not available; Σ PCB₆, sum of 18 PCB congeners]

U.S. Geological Survey station number	Site identifier (fig. 2)	Sample date	Set number	PCB 49	PCB 52	PCB 70	PCB 101	PCB 110	PCB 118	PCB 138	PCB 146	PCB 149
08045359	OF4	3/2/2008	002	<1.0	<1.0	<1.0	<1.0	3.8	1.6	3.7	0.54	3.0
08045359	OF4	11/10/2008	116	<1.0	<1.0	<1.0	<1.0	<1.0	<.1	1.1	.62	3.2
08045359	OF4 duplicate	11/10/2008	116	<1.0	<1.0	<1.0	<1.0	<1.0	<.1	.90	.38	2.8
324638097270901	OF5A	3/2/2008	002	<1.0	<1.0	<1.0	<1.0	E.67	.48	1.4	.23	1.7
324638097270901	OF5A	11/10/2008	116	<1.0	<1.0	<1.0	<1.0	<1.0	.65	1.2	.25	4.1
<i>Sediment-quality guidelines:</i>												
Threshold effect concentration (TEC) ¹				--	--	--	--	--	--	--	--	--
<i>Minimum reporting level (MRL)</i>				--	1.0	1.0	1.0	1.0	.1	.1	.1	1.0
<i>Quality assurance samples:</i>												
Set blank			002	<1.0	<1.0	<1.0	<1.0	<1.0	<.1	<.1	<.1	<1.0
Set spike, in percent recovery			002	53.2	92.5	95.5	97.2	101	115	100	114	76.8
Set blank			116	<1.0	<1.0	<1.0	<1.0	<1.0	<.1	<.1	<.1	<1.0
Set spike, in percent recovery			116	45.8	42.4	49.3	56.1	58.9	73.4	98.4	79.5	50.5
Site identifier (fig. 2)	Sample date	PCB 151	PCB 170	PCB 174	PCB 177	PCB 180	PCB 183	PCB 187	PCB 194	PCB 206	Σ PCB ₆	
OF4		0.50	2.3	1.7	0.85	4.4	0.88	1.5	1.9	1.2	E28	
OF4	11/10/2008	.69	3.3	2.1	1.5	5.3	1.1	1.8	1.5	.94	E23	
OF4 duplicate	11/10/2008	.37	2.5	1.4	1.1	3.9	.79	1.4	1.2	1.4	E18	
OF5A	3/2/2008	.44	2.1	2.3	1.3	3.9	.90	2.0	2.5	1.2	E21	
OF5A	11/10/2008	.31	2.2	1.5	.92	3.6	.69	1.5	1.3	.84	E19	
<i>Sediment-quality guidelines:</i>												
Threshold effect concentration (TEC) ¹				--	--	--	--	--	--	--	--	59.8
<i>Minimum reporting level (MRL)</i>				.1	.1	.1	.1	.1	.1	.1	.1	--
<i>Quality assurance samples:</i>												
Set blank			<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	--
Set spike, in percent recovery			108	94.2	96.9	94.3	96.8	98.2	109	101	100	--
Set blank			<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	--
Set spike, in percent recovery			72.1	184	80.0	81.7	82.2	82.2	82.5	86.9	90.1	--

¹ MacDonald and others (2000).

Meandering Road Creek and Woods Inlet on the basis of suspended, streambed, and lake-bottom sediment samples collected in 2004 and 2006–07. Braun and others (2008) documented the extent of PCB contamination in Meandering Road Creek and Woods Inlet and identified runoff from outfalls 4 and 5 at AFP4 as prominent sources of PCBs in Meandering Road Creek and Woods Inlet. Concentrations of selected PCB congeners analyzed during 2003–07 for the previous USGS studies are listed in appendix 1.

Engineering Controls Used to Alleviate Polychlorinated Biphenyl Contamination at Air Force Plant 4

Lockheed Martin Corporation selected two companies to implement engineering controls to potentially alleviate PCB contamination in the drainage areas of outfalls 4 and 5 at AFP4. During late 2007 and early 2008 (about November 2007–February 2008), the companies used two types of engineering controls to clean up and contain PCBs in outfalls 4 and 5 storm-drainage areas (fig. 2).

The first engineering control was done by Freese and Nichols, Inc., and involved a one-time sweeping of pavement within the drainage areas of outfalls 4 and 5 (fig. 2) to reduce potential PCB migration. Pavement sweeping occurred before 6 a.m. or after 6 p.m., when it was likely few cars or employees would be present. Large, open paved areas were swept using standard, large-capacity pavement-sweeping equipment, whereas smaller paved areas were swept with compact sweeping equipment. Railroad tracks located within the drainage to outfall 4 were swept thoroughly to remove all debris around the rails and in depressions adjacent to rails. The area east of the electrical substation (fig. 2) within the concrete barriers in the outfall 4 drainage area also was swept. All debris was collected and stored in an on-site storage facility. The large-capacity pavement sweepers consist of a high-velocity air blower and vacuum with rotating circular brush heads; this type of equipment ensures that virtually all debris is collected in the hopper and little or no dust is generated. Smaller sweeper/vacuum vehicles of a similar type were used in areas too confined for the large-capacity sweepers. No water spray or mist-producing equipment was used in the sweeping process (Scott Harrison, Lockheed-Martin Corporation, written commun., 2009).

