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

Prepared in cooperation with
The Lower Columbia River Estuary Program and the
National Stream Quality Accounting Network Program

Investigation of the Distribution of Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds in the Lower Columbia River Using Semipermeable Membrane Devices

Water-Resources Investigations Report 99–4051

USGS
science for a changing world

Investigation of the Distribution of Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds in the Lower Columbia River Using Semipermeable Membrane Devices

By Kathleen A. McCarthy and Robert W. Gale

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 99–4051

Prepared in cooperation with the
Lower Columbia River Estuary Program and the
National Stream Quality Accounting Network Program

Portland, Oregon
1999

K. A. McCarthy and R. W. Gale—INVESTIGATION OF THE DISTRIBUTION OF ORGANOCHLORINE AND POLYCYCLIC AROMATIC HYDROCARBON COMPOUNDS IN THE LOWER COLUMBIA RIVER USING SEMIPERMEABLE-MEMBRANE DEVICES—U.S. Geological Survey WRIR Report 99–

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

The use of firm, trade, and brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

For additional information write to:

District Chief
U.S. Geological Survey
10615 SE Cherry Blossom Dr
Portland, OR 97216
E-mail: info-or@usgs.gov

Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Box 25286
Federal Center
Denver, CO 80225
E-mail: infoservices@usgs.gov

CONTENTS

Abstract 1
Summary 1
Background 3
Concurrent Investigations 5
Approach 5
Data Collection and Analyses 5
Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds in Water 5
Deployment of Semipermeable-Membrane Devices 5
Analyses 9
Organic Carbon 10
Environmental Conditions 10
Streambed Sediment 10
Estimation of Dissolved Concentrations 10
Estimation of Total Concentrations 11
Distribution of Organochlorine Polycyclic Aromatic Hydrocarbon Compounds 12
Polychlorinated Dibenzo-*p*-dioxins and Polychlorinated Dibenzofurans 12
Polychlorinated Biphenyls 13
Organochlorine Pesticides 30
Polycyclic Aromatic Hydrocarbon Compounds 44
Acknowledgments 45
References 55
Appendix A.—Molecular structures of polychlorinated dibenzo-*p*-dioxins, polychlorinated dibenzofurans, and polychlorinated biphenyls 59
Appendix B.—Organochlorine and polycyclic aromatic hydrocarbon compounds accumulated in field blanks during low-flow conditions, 1997 63
Appendix C.—Partition coefficients, sampling rates, and equations used to estimate dissolved concentrations of organochlorine and polycyclic aromatic hydrocarbon compounds during low-flow conditions, 1997 73
Appendix D.—Suspended and dissolved organic carbon during low-flow conditions, 1997 83
Appendix E.—Organochlorine and polycyclic aromatic hydrocarbon compounds accumulated in field blanks during high-flow conditions, 1998 87
Appendix F.—Organochlorine and polycyclic aromatic hydrocarbon compounds accumulated in SPMDS during high-flow conditions, 1998 95
Appendix G.—Estimated dissolved concentrations of organochlorine and polycyclic aromatic hydrocarbon compounds during high-flow conditions, 1998 109
Appendix H.—Partition coefficients, sampling rates, and equations used to estimate dissolved concentrations of organochlorine and polycyclic aromatic hydrocarbon compounds during high-flow conditions, 1998 117
Appendix I.—Estimated total concentrations of organochlorine and polycyclic aromatic hydrocarbon compounds during high-flow conditions, 1998 123
Appendix J.—Suspended and dissolved organic carbon during high-flow conditions, 1998 135

FIGURES

1. Map showing study area location and data-collection sites 4
2. Semipermeable membrane device (SPMD), deployment rack, and protective shroud 9
3. Graph showing theoretical accumulation of a dissolved compound from water into a semipermeable membrane device 11

4-9. Diagrams showing:

4. Sum of estimated dissolved concentrations of polychlorinated dibenzo-*p*-dioxins during low-flow conditions in the Columbia River Basin, 1997 13
5. Sum of estimated dissolved concentrations of polychlorinated dibenzofurans during low-flow conditions in the Columbia River Basin, 1997 13

6. Sum of estimated dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997 34
7. Sum of estimated dissolved concentrations of non-*ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997 34
8. Sum of estimated dissolved concentrations of organochlorine pesticides during low-flow conditions in the Columbia River Basin, 1997 45
9. Sum of estimated dissolved concentrations of polycyclic aromatic hydrocarbon compounds during low-flow conditions in the Columbia River Basin, 1997 53
A1. General chemical structures of polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polychlorinated biphenyls (PCBs) 61

TABLES

1. Summary of organochlorine and PAH data collected in the Columbia River Basin, 1997 and 1998 6
2. Semipermeable membrane device deployment during low-flow conditions in the Columbia River Basin, 1997 7
3. Semipermeable membrane device deployment during high-flow conditions in the Columbia River Basin, 1998 8
4. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997 14
5. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997 16
6. Estimated dissolved concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during low-flow conditions in the Columbia River Basin, 1997 17
7. Estimated total concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during low-flow conditions in the Columbia River Basin, 1997 18
8. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997 20
9. *Ortho*-substituted polychlorinated biphenyls in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997 26
10. Non-*ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997 29
11. Non-*ortho*-substituted polychlorinated biphenyls in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997 30
12. Estimated dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997 31
13. Estimated dissolved concentrations of non-*ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997 33
14. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997 35
15. Estimated total concentrations of non-*ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997 41
16. Organochlorine pesticides accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997 42
17. Organochlorine pesticides in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997 44
18. Estimated dissolved concentrations of organochlorine pesticides during low-flow conditions in the Columbia River Basin, 1997 32
19. Estimated total concentrations of organochlorine pesticides during low-flow conditions in the Columbia River Basin, 1997 32
20. Polycyclic aromatic hydrocarbon compounds accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997 33
21. Polycyclic Aromatic Hydrocarbon Compounds in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997 33
22. Estimated dissolved concentrations of polycyclic aromatic hydrocarbon compounds during low-flow conditions in the Columbia River Basin, 1997 33

23. Estimated total concentrations of polycyclic aromatic hydrocarbon compounds during low-flow conditions in the Columbia River Basin, 1997 34
A1. Structures of polychlorinated biphenyl congeners 62
B1. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997 65
B2. *Ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997 66
B3. Non-*ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997 69
B4. Organochlorine pesticides accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997 70
B5. Polycyclic aromatic hydrocarbon compounds accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997 75
C1. Partition coefficients and sampling rates used to estimate dissolved concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during low-flow and high-flow conditions in the Columbia River Basin, 1997 and 1998 76
C2. Partition coefficients, sampling rates, and equations used to estimate dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow and high-flow conditions in the Columbia River Basin, 1997 and 1998 76
C3. Partition coefficients and sampling rates used to estimate dissolved concentrations of non-*ortho*-substituted polychlorinated biphenyls during low-flow and high-flow conditions in the Columbia River Basin, 1997 and 1998 77
C4. Partition coefficients, sampling rates, and equations used to estimate dissolved concentrations of organochlorine pesticides during low-flow conditions in the Columbia River Basin, 1997 78
C5. Partition coefficients, sampling rates, and equations used to estimate dissolved concentrations of polycyclic aromatic hydrocarbon compounds during low-flow conditions in the Columbia River Basin, 1997 80
D1. Organic carbon measured during low-flow conditions in the Columbia River Basin, 1997 85
E1. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998 87
E2. *Ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998 89
E3. Non-*ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998 92
E4. Organochlorine pesticides accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998 93
E5. Polycyclic aromatic hydrocarbon compounds accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998 94
F1. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998 97
F2. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998 98
F3. Non-*ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998 104
F4. Organochlorine pesticides accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998 105
F5. Polycyclic aromatic hydrocarbon compounds accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998 107
G1. Estimated dissolved concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during high-flow conditions in the Columbia River Basin, 1998 110
G2. Estimated dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998 111
G3. Estimated dissolved concentrations of non-*ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998 113

G4. Estimated dissolved concentrations of organochlorine pesticides during high-flow conditions in the Columbia River Basin, 1998 114
G5. Estimated dissolved concentrations of polycyclic aromatic hydrocarbon compounds during high-flow conditions in the Columbia River Basin, 1998 115
H1. Partition coefficients, sampling rates, and equations used to estimate dissolved concentrations of organochlorine pesticides during high-flow conditions in the Columbia River Basin, 1998 118
H2. Partition coefficients, sampling rates, and equations used to estimate dissolved concentrations of polycyclic aromatic hydrocarbon compounds during high-flow conditions in the Columbia River Basin, 1998 120
I1. Estimated total concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during high-flow conditions in the Columbia River Basin, 1998 121
I2. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998 124
I3. Estimated total concentrations of non-*ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998 126
I4. Estimated total concentrations of organochlorine pesticides during high-flow conditions in the Columbia River Basin, 1998 130
I5. Estimated total concentrations of polycyclic aromatic hydrocarbon compounds during high-flow conditions in the Columbia River Basin, 1998 131
J1. Organic carbon measured during high-flow conditions in the Columbia River Basin, 1998 136