The second engineering control was done by Burns and McDonnell Engineering Company, Inc. About 560 square meters of the main electrical substation of AFP4 were regraded and covered with an asphaltic concrete cap (asphalt) (fig. 2). The top 8 centimeters (approximately) of gravel were removed from selected areas of the electrical substation; the soil subgrade was not excavated. Once the overlying gravel was stripped and stockpiled, any remaining gravel was compacted; then the previously stripped gravel was used as fill and compacted to bring the areas to 8 centimeters below the final grade. Dust control measures were used to minimize

dust production. Because the excavated gravel was potentially contaminated with PCBs, the remaining stockpile of gravel was safely disposed of at an off-site location. Areas within the electrical substation, where potentially contaminated gravel was removed and the remaining gravel was compacted, were sprayed with a primer coat of liquid asphalt prior to installing the asphalt cap (fig. 2). The minimum design thickness of the asphalt cap was 8 centimeters, but in some instances the thickness was increased to match the grade of the concrete curb bordering the cap. The cap was sloped to induce drainage toward the outside perimeter (Scott Harrison, Lockheed-Martin Corporation, written commun., 2009).

Approach

Collection and Processing of Suspended-Sediment Samples

Two suspended-sediment samples each were collected at outfall 4 (OF4, fig. 2) and outfall 5 (OF5A, fig. 2) in 2008 for a total of four environmental samples. Suspended-sediment samples were collected by filling one 25-liter Nalgene carboy with runoff from the “first flush” (initial increase in flow) at each of the sample collection sites during a storm. Additional carboys were filled during some storms when the suspended-sediment concentration was too small (on the basis of visual inspection and professional judgment) to provide a sufficient sediment mass for chemical analyses. The limited scope of this project did not include measuring the discharge of Meandering Road Creek or precipitation associated with each storm, which could limit the comparability of samples collected during different storms. The 25-liter carboys were transported to the USGS Texas Water Science Center, North Texas Program Office in Fort Worth and stored on ice until filtering. Filtering each sample took several hours, so processing all samples from a storm typically took 1 to 2 days.

Suspended sediment was isolated from the stormwater samples by in-line filtration following the methods of Mahler and Van Metre (2003). Braun and others (2008) provides a detailed description of how the suspended-sediment samples were collected. One of the samples collected previously (October 10, 2006) at outfall 5 was collected at site OF5B (fig. 2). The small distance between sampling sites OF5A and OF5B should not affect the comparison because there is no additional source of runoff between the two sites.

Analytical Methods

The USGS NWQL analyzed the suspended-sediment samples for 60 halogenated compounds including PCBs, antibacterial and antifungal compounds, organochlorine

8 Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek

pesticides, organofluorine pesticides, and polybrominated diphenyl ethers (PBDEs) and other flame retardants using a custom analytical method. Custom methods have not been completely evaluated with the USGS guidelines for developing official methods. Since the publication of Braun and others (2008), the NWQL revised the analytical method for measuring halogenated compounds, including PCBs, in sediments, which resulted in the following PCB congeners not being quantified for this report: 8, 18, 22, 26, 28, 31, 33, 44, and 95. The 18 PCB congeners analyzed in the samples collected during 2008 are listed in table 1. Although only the PCB congeners that were analyzed are discussed in this report, concentrations of all other compounds that were analyzed in the suspended-sediment samples from outfalls 4 and 5 are listed in appendix 2. The samples were extracted using an accelerated solvent extraction system (ASE) (Dionex Corporation, 2009) at a pressure of 13,800 kilopascals with a 50:50 (volume per volume) mixture of water and isopropyl alcohol at 120 degrees Celsius (°C) for 40 minutes and a 20:80 mixture of water and isopropyl alcohol at 200 °C for an additional 40 minutes. The compounds of interest were isolated from the ASE extract using disposable solid-phase extraction (SPE) cartridges containing chemically modified N-vinylpyrrolidone divinylbenzene resin in addition to amino-propyl-based resin. The SPE cartridge was dried with nitrogen gas and the extracted compounds eluted with a 4:1 mixture of dichloromethane and diethyl ether. The extract was concentrated under a stream of nitrogen gas, cleaned on 2 grams of Florosil eluted with a 94:6 mixture of pentane and acetone, concentrated again under a stream of nitrogen gas, and then exchanged into hexane. The extracts were analyzed on an Agilent Technologies Model 5975 capillary-column gas chromatograph/mass spectrometer (GC/MS) using a 35-percent phenyl methylpolysiloxane capillary-column (Agilent Technologies, 2009) with the MS operated in the electron capture negative ion (ECNI) mode using ammonia as the reactant gas. The halogenated compounds were identified by selected ion monitoring (SIM) using the ions of interest (Mark Burkhardt and Steven Zaugg, U.S. Geological Survey, National Water Quality Laboratory, written commun., 2008). The analytical results and minimum reporting levels (MRLs) are listed in table 1. Compound concentrations quantitatively identified at less than the MRL were reported as estimated (E).

Quality Control

For the four environmental samples collected during this study, the quality control for PCB analyses consisted of one duplicate sample, one laboratory blank sample, and spike and surrogate compound recovery rates for two sets of environmental samples. The recovery of surrogate compounds is monitored by the laboratory with every set of 12 environmental samples (Mark Burkhardt and Steven Zaugg, U.S. Geological Survey, National Water Quality Laboratory, written commun., 2008). The samples collected for this study were analyzed as part of different sets of environmental samples, sets 002 and

116. All PCB congener concentrations in the blank sample were quantified at values less than the applicable PCB congener MRL of either 0.1 or 1.0 microgram per kilogram ($\mu\text{g}/\text{kg}$) (table 1). The average spike recoveries were 97 and 78 percent for sets 002 and 116, respectively. One sample from this study (OF4, November 10, 2008) was selected for duplicate analysis in set 116; however the duplicate for set 002 was not a sample from this study and is not included in this report. In the OF4 duplicate sample, the average relative percent difference (RPD) for compounds with concentrations greater than the respective MRLs was 33 percent. RPD was computed using the equation

$$\text{RPD} = |C_1 - C_2| / ((C_1 + C_2) / 2) \times 100, \quad (1)$$

where

C_1 = concentration from environmental sample; and

C_2 = concentration from duplicate sample.