CONVERSION FACTORS

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
	Temperature[a]	

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

$$°F = (1.8\ °C) + 32$$

METRIC UNITS OF MASS

1 milligram	=	10^{-3} gram
1 microgram	=	10^{-6} gram
1 nanogram	=	10^{-9} gram
1 picogram	=	10^{-12} gram
1 femtogram	=	10^{-15} gram

ABBREVIATIONS and ACRONYMS

C_{SPMD}	SPMD concentration
C_T	total concentration (dissolved plus sorbed)
C_w	dissolved concentration
CERC	Columbia Environmental Research Center
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DOC	dissolved organic carbon
EST	Environmental Sampling Technologies
fg/L	femtograms per liter
ft	feet
K_{oc}	organic carbon-water partition coefficient
K_{ow}	octanol-water partition coefficient
K_{SPMD}	SPMD-water partition coefficient
L	stream load
mg/L	milligrams per liter
ng/L	nanograms per liter
NWQL	National Water Quality Laboratory
OC	organochlorine
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran
pg/L	picograms per liter
Q	stream discharge
R	SPMD sampling rate
s	second
SOC	suspended organic carbon
SPMD	semipermeable membrane device
t	time
USFWS	U.S. Fish and Wildlife Service
USGS	U. S. Geological Survey

Investigation of the Distribution of Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds in the Lower Columbia River Using Semipermeable Membrane Devices

By Kathleen A. McCarthy *and* Robert W. Gale

ABSTRACT

Organochlorine and polycyclic aromatic hydrocarbon compounds are of concern in the Columbia River Basin because of their adverse effects on fish and wildlife. Because these compounds can have important biological consequences at concentrations well below the detection limits associated with conventional water-sampling techniques, we used semipermeable membrane devices (SPMDs) to sample water, and achieved sub-parts-per-quintillion detection limits. We deployed SPMDs during 1997 low-flow conditions and 1998 high-flow conditions at nine main-stem sites and seven tributary sites, spanning approximately 700 miles of the Columbia River. We also collected streambed sediment from three sites. SPMD extracts and sediments were analyzed for polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, polychlorinated biphenyls, organochlorine pesticides and related transformation products, and polycyclic aromatic hydrocarbons. Our data indicate that (1) in the absence of additional sources, mechanisms such as volatilization, dilution, and settling of suspended particles can act to significantly reduce concentrations of contaminants along the river's flow path, (2) elevated concentrations of contaminants in the Portland-Vancouver area are primarily from local rather than upstream sources, (3) elevated concentrations of many compounds tend to be diluted during periods of high discharge, (4) much higher discharge in the main stem considerably dilutes elevated concentrations entering from tributaries, (5) the distribution of hydrophobic organic compounds in streambed sediment is not necessarily indicative of their distribution in the dissolved-phase, and (6) SPMDs can reveal patterns of contaminant occurrence at environmentally relevant concentrations that are undetectable by conventional water-sampling techniques.

SUMMARY

As a result of increasing urbanization, agricultural development, and industrialization throughout the Columbia River Basin, fish and wildlife populations in and near the river are exposed to a wide variety of contaminants from both runoff and atmospheric deposition. Industrial and agricultural chemicals have been correlated with reproductive abnormalities in river otters, bald eagles and ospreys from the basin, and these and other organochlorine (OC) and polycyclic aromatic hydrocarbon (PAH) compounds are also suspected of causing detrimental health effects in several additional species. Many of these compounds also have the tendency to bioaccumulate, and adverse effects can therefore result even from extremely low concentrations in river water.

We used semipermeable-membrane devices (SPMDs) to investigate OC and PAH compounds in the Columbia River Basin at low parts-per-quintillion levels—concentrations several orders of magnitude below detection limits associated with conventional water-sampling techniques. We deployed SPMDs at nine sites along the Columbia main stem and seven sites near the mouths of tributaries during 1997 low-flow conditions and again

during 1998 high-flow conditions (data from the 1998 deployment period are presented in tables in the Appendixes of this report, but are not discussed in the body of the report). Streambed sediment samples were also collected at three of the sites. SPMD extracts and sediments were analyzed for polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs), OC pesticides and related transformation products (referred to throughout this report as simply OC pesticides), and PAHs. Concentrations measured in SPMDs were used to estimate dissolved concentrations in river water and sorbed concentrations associated with suspended and dissolved organic carbon.

Many of the compounds investigated during this study are persistent in the environment. Therefore, even though some have been severely restricted or banned completely over the last few decades, target analytes were present at all sites sampled. Estimates of dissolved-phase concentrations indicate that individual OC compounds were generally present at picogram (10^{-12} gram) to femtogram (10^{-15} gram) per liter levels, and PAHs at nanogram (10^{-9} gram) to picogram per liter levels. Additional organic compounds not targeted during this study were also accumulated in SPMDs at concentrations up to several orders of magnitude greater than target analytes. Although these compounds have not been identified, their prevalence suggests they may be important to our understanding of water-quality conditions in the Columbia River Basin.

During the 1997 low-flow sampling period, concentrations of PCDDs and PCDFs were highest in SPMDs deployed in the Willamette River Basin, the Yakima River, and the Columbia River main stem near the Portland-Vancouver urban area. During the 1998 high-flow sampling period, concentrations of PCDDs and PCDFs were generally similar to or slightly lower than 1997 levels.

Concentrations of PCBs measured during the 1997 low-flow sampling were highest in SPMDs deployed at tributary sites—Johnson Creek and the Willamette River, both in the Portland-Vancouver urban area, and the Wenatchee River, in the upper Columbia River Basin. In the Columbia River main stem, concentrations were slightly elevated in SPMDs from the Columbia City site, just downstream of the Portland-Vancouver urban area, but were lower in SPMDs from more downstream sites. Concentrations of PCBs were lower in 1998 than in 1997 at the Johnson Creek, Willamette River, Wenatchee River and Columbia City sites. At all other sites, 1998 PCB concentrations were similar or slightly reduced compared to the 1997 study period. At the Wenatchee site, concentrations of *ortho*-substituted PCBs were markedly lower in 1998; non-*ortho*-substituted PCBs were not measured at this site in 1998.

The most prevalent OC pesticides detected in SPMDs during the 1997 low-flow deployment were *p,p*'-DDE and *p,p*'-DDD—both metabolites of DDT. Overall pesticide concentrations during this period were elevated in the upper basin at the Vernita and Yakima River sites, at the Warrendale site, and in the Willamette River Basin. During the 1998 high-flow sampling period, concentrations were lower at the Warrendale and Longview sites and similar or slightly reduced at all other sites except Johnson Creek. Levels of several pesticides were somewhat elevated at the Johnson Creek site in 1998, likely due to the residential and agricultural land use that has characterized this relatively small drainage basin for many years.

PAH concentrations in SPMDs during 1997 low-flow conditions were lowest at main-stem sites in the upper Columbia River Basin and highest at the Warrendale and Willamette River Basin sites. During the 1998 study period, PAH concentrations were similar or slightly lower at most sites, but were considerably reduced in SPMDs from the Warrendale site.

The spatial and temporal distribution of hydrophobic organic compounds observed during this study provide important insights into the sources and transport of these compounds in the Columbia River system. Although differences in dissolved concentration estimates were often small relative to the uncertainty inherent in our approach, the consistency in many of the observed patterns suggests they are authentic.

- Consistently low levels of compounds measured at the Hayden Island site—just upstream of the mouth of the Willamette River—and at the Bradwood site—the most downstream site sampled—suggest that in the absence of additional sources, mechanisms such as volatilization, dilution, and settling of suspended particles can act to significantly reduce concentrations of contaminants along the river's flow path.

- Consistently low levels of compounds measured at the Hayden Island site, coupled with other data from upstream sites, indicate that elevated concen-

trations of contaminants in the Portland-Vancouver area are primarily from local rather than upstream sources.

- Concentrations of many compounds are diluted with increased discharge, except in Johnson Creek.
- Concentrations of many OC and PAH compounds may be elevated at tributary sites, but the much higher discharge in the main stem considerably dilutes these concentrations.
- The distribution of hydrophobic organic compounds in streambed sediment is not necessarily indicative of their distribution in river water.
- SPMDs can reveal patterns of contaminant occurrence at environmentally relevant concentrations that are undetectable by conventional water-sampling techniques.

BACKGROUND

The Columbia River drains approximately 260,000 square miles (670,000 square kilometers) in the Pacific Northwest and travels more than 1,200 river miles (1,900 kilometers) from its headwaters in the Canadian Rockies to its mouth at the Oregon-Washington border (fig. 1). As a result of increasing urbanization, agricultural development, and industrialization throughout the basin, fish, wildlife, and human populations in and near the Lower Columbia River are exposed to a wide variety of contaminants from both runoff and atmospheric deposition.