Selected PCB congeners and chlorinated pesticides were added as surrogates prior to extraction to monitor the extraction process. The average surrogate recoveries for set 002 were 71, 47, and 47 percent for 4,4-dibromooctafluorobiphenyl ($C_{12}Br_2F_8$), 2,2',3,3',5,5',6,6'-octachlorobiphenyl (PCB 202- $^{13}C_{12}$), and 1,1'-Bis(*p*-chlorophenyl)-2,2,2-trichloroethane (DDT- d_8), respectively. The average surrogate recoveries for set 116 were 40, 59, and 76 percent for $C_{12}Br_2F_8$, PCB 202- $^{13}C_{12}$, and DDT- d_8 , respectively. All surrogate recoveries are listed in appendix 2. Because a new, custom analytical method was used, acceptable ranges for spike and surrogate recoveries had not been established, and no past results using the same analytical method were available for comparison.

Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek

Because of the small number of samples collected, it was not possible to statistically test if concentrations of PCB congeners obtained in this study were statistically different from concentrations of PCB congeners obtained during previous USGS studies. Eight suspended-sediment samples were collected at outfall 4 and three suspended-sediment samples (and one duplicate) at outfall 5 in previous studies, before the implementation of engineering controls (sweeping and capping) at AFP4. For comparison, results for the same 18 PCB congeners that were analyzed in suspended-sediment samples collected from outfalls 4 and 5 in the previous studies are listed in appendix 1. For this study, two suspended-sediment samples were collected at each of the outfalls in 2008, after the engineering controls had been implemented.

At outfall 4, $\sum PCB_c$ before implementation of engineering controls ranged from E18 to E310 $\mu\text{g}/\text{kg}$ (appendix 1) and after implementation $\sum PCB_c$ was E23 and E28 $\mu\text{g}/\text{kg}$ (table 1).

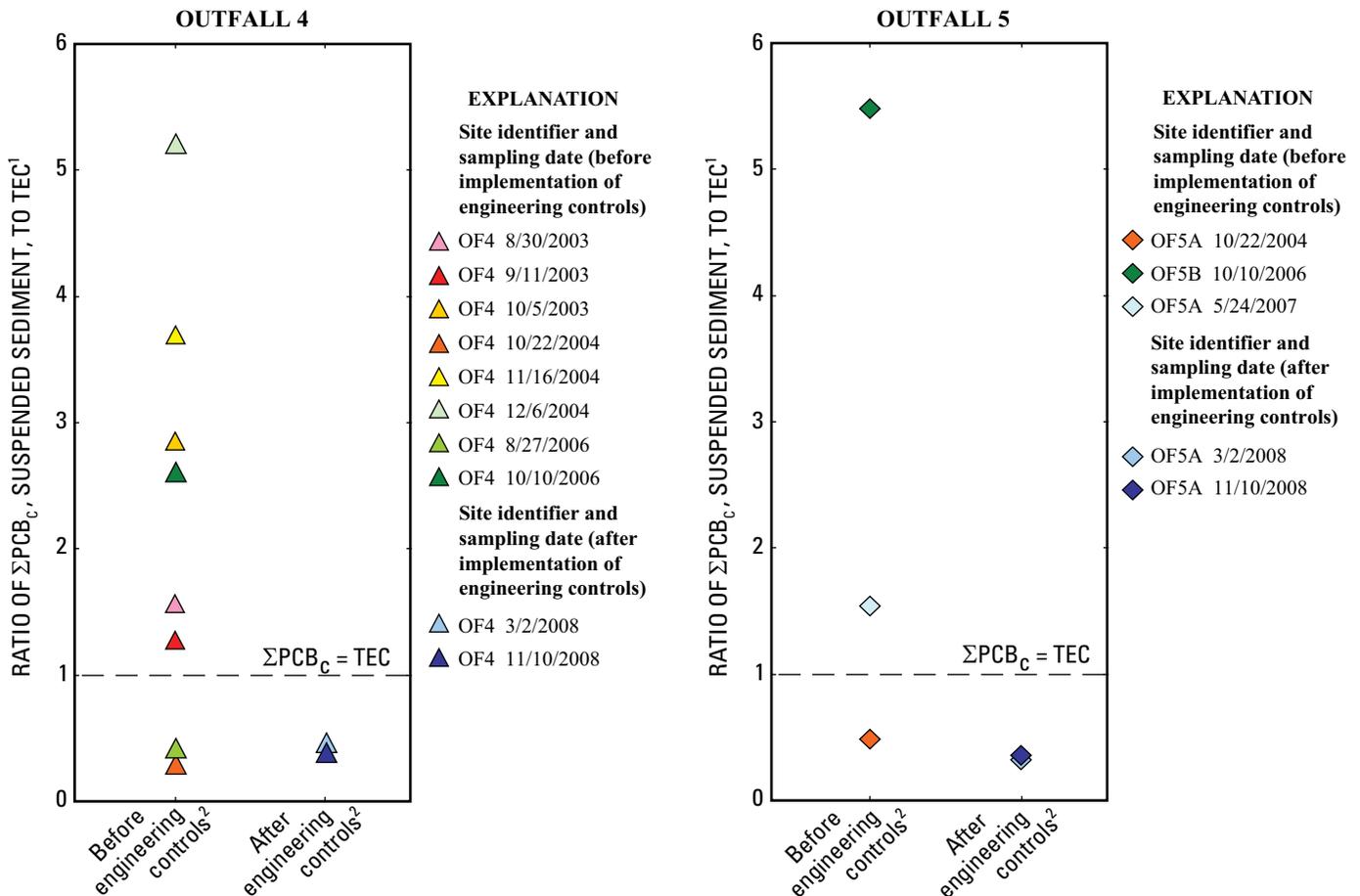
At outfall 5, ΣPCB_c before implementation of engineering controls ranged from E29 to E330 $\mu g/kg$ (appendix 1) and after implementation ΣPCB_c was E19 and E21 $\mu g/kg$ (table 1). The ΣPCB_c at both outfalls before the engineering controls was higher than the ΣPCB_c after the engineering controls.

Analyses of the results are limited to comparison to TEC benchmark values (sediment-quality guidelines) and graphical analysis of normalized concentrations of the selected congeners because of the small dataset. To compare PCB congener concentrations to the TEC, ratios of ΣPCB_c to the TEC were determined (fig. 3). For each sample, ΣPCB_c was compared to the TEC of 59.8 $\mu g/kg$ for total PCBs established by MacDonald and others (2000); in samples with ratios greater than 1, ΣPCB_c exceeds the TEC. ΣPCB_c exceeded the TEC for 75 percent of the samples collected at outfall 4 and 67 percent of the samples collected at outfall 5 before the implementation of engineering controls. ΣPCB_c did not exceed the TEC in samples collected at either outfall 4 or outfall 5

(two at each outfall) after the implementation of engineering controls.

Of the 18 PCB congeners that were quantified, 10 congeners were selected for graphical analysis on the basis of their detection frequency, range of chlorination, concentrations, and concentration variation between sampling sites. To normalize PCB concentrations, ratios of individual concentrations of PCB congeners to the sum of the 10 selected PCB congeners were determined, hereinafter referred to as congener ratios. The relative prominence of the 10 selected PCB congeners was evaluated by graphical analysis of congener ratios (fig. 4).

Before the implementation of engineering controls, congeners 110, 138, and 180 were most prominent on the basis of normalized concentrations of PCB congeners in the suspended-sediment samples at outfall 4 (fig. 4); this conclusion, as well as subsequent conclusions in this paragraph, are based solely on visual observations of figure 4. After the implementation of engineering controls, an overall decrease

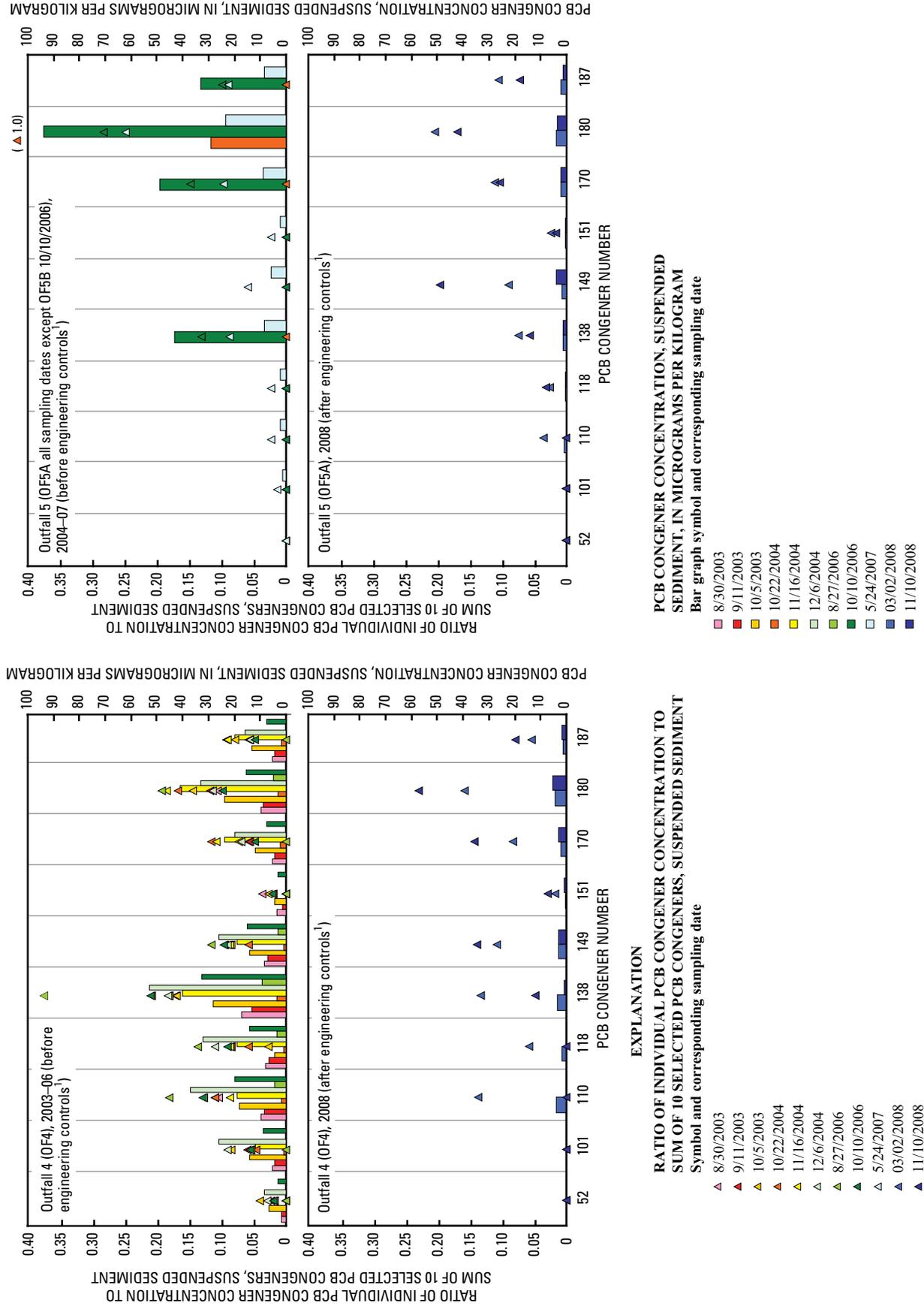


¹ Threshold effect concentration (MacDonald and others, 2000).