Several studies have shown that persistent organochlorine (OC) compounds are pervasive in biota, sediment, and water sampled in the Columbia River Basin. L. Lefkovitz, E. Crecelius, and N. McElroy (Battelle, unpub. data, 1996) used 2 configurations of semipermeable-membrane devices (SPMDs) to concentrate OC pesticides and polychlorinated biphenyls (PCBs) from river water at 10 sites in the basin extending from the Yakima River to the Columbia River at Longview. They found OC compounds present at all sites, with the highest pesticide concentrations in the Yakima River and the highest PCB concentrations in the Columbia Slough and the Willamette River near the Portland-Vancouver area.

A water-quality study by the Lower Columbia River Bi-State Program (1990-96) found developmental deformities and higher concentrations of PCBs, OC pesticides, polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and heavy metals in river otter from the Lower Columbia River relative to those from a reference area (Henny *et al.*, 1996). For many of the compounds analyzed, the highest concentrations were found in otter collected near the Portland-Vancouver area. Data collected during the same study showed that bald eagles nesting along the Columbia River were not reproducing as successfully as eagles nesting in other areas of Oregon and Washington (Columbia River Bi-State Study, June 1996). Eagle eggs sampled contained dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyldichloroethane (DDD)—degradation products of the once widely used OC pesticide dichlorodiphenyltrichloroethane (DDT)—PCBs, PCDDs, and PCDFs at concentrations that exceeded the estimated no-effect levels and that were associated with reduced productivity in other studies (Anthony *et al.*, 1993; Wiemeyer *et al.*, 1993; Giesy *et al.*, 1995; Elliott *et al.*, 1996; Elliot *et al.*, 1996).

The Willamette River flows into the Lower Columbia River in the Portland-Vancouver urban area, and is a source of OC compounds in the lower Columbia River. These compounds have been detected in streambed sediment, suspended sediment, and fish tissue in the Willamette Basin by several investigators (Fuhrer, 1989; Edwards, 1992; Curtis *et al.*, 1993; Rinella, 1993; Harrison *et al.*, 1995; Bonn, 1998; Wentz *et al.*, 1998). During storm sampling, these compounds were also detected in filtered water collected from Johnson Creek, the Pudding River, and the Willamette River near Portland (Harrison *et al.*, 1995). Fuhrer *et al.* (1996) detected a number of organic compounds, including OC pesticides, in stream water in the lower Columbia Basin, and found the largest number of detections and the highest concentrations at their Willamette River site.

The upper Columbia River Basin, above Bonneville Dam, can also act as a source of materials to the lower basin, and several studies have detected OC compounds in biota, sediment, and water sampled in the upper basin (Williamson *et al.*, 1998; Munn and Gruber, 1997; Gruber and Munn, 1996, Wagner *et al.*, 1995; Embrey and Block, 1995; Rinella *et al.*, 1992).

OC and PAH compounds are ubiquitous in the lower Columbia River Basin and result from urban, agricultural, and industrial activities. The objective of this

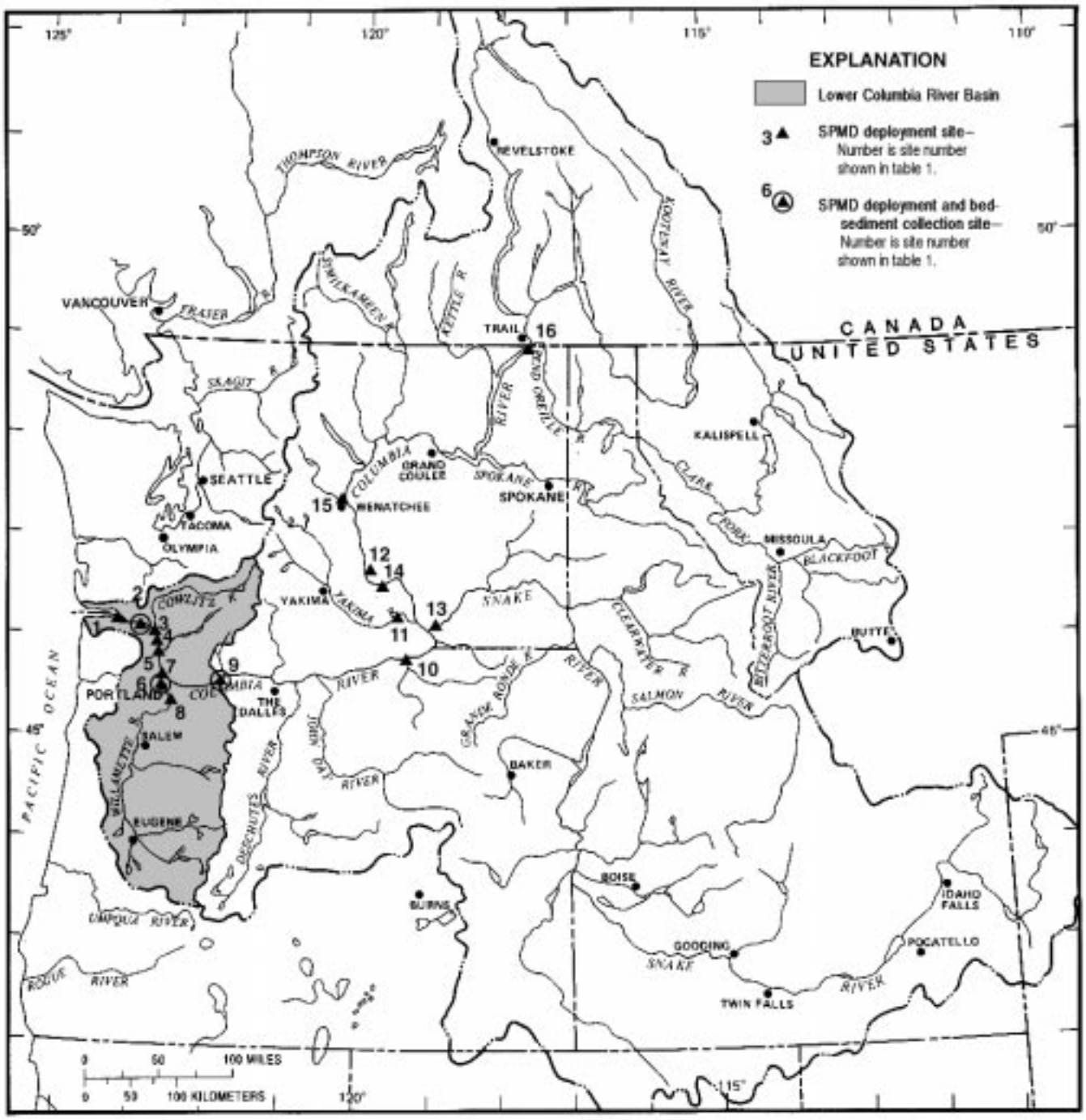

Figure 1. Study area location and data-collection sites.

study was to identify the relative magnitudes of riverine sources of OC and PAH compounds in the lower Columbia River Basin by measuring them within various reaches of the main stem and near the mouths of selected tributaries.

CONCURRENT INVESTIGATIONS

Concurrent studies are underway to evaluate the biological effects of OC and PAH compounds in the Columbia River Basin. The Forest and Rangeland Ecosystem Science Center (Corvallis, Oregon) of the U.S. Geological Survey (USGS) is conducting a study along the Columbia River to evaluate the relationship between osprey (*Pandion haliaetus)* reproduction and the contaminant residue patterns in their eggs. In a separate study, the USGS's Biomonitoring of Environmental Status and Trends Program collected fish at selected sites within the Columbia River Basin. After being examined and assessed for gross indications of fish health, tissues from these fish are being analyzed for contaminant residues and biomarkers—biochemical, physiological, or histological indicators of exposure to contaminants. The U. S. Fish and Wildlife Service (USFWS) also deployed SPMDs at many of the sites sampled during the current study. Dialysates from these SPMDs will be evaluated by the H4IIE rat hepatoma cell bioassay method (Tillitt *et al.*, 1991), which provides a measure of the overall toxicity of compounds present in the river.

APPROACH

Because of their very low water solubilities, OC and PAH compounds in water tend to sorb to sediment and dissolved organic material, and the dissolved fractions of these compounds are therefore low. However, adverse biological impacts can result from even extremely low concentrations of the dissolved phase of some these compounds, particularly those that accumulate in aquatic organisms. Because such low dissolved concentrations are not detectable by conventional water-sampling methods, they are typically measured by analyzing large-volume unfiltered water samples. Dissolved concentrations are then estimated using dissolved and particulate organic carbon data and partition coefficients. To overcome some of the difficulties inherent in large-volume water sampling, SPMDs (fig. 2) were used in this study to measure the dissolved concentrations of OC and PAH compounds. In addition, SPMDs provide the advantage of time-integrated sampling for most OC and PAH compounds, and thus are better suited than conventional point-in-time sampling techniques for investigating episodic contaminant discharges. Huckins *et al.* (1993) provide a description of SPMDs and the theory underlying their application.