² Engineering controls (asphalt caps and sweeping) implemented late 2007 and early 2008, about November 2007–February 2008, to potentially alleviate PCB contamination in drainage areas of outfalls 4 and 5.

Figure 3. Ratios of total polychlorinated biphenyl (PCB) concentrations (sum of 18 reported congeners [ΣPCB_c]) to threshold effect concentration, a consensus-based sediment-quality guideline for PCBs, for suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2003–08.

10 Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek



¹ Engineering controls (asphalt caps and sweeping) implemented late 2007 and early 2008, about November 2007–February 2008, to potentially alleviate PCB contamination in drainage areas of outfalls 4 and 5.

Figure 4. Ratio of individual polychlorinated biphenyl (PCB) congener concentrations to sum of 10 selected PCB congeners for suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2003–08.

in concentrations of PCB congeners was observed in addition to a decrease in the prominence of the congener 110 and 138 ratios. An increase in the prominence of the congener 149 ratio was also observed after the implementation of engineering controls. This shift in prominence from lighter, less chlorinated congeners (110 and 138) to a heavier, more chlorinated congener (149) might have resulted from the engineering controls implemented at AFP4 near the sample collection sites. Additionally, the heavier, more chlorinated congeners are more likely to sorb to solids, while less chlorinated congeners are more likely to volatilize (Eisenreich, Capel, and Looney, 1983; Eisenreich and others, 1992; Pearson and others, 1996). The agitation associated with sweeping activities and gravel stripping might have induced volatilization that would have favored removal of the lighter congeners. The shift in congener ratios might also have resulted from the transition in analytical methods, or it could be the result of the small number of samples available for comparison.

Before the implementation of engineering controls, the suspended-sediment PCB concentrations at outfall 5 (fig. 4) exhibited a congener ratio pattern dominated by congener 138 and the more highly chlorinated PCB congeners (170, 180, and 187). PCB congeners 110 and 118, which were more prevalent at outfall 4, were either not detected at outfall 5 or detected at much lower concentrations, resulting in smaller congener ratios for outfall 5. After the implementation of engineering controls, a decrease in concentrations of PCB congeners was observed in addition to a decrease in prominence of congeners 138 and 180. An increase in the prominence of congener 149 also occurred. The same possible explanations given for the shift in congener ratios at outfall 4 apply to the shift in congener ratios at outfall 5.

Summary

Meandering Road Creek is an intermittent stream and tributary to Lake Worth, a reservoir on the West Fork Trinity River on the western edge of Fort Worth, Texas. U.S. Air Force Plant 4 (AFP4) is on the eastern shore of Woods Inlet, an arm of Lake Worth that extends south from the main body of the lake. Meandering Road Creek gains inflow from several stormwater outfalls as it flows across AFP4 to its terminus at Woods Inlet. Lake Worth and Meandering Road Creek have been the subject of several studies to characterize concentrations of polychlorinated biphenyls (PCBs) (and other contaminants) in the water and sediments of these water bodies; the sources of the PCBs are believed to originate primarily from AFP4. Two previous U.S. Geological Survey (USGS) reports documented elevated PCB concentrations in surficial sediment samples collected in Woods Inlet relative to those in surficial sediment samples collected in other parts of Lake Worth; the first report using samples collected during 2000–2001, the second using samples collected in 2003. The second report also identified some of the sources of PCBs to Lake Worth.

These reports were followed by a third USGS report that documented the extent of PCB contamination in Meandering Road Creek and Woods Inlet on the basis of samples collected during 2004 and 2006–07 and identified runoff from outfalls 4 and 5 at AFP4 as prominent sources of PCBs to Meandering Road Creek and Woods Inlet.

This report describes the results of a fourth study by the USGS, in cooperation with the Lockheed Martin Corporation, to investigate the concentration of PCBs in suspended-sediment samples in storm runoff from outfalls 4 and 5 at AFP4 following the implementation of engineering controls designed to potentially alleviate PCB contamination in the drainage areas of these outfalls. The first engineering control consisted of a one-time sweeping of pavement within the drainage areas of outfalls 4 and 5 to reduce potential PCB migration. The second engineering control involved regrading and installing an asphalt cap over about 560 square meters of the main electrical substation of AFP4. The USGS collected suspended-sediment samples from outfalls 4 and 5 during storms on March 2 and November 10, 2008, and analyzed the samples for selected PCBs. The sums of concentrations of 18 reported PCB congeners (ΣPCB_c) in suspended-sediment samples collected during 2003–07 (before implementation of engineering controls) for the previous USGS studies are compared to ΣPCB_c in suspended-sediment samples collected during 2008 (after implementation of engineering controls). Because of the small number of samples collected and lack of runoff and precipitation data to evaluate comparability of sampling conditions before and after implementation of engineering controls, all conclusions are preliminary.

ΣPCB_c in suspended-sediment samples before implementation of engineering controls ranged from estimated (E)18 to E310 micrograms per kilogram ($\mu\text{g}/\text{kg}$) and E29 to E330 $\mu\text{g}/\text{kg}$ for outfalls 4 and 5, respectively. ΣPCB_c after implementation was E23 and E28 $\mu\text{g}/\text{kg}$ and E19 and E21 $\mu\text{g}/\text{kg}$ for outfalls 4 and 5, respectively. The ΣPCB_c at both outfalls before the engineering controls was higher than the ΣPCB_c after the engineering controls.