DATA COLLECTION AND ANALYSES

SPMDs were used to sample nine sites on the Columbia River main stem and seven tributary sites for PAH and OC compounds during low-flow conditions in the late summer and early fall of 1997, and again during high-flow conditions in 1998 (tables 1-3). High flows in the Columbia River main stem result primarily from snowmelt, and the 1998 sampling at most sites was conducted during late spring and early summer to capture peak discharges. In contrast, high flows in the Willamette subbasin result largely from winter rainfall, and therefore the 1998 sampling at the Willamette River and Johnson Creek sites was conducted during the winter.

To help in the interpretation of SPMD data, water temperature was also monitored and water samples were collected for analyses of dissolved and suspended organic carbon. During the 1997 low-flow sampling period, streambed sediment was collected from three of the sites and analyzed for the full suite of OC and PAH compounds.

Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds in Water

The SPMDs used in this study were purchased from Environmental Sampling Technologies (EST), St. Joseph, Missouri. They were standard SPMDs (Huckins *et al.*, 1999) consisting of a 91.4-cm length of 2.5-cm wide low-density polyethylene lay-flat tubing containing a thin film (1 mL, 0.915 g) of triolein—a large-molecular-weight, neutral lipid characteristic of many fats and oils (fig. 2).

Deployment of Semipermeable Membrane Devices

SPMDs, mounted on deployment racks (fig. 2), were shipped from the manufacturer in sealed 1-gallon metal cans and refrigerated until use. The sealed cans were transported to the field on ice. In the field, the mounted SPMDs were removed from the storage cans

Table 1. Summary of organochlorine and polycyclic aromatic hydrocarbon data collection in the Columbia River Basin, 1997 and 1998

[—, not available; for tributary sites, Columbia River mile indicates river mile at which tributary enters main stem; see figure 1 for site locations]

Site Name	Site Number	Surface-Water Station Number	Columbia River Mile	Data Collected	
				Water	Sediment
Main-Stem Sites					
Bradwood	01	—	39	X	
Beaver Army Terminal	02	14246900	54	X	X
Longview	03	—	69	X	
Columbia City	04	—	82	X	
Hayden Island	07	—	102	X	
Warrendale	09	14128870	141	X	X
Umatilla	10	—	289	X	
Vernita Bridge	14	12472900	388	X	
Northport	16	12400520	735	X	
Tributary Sites					
Lake River	05	—	87	X	
Willamette River	06	14211720	101	X	X
Johnson Creek	08	14211550	—[a]	X	
Yakima River	11	12510500	335	X	
Lower Crab Creek	12	12472600	411	X	
Snake River	13	13353200	324	X	
Wenatchee River	15	—	468	X	

[a]Johnson Creek is tributary to the Willamette River at Willamette River mile 18

(by grasping the mounting rack rather than the SPMD), transferred into stainless steel deployment cannisters (which serve as protective shrouds), and placed in the stream. SPMDs were typically exposed to the atmosphere less than 15 minutes before being submerged in the river.

Each cannister contained 5 SPMDs. Individual deployments consisted of either 1 or 3 cannisters (5 or 15 SPMDs per deployment), depending on the suite of compounds to be analyzed. Cannisters were secured at each site with anchors and, in some cases, a tether line attached to a fixed structure. Floats were used to ensure that the cannisters did not rest on the streambed. SPMDs were left in place for approximately 35 days. At the end of this 5-week deployment period, the mounted SPMDs were removed from the cannisters (by grasping the mounting rack rather than the SPMD), sealed in cans, and shipped on ice to the EST laboratory. Again, SPMDs were typically exposed to the atmosphere less than 15 minutes before being sealed in shipping containers.

Field Quality Control.—SPMDs were deployed in duplicate at selected locations to help quantify the overall precision of the sampling and analytical methods. At selected sites, field-blank SPMDs were exposed to the atmosphere during both deployment and retrieval to help quantify sample contamination resulting from handling and exposure to the atmosphere. Duplicate deployments and field blanks each consisted of the same number of SPMDs (5 or 15) as the associated primary deployment. All SPMD sets—primary deployments, duplicate deployments, and field blanks—were processed and analyzed using the same methods.

For each class of compounds, analyte concentrations measured in field-blank SPMDs (Appendixes B and E) were generally much lower than those measured

Table 2. Simipermeable membrane device deployment during low-flow conditions in the Columbia River Basin, 1997
[—, no data available; C, degrees Celsius; ft^3/s, cubic feet per second; ft/s, feet per second; S, slight; M, moderate; H, heavy]

Site Name	Site Number	Date Deployed	Date Retrieved	Exposure Period (days)	Quality Control		Exposure-Period Average			Membrane Fouling
					Field Blank	Dupli-cate	Water Temperature (C)	Stream Discharge (ft^3/s)	Estimated Water Velocity (ft/s)	
Phase 1 Deployment										
Bradwood	01	August 4	September 8	35			21.7	—	0.5 - 1	M
Beaver Army Terminal	02	August 4	September 8	35			21.2	201,000[b]	1.5 - 3	S
Longview	03	August 5	September 9	35		X	21.5	—	1.5 - 3	S-M
Columbia City	04	August 5	September 9	35			21.6	—	1.5 - 3	S-M
Willamette River	06	August 6	September 10	35	X	X	21.9	11,200[b]	0.5 - 1	M
Johnson Creek	08	August 6	September 10	35			17.6	31[b]	1.5 - 3	S-M
Umatilla	10	August 8	September 15	38	X		20.2	171,000[c]	0.5 - 1	M
Yakima River	11	August 11	September 15	35		X	20.7	2,250[d]	1.5 - 3	M-H
Lower Crab Creek	12	August 11	September 16	36	X		20.6	328[d]	1.5 - 3	S-M
Snake River	13	August 12	September 15	34			20.1[a]	39,500[e]	3 - 4.5	M
Vernita Bridge	14	August 12	September 16	35			—	128,000[f]	> 5	M-H
Wenatchee River	15	August 13	September 16	34			16.6	1,410[g]	1.5 - 3	S-M
Northport	16	August 13	September 17	35	X	X	16.9	112,000[h]	1.5 - 3	S-M
Phase 2 Deployment										
Lake River	05	October 15	November 20	36			11.6	—	0.5 - 1	M
Hayden Island	07	October 15	November 20	36			12.5	—	0.5 - 1	S-M
Warrendale	09	October 15	November 20	36			12.8	156,000[i]	1.5 - 3	S-M

[a]SPMDs and temperature logger at the Snake River site were periodically exposed to air due to fluctuating river stage.

[b]Discharge from U.S. Geological Survey stream-gaging station near site (Hubbard *et al*., 1998).

[c]Discharge estimated from McNary Dam outflow, approximately 3.5 miles upstream of site (U.S. Army Corps of Engineers Water Management Division FTP site, accessed July 20, 1998 at URL ftp://ftp.nwd-wc.usace.army.mil/pub/data_request/).

[d]Discharge from U.S. Geological Survey stream-gaging station near site (Wiggins *et al*., 1998).

[e]Discharge estimated from U.S. Geological Survey stream-gaging station 13353000, approximately 1 mile upstream of site (Wiggins *et al*., 1998).

[f]Discharge estimated from U.S. Geological Survey stream-gaging station 12472800, approximately 6 miles upstream of site (Wiggins *et al*., 1998).

[g]Discharge estimated from U.S. Geological Survey stream-gaging station 12462500, approximately 5 miles upstream of site (Wiggins *et al*., 1998).

[h]Discharge estimated from U.S. Geological Survey stream-gaging station 12399500, approximately 10 miles upstream of site (Wiggins *et al*., 1998).

[i]Discharge estimated from Bonneville Dam outflow, approximately 3 miles upstream of site (U.S. Army Corps of Engineers Water Management Division FTP site, accessed July 20, 1998 at URL ftp://ftp.nwd-wc.usace.army.mil/pub/data_request/).

Table 3. Simipermeable membrane device deployment during high-flow conditions in the Columbia River Basin, 1998

[—, no data available; C, degrees Celsius; ft^3/s, cubic feet per second; ft/s, feet per second; S, slight; M, moderate; H, heavy]

Site Name	Site Number	Date Deployed	Date Retrieved	Exposure Period (days)	Quality Control		Exposure-Period Average			Membrane Fouling
					Field Blank	Duplicate	Water Temperature (C)	Stream Discharge (ft^3/s)	Esti-mated Water Velocity (ft/s)	
Phase 1 Deployment										
Willamette River	06	January 15	February 18	34	X	X	7.8	80,500[b]	1.5 - 3	S-M
Johnson Creek	08	January 15	February 18	34			8.3	194[b]	3 - 4.5	M
Phase 2 Deployment										
Bradwood	01	May 19	June 22	34			14.7	—	1.5 - 3	S
Beaver Army Terminal	02	May 19	June 22	34	X	X	14.5	385,000[b]	3 - 4.5	M
Longview	03	May 21	June 23	33			14.7	—	3 - 4.5	S
Hayden Island	07	May 21	June 24	34			15.4	—	0.5 - 1	S
Columbia City	04	May 22	June 23	32			15.2	—	3 - 4.5	S
Lake River	05	May 22	June 23	32			16.5	—	0.5 - 1	S-M
Warrendale	09	May 22	June 24	33			14.9	316,000[c]	3 - 4.5	S
Northport	16	June 2	July 6	34			—	130,000[d]	> 5	M-H
Lower Crab Creek	12	June 3	July 7	34			21.3	3[b]	1.5 - 3	S-M
Wenatchee River	15	June 3	July 7	34			12.7	6,810[e]	3 - 4.5	M
Yakima River	11	June 4	July 7	33	X	X	19.5	3,590[f]	3 - 4.5	M
Snake River	13	June 4	July 8	34			16.5[a]	107,000[g]	> 5	M
Vernita Bridge	14	June 4	July 7	33	X	X	15.6	160,000[h]	> 5	M-H
Umatilla	10	June 5	July 8	33			16.5	277,000[i]	1.5 - 3	M-H

[a]SPMDs and temperature logger at the Snake River site were periodically exposed to air due to fluctuating river stage.

[b]Discharge from U.S. Geological Survey stream-gaging station near site (unpublished data, 1998).

[c]Discharge estimated from Bonneville Dam outflow, approximately 3 miles upstream of site (U.S. Army Corps of Engineers Water Management Division FTP site, accessed September 24, 1998 at URL ftp://ftp.nwd-wc.usace.army.mil/pub/data_request/).

[d]Discharge estimated from U.S. Geological Survey stream-gaging station 12399500, approximately 10 miles upstream of site (unpublished data, 1998).

[e]Discharge estimated from U.S. Geological Survey stream-gaging station 12462500, approximately 5 miles upstream of site (unpublished data, 1998).

[f]Discharge estimated from Bureau of Reclamation data (unpublished data, 1998).

[g]Discharge estimated from U.S. Geological Survey stream-gaging station 13353000, approximately 1 mile upstream of site (unpublished data, 1998).

[h]Discharge estimated from U.S. Geological Survey stream-gaging station 12472800, approximately 6 miles upstream of site (unpublished data, 1998).

[i]Discharge estimated from McNary Dam outflow, approximately 3.5 miles upstream of site (U.S. Army Corps of Engineers Water Management Division FTP site, accessed September 24, 1998 at URL ftp://ftp.nwd-wc.usace.army.mil/pub/data_request/).

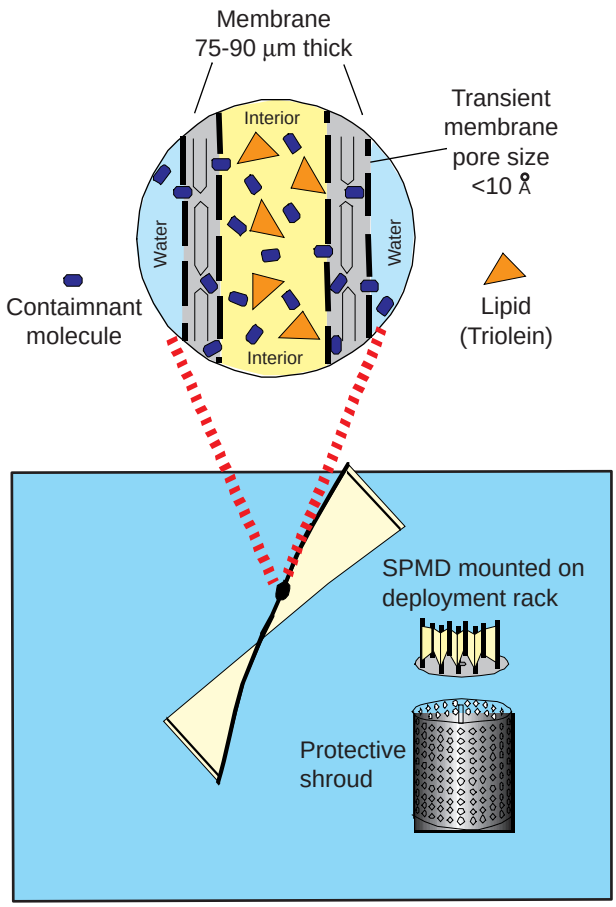

Figure 2. Semipermeable membrane device (SPMD), deployment rack, and protective shroud. (After Huckins et al., 1998)

in deployed SPMDs, showing that handling and exposure to the atmosphere did not introduce significant contamination. In addition, for each deployment period, analyte concentrations were similar in all field-blank SPMDs. SPMD data from each river deployment were therefore corrected for atmospheric contamination, based on average concentrations of all field blanks exposed during that period.

Results from duplicate field deployments (presented with regular deployment results in the following sections) indicate precision adequate for a reconnaissance-level study. With the exception of the 1997 duplicate deployment at the Northport site, results from most duplicate samples differed by less than a factor of two, and as expected, the greatest differences were in analytes present at concentrations near the detection limits. There were considerably larger differences between the Northport duplicate samples. The second Northport sample had consistently higher concentrations of all analytes except PCDDs and PCDFs, which were either not detected or present at levels that could not be quantified. The reasons for the discrepancies in the Northport duplicate data are not known, but we hypothesize that the second sample was somehow contaminated and the first sample is more representative of riverine conditions at site 16. Data from the 1998 deployment support this assumption, but the results remain ambiguous and should be interpreted cautiously.

Analyses

At the EST laboratory, exterior debris and periphyton were removed and SPMDs were spiked with a cocktail of surrogate compounds prepared by the USGS Columbia Environmental Research Center (CERC), Columbia, Missouri, to monitor analyte recovery. Spiked SPMDs were dialyzed in hexane, and dialysates were purified using high-performance gel-permeation chromatography and sealed in glass ampules. Purified dialysates from the 1997 low-flow deployments and from the phase-1 1998 high-flow deployment were sent to the CERC for analyses. Purified dialysates from the phase-2 high-flow deployment were sent to the Midwest Research Institute (MRI), Kansas City, Missouri, for analyses.

In the analytical laboratories, enriched dialysates were divided into separate portions for analyses of (1) PCDDs, PCDFs, and PCBs, (2) OC Pesticides and transformation products, and (3) PAHs. (See appendix A for illustrations and definitions of PCDD, PCDF, and PCB congeners.) Each of these portions was prepared for analysis with specific fractionation and enrichment procedures. PCDDs, PCDFs, and non-*ortho*-substituted PCBs were analyzed by gas chromatography-high resolution mass spectrometry. OC pesticides and *ortho*-substituted PCBs were analyzed by gas chromatography with electron capture detection. PAH compounds were analyzed by gas chromatography-mass spectrometry. Complete details of the methods used at the CERC laboratory are described by Gale and Orazio (1998); further details of methods used at the EST and MRI laboratories are available from EST and MRI.

Laboratory Quality Control.—Quality control samples processed with SPMD samples included procedural blanks and procedural spikes for each class of analytes. Procedural blanks were used to identify and quantify background contamination that occurred during sample preparation and analyses. Procedural spikes were used to monitor the overall efficiency of the sample preparation and analytical processes. Reported SPMD

Figure 2. Semipermeable membrane device (SPMD), deployment rack, and protective shroud. (After Huckins et al., 1998)

concentrations were corrected for surrogate recoveries (when applicable) and for procedural and field-blank backgrounds. Further details of the quality-control methods used at the analytical laboratories and the specific methods used for data correction are available in Gale and Orazio (1998) and from MRI.

Organic Carbon

Grab samples for analyses of dissolved and suspended organic carbon were collected at selected sites during the deployment and retrieval of SPMDs. These samples were collected in baked glass bottles, sealed with aluminum-foil-lined caps, and stored on ice immediately following collection. The samples were filtered in the District laboratory within 24 hours, then shipped on ice to the USGS National Water Quality Laboratory (NWQL; Denver, Colorado) for analyses (Wershaw et al., 1987).

To assure the quality of organic-carbon data, equipment blank samples were processed using organic-free water and analyzed along with the field samples. Duplicate samples were also collected, processed, and analyzed along with the primary environmental samples. Standard quality-control procedures were followed at the USGS NWQL (Pirkey and Glodt, 1998).

Environmental Conditions

Hobo XT temperature loggers (Onset Instruments Corp., Pocasset, Massachusetts) were deployed along with SPMDs at each site. The loggers recorded ambient water temperature at 48-minute intervals during the entire deployment period. Duplicate temperature loggers were deployed at selected sites during each deployment period. Water velocity at each site was visually estimated at the beginning and end of each period, and the degree of membrane fouling was estimated during processing in the laboratory. These conditions are summarized in tables 2 and 3.

Streambed Sediment

Streambed sediment samples were collected following procedures described by Shelton and Capel (1994). Samples were processed by wet sieving through a 63-µm stainless steel sieve with native water. The sediment samples were placed in 1-quart methanol-rinsed glass containers, and shipped on ice to the CERC for analyses.

At the CERC, sediment samples were air dried and homogenized, and sample aliquots for analyses of (1) PCDDs, PCDFs, and PCBs, (2) OC Pesticides and transformation products, and (3) PAHs were prepared with specific fractionation and enrichment processes (Gale and Orazio, 1998). Analyses were performed as described in the earlier section on SPMDs. Quality control samples processed with sediment samples included method replicates, procedural blanks, procedural spikes, and positive-control matrix samples for each class of analytes. Further details of the methods used are described by Gale and Orazio (1998).