The ΣPCB_c in suspended-sediment samples collected at AFP4 before and after implementation of engineering controls also is compared to the threshold effect concentration (TEC), the concentration below which adverse effects to benthic biota rarely occur. ΣPCB_c exceeded the TEC for 75 percent of the samples collected at outfall 4 and 67 percent of the samples collected at outfall 5 before the implementation of engineering controls. ΣPCB_c did not exceed the TEC in samples collected at either outfall 4 or outfall 5 after the implementation of engineering controls.

The relative prominence of 10 selected PCB congeners was evaluated by graphical analysis of ratios of individual concentrations of the 10 PCB congeners to the sum of these PCB congeners. Before the implementation of engineering controls, PCB congeners 110, 138, and 180 were most prominent on the basis of normalized concentrations of PCB congeners in the suspended-sediment samples at outfall 4 (on the basis of visual observations of the graphical data). After the

implementation of engineering controls, an overall decrease in concentrations of PCB congeners was observed in addition to a decrease in the prominence of congeners 110 and 138 and an increase in the prominence of congener 149. This shift in prominence from lighter, less chlorinated congeners (110 and 138) to a heavier, more chlorinated congener (149) might have resulted from the engineering controls implemented at AF4. Before the implementation of engineering controls, the suspended-sediment PCB concentrations at outfall 5 exhibited a congener ratio pattern dominated by congener 138 and the more highly chlorinated PCB congeners (170, 180, and 187). After the implementation of engineering controls, a decrease in concentrations of PCB congeners was observed in addition to a decrease in the prominence of congeners 138 and 180 and an increase in the prominence of congener 149. The shift in congener ratios at outfall 5 also might have resulted from the engineering controls.

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Appendixes 1–2

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Appendix 1. Concentrations of selected polychlorinated biphenyl congeners in suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2003–07.

[In micrograms per kilogram except as noted; PCB, polychlorinated biphenyl; OF4, outfall 4; E, estimated (quantitatively identified at less than minimum reporting level); <, nondetection less than minimum reporting level; OF5, outfall 5; dup, duplicate; --, not available; Σ PCB_e, sum of 18 PCB congeners]

U.S. Geological Survey station number	Site identifier (fig. 2)	Sample date	PCB 49	PCB 52	PCB 70	PCB 101	PCB 110	PCB 118	PCB 138	PCB 146	PCB 149	PCB 151
08045359	OF4	08/30/2003	E0.75	E1.6	E2.6	E5.1	9.7	E8.0	17	E2.4	E8.4	E3.5
08045359	OF4	09/11/2003	E.60	E1.8	E2.3	E4.5	E8.3	E6.4	E13	E2.1	E7.1	E1.5
08045359	OF4	10/05/2003	<11	E6.6	<11	14	18	E4.4	28	E3.4	14	E4.4
08045359	OF4	10/22/2004	<1.0	<1.0	<1.0	E.8	1.9	1.0	3.6	<1.0	1.0	<1.0
08045359	OF4	11/16/2004	<19	<19	<19	E12	E19	E19	E40	<19	E19	<19
08045359	OF4	12/06/2004	<14	E8.2	E10	E26	E37	E32	E53	<14	E26	<14
08045359	OF4	08/27/2006	<36	<36	<36	<36	E4.5	E3.4	E9.4	<36	E2.9	<36
08045359	OF4	10/10/2006	<10	E3.0	E6.8	E8.7	20	14	33	E3.9	15	E3.3
324638097270901	OF5A	10/22/2004	<45	<45	<45	<45	<45	<45	<45	<45	<45	<45
324638097270901	OF5B ¹	10/10/2006	<140	<140	<140	<140	<140	<140	E43	<140	<140	<140
324638097270901	OF5A	05/24/2007	<2.0	<2.0	<2.0	E1.2	2.2	2.1	8.2	<2.0	5.5	2.1
324638097270901	OF5A dup	05/24/2007	<2.0	<2.0	<2.0	E1.4	2.5	2.4	8.7	<2.0	5.7	2.2

Sediment-quality guidelines:

Threshold effect concentration (TEC)² -- -- -- -- -- -- -- -- -- -- --

Site identifier (fig. 2)	Sample date	PCB 170	PCB 174	PCB 177	PCB 180	PCB 183	PCB 187	PCB 194	PCB 206	Σ PCB _e	Surrogates, in percent recovery (acceptable range)		
											Isodrin	alpha-HCH-d6	Nonachloro-biphenyl
OF4	08/30/2003	E5.4	E4.5	E2.4	9.9	E3.4	E5.3	E2.8	<0.16	E93	--	--	--
OF4	09/11/2003	E4.2	E3.2	E2.0	E8.8	E2.2	E4.4	E2.1	<1.0	E75	--	--	--
OF4	10/05/2003	12	E10	E5.4	24	E5.0	13	E3.4	<11	E170	--	--	--
OF4	10/22/2004	2.0	1.0	E.6	2.9	<1.0	1.6	1.0	<1.0	E18	69 (42–94)	79 (21–140)	170 (19–125)
OF4	11/16/2004	E24	E13	<19	E41	<19	E20	E14	<19	E220	57 (42–94)	77 (21–140)	120 (19–125)
OF4	12/06/2004	E20	E11	E8.8	E33	<14	E16	E9.7	<14	E310	61 (42–94)	85 (21–140)	110 (19–125)
OF4	08/27/2006	<36	<36	<36	E4.8	<36	<36	<36	<36	E25	72 (41–121)	83 (58–124)	76 (14–142)
OF4	10/10/2006	E7.5	E5.3	E3.5	15	<10	E7.6	E3.7	E2.9	E160	76 (41–121)	75 (58–124)	81 (14–142)
OF5A	10/22/2004	<45	<45	<45	E29	<45	<45	<45	<45	E29	76 (42–94)	83 (21–140)	140 (19–125)
OF5B ¹	10/10/2006	E49	E31	<140	E94	<140	E33	E51	E27	E330	87 (41–121)	82 (58–124)	88 (14–142)
OF5A	05/24/2007	9.0	8.4	5.9	23	4.1	8.4	7.9	4.2	E93	50 (41–121)	66 (58–124)	92 (14–142)
OF5A dup	05/24/2007	9.3	8.7	6.1	21	4.3	8.7	7.9	4.2	E94	50 (41–121)	62 (58–124)	90 (14–142)