ESTIMATION OF DISSOLVED CONCENTRATIONS

Laboratory analyses of enriched SPMD dialysates provided a direct measure of the mass of analytes accumulated in the SPMD during the deployment period. In this section, we discuss the process by which water concentrations were estimated from these SPMD data.

Huckins *et al.* (1993) described the theoretical process of mass transfer from water into SPMDs and developed mathematical models for estimating dissolved concentrations from analytes accumulated in the SPMD lipid phase. Subsequent work has demonstrated that the entire SPMD (lipid plus membrane) is important in compound uptake (Petty *et al.*, 1994; Meadows *et al.*, 1998) and the mathematical models of Huckins *et al.* (1993) have been expanded to account for this (Huckins *et al.*, 1999). We briefly summarize this theory below.

The theoretical relationship between the concentration of compound *i* in water and in an SPMD (lipid plus membrane) is given by (Huckins *et al.*, 1999):

$$C_{i,SPMD} = C_{i,WATER} \cdot K_{i,SPMD} \cdot \left[1 - e^{\frac{-R_i \cdot t}{K_{i,SPMD} \cdot V_{SPMD}}} \right] \quad (1)$$

where $C_{i,SPMD}$ is the concentration of *i* in the SPMD (mass per volume of SPMD), $C_{i,WATER}$ is the constant concentration of *i* dissolved in water (dissolved mass per volume of water), $K_{i,SPMD}$ is the SPMD-water partition coefficient (volume of water per volume of SPMD) for *i*, R_i is the SPMD sampling rate (volume of water from which analytes are extracted per time) for *i*, *t* is the duration of the SPMD exposure (time), and V_{SPMD} is the total volume of the SPMD, (membrane plus lipid; 4.9 mL for the standard configuration used in this study). A

graphical representation of this relationship over time (fig. 3) shows that the accumulation of a compound by an SPMD goes through an early linear phase and gradually approaches an equilibrium concentration. The time when one-half of the equilibrium concentration is reached is given by:

$$t_{i,\,0.5} = \frac{-\ln(0.5) \cdot K_{i,\,SPMD} \cdot V_{SPMD}}{R_i} \qquad (2)$$

For standardized SPMDs, such as those used in this study, the duration of the linear uptake phase, approximately $t_{0.5}$, and the time required to approach equilibrium vary with the magnitudes of $K_{i,SPMD}$ and R_i. For compounds with a sufficiently large $t_{0.5}$, the duration of the linear uptake phase is longer than our 5-week SPMD deployments. Water concentrations for these compounds, time-averaged over the duration of the deployment, can be estimated by a linear approximation of equation 1:

$$C_{i,\,WATER} = \frac{C_{i,\,SPMD} \cdot V_{SPMD}}{R_i \cdot t} \qquad (3)$$

For compounds with a sufficiently small $t_{0.5}$, our 5-week deployment period was adequate for SPMDs to approach equilibrium with the water. An equilibrium approximation of equation 1 can be used to estimate time-averaged water concentrations for these compounds:

$$C_{i,\,WATER} = \frac{C_{i,\,SPMD}}{K_{i,\,SPMD}} \qquad (4)$$

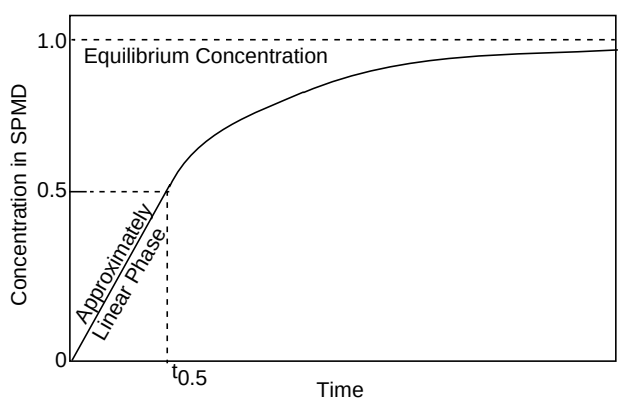

Figure 3. Theoretical accumulation of a dissolved ompound from water into a SPMD.

Although equations 1, 3, and 4 appear to provide straightforward methods for calculating time-averaged water concentrations from concentrations measured in SPMDs, accurate values for $K_{i,SPMD}$ and R_i are not generally available. For a number of compounds, partition coefficients and sampling rates have been measured under controlled laboratory or specific field conditions, but data available show that R_i values vary depending on conditions such as water temperature, water velocity, and membrane fouling (Huckins *et al.*, 1997; Huckins *et al.*, 1999). Unfortunately, the nature of these dependencies are not completely characterized. We have therefore taken a conservative approach by not adjusting R_i values to account for our specific field conditions. As a result, in the following sections we provide only approximations of the exposure-period average dissolved concentrations of OC and PAH compounds. Although we are not able to quantify the uncertainty in these concentrations, we estimate their absolute error to be less than an order of magnitude, and are somewhat more confident in the validity of site-to-site differences. Subtle patterns in the data may therefore not be authentic, but we discuss the most distinct patterns in later sections. (It is important to note that since the implementation of this study, a technique using permeability reference compounds to provide more accurate estimates of field R_i values and thus increase the accuracy of aqueous concentration estimates from SPMD data has been described by Huckins *et al.* (1997) and Huckins *et al.* (1999).)

ESTIMATION OF TOTAL CONCENTRATIONS

In addition to the dissolved mass discussed in the previous section, the total concentration of a hydrophobic compound in water includes the mass associated with suspended sediment and dissolved organic macromolecules. Assuming that partitioning to the organic phase of suspended sediment is the primary process of sediment sorption (Chiou *et al.*, 1983), the total concentration of compound *i* in water can be approximated as:

$$C_{i,\,TOTAL} = C_{i,\,WATER} \cdot \left[1 + K_{i,\,OC} \cdot \frac{(SOC + DOC)}{10^6}\right] \qquad (5)$$

where $C_{i,TOTAL}$ is the total concentration of compound *i* in the water (dissolved plus sorbed mass per volume of water), $K_{i,oc}$ is the organic-carbon partition coefficient for *i* in water (volume of water per mass of organic carbon), *SOC* is the concentration of suspended organic carbon in the water (milligrams per liter of water), and *DOC* is the concentration of dissolved organic carbon in the water (milligrams per liter of water).

Estimates of the exposure-period average total concentrations of selected compounds were calculated using equation 5 and are presented in the following sections. Similar to estimates of dissolved concentrations, we consider estimates of total concentration to be accurate to within approximately an order of magnitude, but are somewhat more confident in the validity of site-to-site differences.

DISTRIBUTION OF ORGANOCHLORINE AND POLYCYCLIC AROMATIC HYDROCARBON COMPOUNDS

The distribution of OC and PAH compounds measured in the Columbia River Basin during the summer and fall of 1997 are presented and discussed in the following sections. Data from the 1998 winter and spring study period are not discussed in the following sections, but are presented in Appendixes E-J and discussed briefly in the Summary section. (It should be noted that because data were collected only once during low-flow conditions and once during high-flow conditions, we do not have a measure of the variability within either flow regime; therefore, differences in concentrations measured during these two deployment periods cannot necessarily be attributed to the difference in flow regimes.)

Polychlorinated Dibenzo-*p*-Dioxins and Polychlorinated Dibenzofurans

PCDDs and PCDFs are produced naturally during events such as volcanic eruptions and forest fires and as byproducts of anthropogenic processes such as waste incineration, production and use of certain wood preservatives, kraft pulp bleaching, and chlorination of sewage effluent. PCDDs and PCDFs can also result from the breakdown or incineration of other OC compounds. (See Appendix A for illustrations and definitions of the various PCDD and PCDF congeners.)

The most commonly detected PCDDs and PCDFs in the Columbia River Basin during the 1997 sampling period were some of the tetrachloro- and heptachloro-substituted congeners, excluding the highly toxic 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. PCDD concentrations measured in SPMDs (table 4) indicate that levels were relatively low in the Columbia River main stem at the Hayden Island site (in the Portland-Vancouver vicinity), and all sites above the urban area. In the lower main stem, levels were highest in SPMDs from the Columbia City site, just downstream of the urban area, and somewhat lower in SPMDs from more downstream sites. PCDFs showed a similar distribution, though levels were somewhat elevated at the Warrendale and Vernita sites relative to other sites.

At tributary sites (table 4), PCDD concentrations measured in SPMDs deployed in the Yakima River and in the vicinity of the Portland-Vancouver urban area—in the Willamette River and Johnson Creek—were elevated relative to other tributaries. PCDFs showed a similar pattern, except in Johnson Creek, where levels of tetrachlorodibenzofurans were considerably higher than at other sites.

Some PCDDs and PCDFs can be inadvertently generated during the production of certain OC pesticides; this may be the source of these compounds in the Yakima River Basin, which has been in agricultural use for several decades. While potential urban and industrial sources of these compounds exist at many locations along the Columbia River main stem below the Warrendale site, our data suggest that the most important sources are located in the Willamette River Basin and the Portland-Vancouver reach of the Columbia River main stem, downstream of the Hayden Island site.