Sediment-quality guidelines:

Threshold effect concentration (TEC)² -- -- -- -- -- -- -- -- -- 59.8 -- -- --

¹ Sample required custom preparation (air dried) at laboratory because normal centrifugation could not separate solids from water.

² MacDonald and others (2000).

18 Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek

Appendix 2. Concentrations of antibacterial, antifungal, pesticide, and flame retardant compounds in suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2008.

[In micrograms per kilogram except as noted; OF4, outfall 4; <, nondetection less than minimum reporting level; E, estimated (quantitatively identified at less than minimum reporting level; dup, duplicate; OF5, outfall 5; --, not available; Σ, sum; ΣPCB₁₈, sum of 18 PCB congeners (table 1); C₁₂Br₂F₈, 4,4-dibromooctafluorobiphenyl; PCB 202-¹³C₁₂, 2,2',3,3',5,5',6,6'-octachlorobiphenyl; DDT-*d*₈, 1,1'-Bis(*p*-chlorophenyl)-2,2,2-trichloroethane]

U.S. Geological Survey station number	Site identifier (fig. 2)	Sample date	Set number	Octachloro-styrene	Antibacterial/ antifungal		Pesticides			
					Methoxy-triclosan	Triclo-san	Ben-fluralin (benefin)	Chlori-dazon (PCA)	Chlor-pyrifos	<i>cis</i> -Chlor-dane
08045359	OF4	3/2/2008	002	<1.0	<1.0	17	E0.15	0.16	3.5	1.1
08045359	OF4	11/10/2008	116	<1.0	<1.0	9.2	E.015	<.1	<.1	1.3
08045359	OF4 dup	11/10/2008	116	<1.0	<1.0	9.0	E.015	<.1	<.1	.93
324638097270901	OF5A	3/2/2008	002	<1.0	<1.0	<5.0	<.1	<.1	1.2	.33
324638097270901	OF5A	11/10/2008	116	<1.0	<1.0	27	<.1	<.1	<.1	.46
Sediment quality guidelines:										
Threshold effect concentration (TEC) ¹			--	--	--	--	--	--	--	--
Minimum reporting level (MRL)			--	1.0	1.0	5.0	.1	.1	.1	.1
Quality assurance samples:										
Set blank			002	<1.0	<1.0	E.43	<.1	E.085	<.1	<.1
Set spike, in percent recovery			002	86.6	152	94	36.9	158	86.3	87.5
Set blank			116	<1.0	<1.0	1.31	<.1	<.1	<.1	<.1
Set spike, in percent recovery			116	77.4	92.7	102	52.6	98.9	73.2	89.7

Site identifier (fig. 2)	Sample date	Pesticides										
		<i>cis</i> -Nonachlor	Cyfluthrin	Cyhalothrin	DCPA (Dacthal)	Desulfinyl fipronil	Dieldrin	Endosulfan I	Fipronil	Fipronil sulfide	Hexachlorobenzene (HCB)	Oxy-chlor-dane
OF4	3/2/2008	0.33	E11	E2.2	1.2	E0.08	0.85	0.56	1.3	E0.02	0.29	<1.0
OF4	11/10/2008	.38	3.6	8.2	.41	.28	1.5	.24	<.1	E.034	<.1	<1.0
OF4 dup	11/10/2008	.27	2.8	6.7	.31	.18	1.1	.15	<.1	E.034	<.1	<1.0
OF5A	3/2/2008	E.07	E2.9	E.25	.32	E.03	.12	.15	.28	E.01	<.1	<1.0
OF5A	11/10/2008	E.10	2.6	4.9	.38	.11	.41	E.09	1.5	E.025	<.1	<1.0
Sediment quality guidelines:												
Threshold effect concentration (TEC) ¹		--	--	--	--	--	1.90	--	--	--	--	--
Minimum reporting level (MRL)		.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	1.0
Quality assurance samples:												
Set blank		<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	E.079	<1.0
Set spike, in percent recovery		87.3	56.5	43.4	114	70.5	105	80.4	66.0	19.8	150	78.4
Set blank		<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	E.091	<1.0
Set spike, in percent recovery		80.1	112	86.4	82.4	62.4	77.6	69.0	73.0	74.4	75.0	93.8

Appendix 2. Concentrations of antibacterial, antifungal, pesticide, and flame retardant compounds in suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2008—Continued.

Site identifier (fig. 2)	Sample date	Pesticides										
		Oxy-fluor-fen	Pendi-methlin	Penta-chloro-nitro-benzene	<i>p,p'</i> -DDD	<i>p,p'</i> -DDE	<i>p,p'</i> -DDT	Teflu-thrin	Tetra-difon	<i>trans</i> -Chlor-dane	<i>trans</i> -Nonachlor	Tri-fluralin
OF4	3/2/2008	<5.0	E1.0	<1.0	<1.0	E0.88	<1.0	<0.1	<0.1	0.88	0.68	E0.25
OF4	11/10/2008	<5.0	<1.0	<1.0	<1.0	E.81	<1.0	<.1	<.1	.95	.61	E.024
OF4 dup	11/10/2008	<5.0	<1.0	<1.0	<1.0	E.62	<1.0	<.1	<.1	.71	.42	E.016
OF5A	3/2/2008	<5.0	<1.0	<1.0	<1.0	E.41	<1.0	<.1	<.1	.23	.16	<.10
OF5A	11/10/2008	<5.0	<1.0	<1.0	<1.0	3.7	<1.0	<.1	<.1	.38	.21	<.10
<i>Sediment quality guidelines:</i>												
Threshold effect concentration (TEC) ¹		--	--	--	4.88	3.16	4.16	--	--	--	--	--
<i>Minimum reporting level (MRL)</i>		5.0	1.0	1.0	1.0	1.0	1.0	.1	.1	.1	.1	.1
<i>Quality assurance samples:</i>												
Set blank		<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<.1	<.1	<.1	<.1	<.1
Set spike, in percent recovery		116	67.0	114	97.6	134	110	51.8	54.5	82.7	76.7	38.3
Set blank		<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<.1	<.1	<.1	<.1	<.1
Set spike, in percent recovery		79.5	74.3	93.3	74.6	103	100	77.2	80.6	82.9	83.6	49.9
Site identifier (fig. 2)	Sample date	Polybrominated diphenyl ethers (PBDEs) and other flame retardants										
		PBDE 47	PBDE 66	PBDE 71	PBDE 85	PBDE 99	PBDE 100	PBDE 138				
OF4	3/2/2008	13	0.59	<0.1	0.92	14	4.5	0.49				
OF4	11/10/2008	6.4	.31	<.1	.62	9.5	2.4	.66				
OF4 dup	11/10/2008	3.8	.23	<.1	.41	4.7	1.3	.87				
OF5A	3/2/2008	3.5	.20	<.1	.28	4.3	1.3	.37				
OF5A	11/10/2008	2.5	<.1	<.1	.34	3.6	.95	.35				
<i>Sediment quality guidelines:</i>												
Threshold effect concentration (TEC) ¹		--	--	--	--	--	--	--				
<i>Minimum reporting level (MRL)</i>		.1	.1	.1	.1	.1	.1	.1				
<i>Quality assurance samples:</i>												
Set blank		.344	<.1	<.1	<.1	E.098	<.1	<.1				
Set spike, in percent recovery		256	60	106	117	130	109	112				
Set blank		.342	<.1	<.1	<.1	E.078	E.031	<.1				
Set spike, in percent recovery		136	46.7	83.0	84.4	84.0	83.5	79.8				

20 Polychlorinated Biphenyls in Suspended-Sediment Samples from Outfalls to Meandering Road Creek

Appendix 2. Concentrations of antibacterial, antifungal, pesticide, and flame retardant compounds in suspended-sediment samples collected from outfalls 4 and 5, Air Force Plant 4, Fort Worth, Texas, 2008—Continued.

Site identifier (fig. 2)	Sample date	Polybrominated diphenyl ethers (PBDEs) and other flame retardants						
		PBDE 153	PBDE 154	PBDE 183	Declorane plus	Firemaster 680 [1,2-bis(2,4,6-Tribromophenoxy) ethane]	Penta-bromotoluene	
OF4	3/2/2008	3.0	2.0	1.2	4.5	1.7	<1.0	
OF4	11/10/2008	2.3	1.2	1.4	6.9	5.8	<1.0	
OF4 dup,	11/10/2008	2.1	.93	1.5	4.3	4.5	<1.0	
OF5A	3/2/2008	1.8	.79	.88	4.0	.49	<1.0	
OF5A	11/10/2008	.94	.66	1.4	19	3.3	<1.0	
<i>Sediment quality guidelines:</i>								
Threshold effect concentration (TEC) ¹		--	--	--	--	--	--	
<i>Minimum reporting level (MRL)</i>		.1	.1	.1	.1	.1	1.0	
<i>Quality assurance samples:</i>								
Set blank		<.1	<.1	<.1	<.1	<.1	<1.0	
Set spike, in percent recovery		106	101	85.3	102	91.7	112	
Set blank		<.1	<.1	<.1	<.1	<.1	<1.0	
Set spike, in percent recovery		78.9	79.2	70.5	94.4	79.8	93.5	
Site identifier (fig. 2)	Sample date	Calculated				Surrogates, in percent recovery		
		ΣPesticides	ΣDDTs	ΣPCB _c	ΣFlame retardants	C ₁₂ Br ₂ F ₈	PCB 202- ¹³ C ₁₂	DDT-d ₈
OF4	3/2/2008	26	0.88	28	46	64.1	47.2	51.8
OF4	11/10/2008	17	.81	23	37	42.7	56.7	71.6
OF4 dup	11/10/2008	14	.63	18	25	40.6	63.1	80.2
OF5A	3/2/2008	6.0	.41	21	18	78.0	47.0	42.1
OF5A	11/10/2008	11	3.7	19	33	37.1	57.2	75.7
<i>Sediment quality guidelines:</i>								
Threshold effect concentration (TEC) ¹		--	5.28	59.8	--	--	--	--
<i>Minimum reporting level (MRL)</i>		--	--	--	--	--	--	--
<i>Quality assurance samples:</i>								
Set blank		--	--	--	--	34.8	46.1	48.4
Set spike, in percent recovery		--	--	--	--	72.0	92.4	91.4
Set blank		--	--	--	--	57.3	74.9	105
Set spike, in percent recovery		--	--	--	--	54.6	75.1	84.0

¹ MacDonald and others (2000).

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