The more highly chlorinated, hydrophobic PCDD and PCDF congeners were detected in streambed sediment—the hexa-, hepta-, and octachlorinated congeners. The site-to-site pattern of these compounds measured in sediment from the Beaver Army Terminal, Willamette River, and Warrendale sites (table 5) was consistent with the pattern suggested by SPMD data—concentrations were highest in Willamette River sediment and lowest at the Warrendale site, upstream of the urban area.

Estimated dissolved and total concentrations in river water.—Estimates of the dissolved concentrations of PCDDs and PCDFs (table 6) indicate that these compounds were generally present in the dissolved phase at femtogram (10^{-15} gram) or picogram (10^{-12} gram) per liter (fg/L or pg/L) levels. Estimates of dissolved concentrations show site-to-site patterns similar to SPMD concentrations (figs. 4 and 5). However, dissolved concentration estimates of the most hydrophobic congeners (e.g., hepta- and octachlorinated congeners) were markedly higher than for the tetra- and pentachlorinated congeners. This is particularly evident in figure 4 for the Johnson Creek and Yakima River sites—the only sites where octachlorodibenzo-*p*-dioxin was detected in SPMDs.

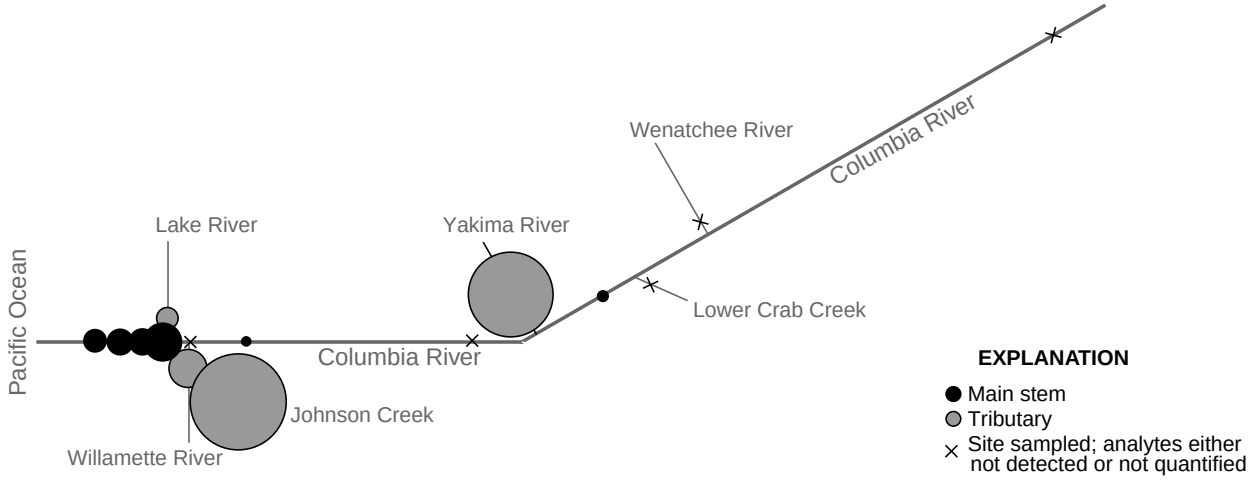

Figure 4. Sum of estimated dissolved concentrations of polychlorinated dibenzo-*p*-dioxins during low-flow conditions in the Columbia River Basin, 1997. (Areas of symbols are proportional to the sum of congener-class total concentrations reported in table 6.)

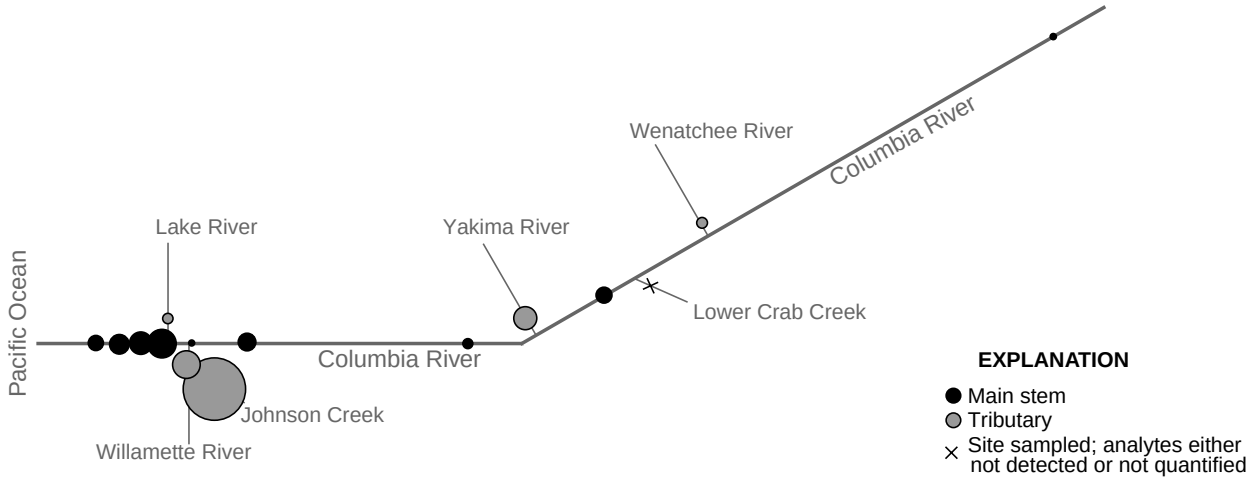

Figure 5. Sum of estimated dissolved concentrations of polychlorinated dibenzofurans during low-flow conditions in theColumbia River Basin, 1997. (Areas of symbols are proportional to the sum of congener-class total concentrations reported in table 6.)

As indicated by their organic-carbon partition coefficient (K_{oc}) values (table 7), PCDDs and PCDFs are highly hydrophobic compounds. Their tendency to sorb to sediment and dissolved organic material increases with their degree of chlorination. As a result, most of the mass of these compounds in water is sorbed to organic matter rather than dissolved. This phenomenon is clearly revealed by estimates of total concentrations (table 7), which are considerably higher than estimates of dissolved concentrations (table 6). Total concentrations of PCDDs in Johnson Creek and the Yakima River were particularly high due to the abundance of the heptachloro- and octachloro-substituted congeners at these sites.

Polychlorinated Biphenyls

PCBs were once widely used for a variety of industrial purposes such as heat-resistant oils in electrical transformers and capacitors, natural-gas transmission turbines, and other heat-transfer systems, as well as for

Table 4. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in picograms (10^{-12} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)			Columbia City (82)	Lake River (87)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
			Duplicates		RD			Duplicates		RD		
	Site 01	Site 02	Site 03			Site 04	Site 05	Site 06			Site 08	Site 07
Polychlorinated dibenzo-*p*-dioxins:												
2,3,7,8-Tetra	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	NQ	ND
Total Tetra	16.	30.	32.	25.	[25]	65.	NQ	74.	45.	[49]	11.	ND
1,2,3,7,8-Penta	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	NQ	ND
Total Penta	ND	ND	ND	ND	[—]	NQ	ND	NQ	ND	[—]	NQ	ND
1,2,3,4,7,8-Hexa	ND	ND	ND	ND	[—]	ND	ND	ND	NQ	[—]	ND	ND
1,2,3,6,7,8-Hexa	ND	ND	NQ	ND	[—]	NQ	ND	NQ	NQ	[—]	4.8	ND
1,2,3,7,8,9-Hexa	ND	ND	ND	ND	[—]	ND	ND	NQ	ND	[—]	NQ	ND
Total Hexa	ND	ND	ND	ND	[—]	ND	ND	ND	NQ	[—]	NQ	ND
1,2,3,4,6,7,8-Hepta	5.8	7.1	6.6	6.5	[2]	14.	6.5	14.	14.	[<1]	30.	NQ
Total Hepta	12.	14.	14.	13.	[7]	30.	15.	29.	30.	[3]	54.	NQ
Octa	ND	NQ	NQ	NQ	[—]	NQ	NQ	NQ	60.	[—]	92.	ND
Polychlorinated dibenzofurans:												
2,3,7,8-Tetra	8. 1	14.	18.	14.	[25]	24.	NQ	22.	19.	[15]	38.	NQ
Total Tetra	38.	69.	91.	72.	[23]	130.	23.	110.	76.	[37]	720.	7.8
1,2,3,7,8-Penta	ND	ND	ND	ND	[—]	NQ	ND	4.4	NQ	[—]	NQ	ND
2,3,4,7,8-Penta	ND	ND	ND	ND	[—]	NQ	ND	NQ	NQ	[—]	6.2	ND
Total Penta	8. 4	10.	12.	10.	[18]	22.	NQ	30.	22.	[31]	62.	ND
1,2,3,4,7,8-Hexa	ND	ND	ND	ND	[—]	ND	ND	NQ	NQ	[—]	NQ	ND
1,2,3,6,7,8-Hexa	ND	ND	ND	ND	[—]	ND	ND	ND	NQ	[—]	ND	ND
1,2,3,7,8,9-Hexa	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
2,3,4,6,7,8-Hexa	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
Total Hexa	ND	ND	ND	ND	[—]	NQ	ND	NQ	NQ	[—]	NQ	ND
1,2,3,4,6,7,8-Hepta	ND	ND	ND	ND	[—]	NQ	ND	ND	NQ	[—]	NQ	ND
1,2,3,4,7,8,9-Hepta	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
Total Hepta	NQ	NQ	NQ	NQ	[—]	8. 1	NQ	7.8	6.9	[12]	13.	ND
Octa	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND

Table 4. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in picograms (10^{-12} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Yakima River (335)			Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)		
				Duplicates		RD				Duplicates		RD
	Site 09	Site 10	Site 13	Site 11			Site 14	Site 12	Site 15	Site 16		
Polychlorinated dibenzo-*p*-dioxins:												
2,3,7,8-Tetra	ND	ND	ND	ND	NQ	[—]	ND	ND	ND	ND	ND	[—]
Total Tetra	12.	NQ	ND	110.	95.	[15]	16.	ND	NQ	ND	ND	[—]
1,2,3,7,8-Penta	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Total Penta	ND	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
1,2,3,4,7,8-Hexa	ND	ND	ND	NQ	ND	[—]	ND	ND	ND	ND	ND	[—]
1,2,3,6,7,8-Hexa	ND	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
1,2,3,7,8,9-Hexa	ND	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
Total Hexa	ND	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
1,2,3,4,6,7,8-Hepta	5.3	NQ	NQ	23.	25.	[8]	NQ	NQ	NQ	NQ	ND	[—]
Total Hepta	NQ	NQ	NQ	42.	45.	[7]	NQ	NQ	NQ	NQ	ND	[—]
Octa	NQ	ND	ND	63.	63.	[<1]	ND	ND	ND	NQ	ND	[—]
Polychlorinated dibenzofurans:												
2,3,7,8-Tetra	15.	5.3	ND	7.1	NQ	[—]	11.	ND	NQ	ND	ND	[—]
Total Tetra	57.	23.	13.	65.	63.	[3]	53.	NQ	24.	8.2	ND	[—]
1,2,3,7,8-Penta	ND	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
2,3,4,7,8-Penta	ND	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
Total Penta	8.1	NQ	NQ	26.	20.	[26]	NQ	NQ	NQ	ND	ND	[—]
1,2,3,4,7,8-Hexa	ND	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
1,2,3,6,7,8-Hexa	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
1,2,3,7,8,9-Hexa	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
2,3,4,6,7,8-Hexa	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Total Hexa	ND	ND	ND	ND	NQ	[—]	ND	ND	ND	ND	ND	[—]
1,2,3,4,6,7,8-Hepta	ND	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
1,2,3,4,7,8,9-Hepta	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Total Hepta	NQ	NQ	ND	8.2	7.8	[5]	NQ	ND	NQ	ND	ND	[—]
Octa	ND	ND	ND	NQ	NQ	[—]	ND	ND	NQ	ND	ND	[—]

[a]Percent relative difference between two values, V_1 and V_2, is calculated as

$$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2)/2} \right| \cdot 100$$

[b]SPMD's at the Snake River site were periodically exposed to air due to fluctuating river stage and were thus compromised; analytical results are presented for informational purposes only.

Table 5. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributary); concentrations, reported in picograms (10^{-12} grams) per gram of sediment (dry weight), are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary site]

	Beaver Army Terminal (54)	Willamette River (101)	Warrendale (141)
	Site 02	Site 06	Site 09
Polychlorinated dibenzo-*p*-dioxins:			
2,3,7,8-Tetra	ND	ND	ND
Total Tetra	NQ	NQ	ND
1,2,3,7,8-Penta	NQ	NQ	ND
Total Penta	NQ	1.9	ND
1,2,3,4,7,8-Hexa	NQ	0.9	ND
1,2,3,6,7,8-Hexa	2.1	4.4	NQ
1,2,3,7,8,9-Hexa	1.6	2.7	0.5
Total Hexa	14.	26.	3.9
1,2,3,4,6,7,8-Hepta	32.	86.	8.5
Total Hepta	65.	130.	23.
Octa	370.	990.	110.
Polychlorinated dibenzofurans:			
2,3,7,8-Tetra	ND	ND	ND
Total Tetra	ND	ND	ND
1,2,3,7,8-Penta	ND	NQ	ND
2,3,4,7,8-Penta	ND	NQ	ND
Total Penta	ND	NQ	ND
1,2,3,4,7,8-Hexa	NQ	17.	ND
1,2,3,6,7,8-Hexa	0.6	3.9	NQ
1,2,3,7,8,9-Hexa	ND	ND	ND
2,3,4,6,7,8-Hexa	NQ	1.2	NQ
Total Hexa	6.6	23.	NQ
1,2,3,4,6,7,8-Hepta	NQ	19.	ND
1,2,3,4,7,8,9-Hepta	0.6	3.2	ND
Total Hepta	NQ	45.	ND
Octa	ND	NQ	ND

hydraulic fluids, lubricants, and pesticide extenders. Although no longer manufactured in the United States, PCBs are very stable and persist in the environment. (See Appendix A for general chemical structures of the various PCB congeners.)

Overall SPMD concentrations of *ortho*-substituted PCBs measured during the 1997 low-flow study period (table 8) were highest in SPMDs deployed at tributary sites—Johnson Creek and the Willamette River, both in the Portland-Vancouver urban area, and the Wenatchee River, in the upper basin. Elliott *et al.* (in press) also found elevated levels of PCBs in the livers of mink and river otter from the Columbia main stem in the vicinity of the Wenatchee River. Concentrations of most *ortho*-substituted PCBs in streambed sediment were also elevated at the Willamette River site relative to the other two sites sampled (table 9). In the Columbia River main stem, differences in *ortho*-substituted PCB concentrations were small relative to uncertainty, but the data suggest some patterns. Concentrations were somewhat elevated in SPMDs from the Warrendale and Vernita sites, but in both cases were lower in SPMDs from

Table 6. Estimated dissolved concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); dissolved concentrations were calculated using equation (3) and are reported to one significant digit, in femtograms (10^{-15} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients and sampling rates used in calculations are summarized in table C1; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Lake River (87[c])	Willamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Yakima River (335)	Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 08	Site 07	Site 09	Site 10	Site 11	Site 14	Site 12	Site 15	Site 16
Polychlorinated dibenzo-*p*-dioxins:															
2,3,7,8-Tetra	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Tetra	100	200	200	500	—	600	80	—	90	—	800	100	—	—	—
1,2,3,7,8-Penta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Penta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,7,8-Hexa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	—	—	—	—	—	—	200	—	—	—	—	—	—	—	—
1,2,3,7,8,9-Hexa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hexa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	200	200	200	500	200	500	1,000	—	200	—	800	—	—	—	—
Total Hepta	400	500	500	1,000	500	1,000	2,000	—	—	—	1,000	—	—	—	—
Octa	—	—	—	—	—	—	8,000	—	—	—	6,000	—	—	—	—
Polychlorinated dibenzofurans:															
2,3,7,8-Tetra	40	70	90	100	—	100	200	—	80	30	40	60	—	—	—
Total Tetra	200	400	500	700	100	600	4,000	40	300	100	300	300	—	100	40
1,2,3,7,8-Penta	—	—	—	—	—	30	—	—	—	—	—	—	—	—	—
2,3,4,7,8-Penta	—	—	—	—	—	—	40	—	—	—	—	—	—	—	—
Total Penta	50	60	80	100	—	200	400	—	50	—	200	—	—	—	—
1,2,3,4,7,8-Hexa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,7,8,9-Hexa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2,3,4,6,7,8-Hexa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hexa		—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,7,8,9-Hepta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hepta	—	—	—	80	—	80	100	—	—	—	80	—	—	—	—
Octa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 7. Estimated total concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during low-flow conditions in the Columbia River Basin, 1997

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in femtograms (10^{-15} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.40		2.35		2.30		2.30		3.10[b]		1.85		1.85		2.30[c]	
Polychlorinated dibenzo-*p*-dioxins:																	
2,3,7,8-Tetra	6.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Tetra	6.4	900	86%	2,000	86%	2,000	86%	3,000	86%	—	—	3,000	83%	500	83%	—	—
1,2,3,7,8-Penta	6.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Penta	6.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,7,8-Hexa	7.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	7.6	—	—	—	—	—	—	—	—	—	—	—	—	10,000	99%	—	—
1,2,3,7,8,9-Hexa	7.6[d]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hexa	7.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	7.6[d]	20,000	99%	20,000	99%	20,000	99%	50,000	99%	30,000	99%	40,000	99%	80,000	99%	—	—
Total Hepta	7.6	40,000	99%	50,000	99%	50,000	99%	100,000	99%	60,000	99%	80,000	99%	100,000	99%	—	—
Octa	7.8	—	—	—	—	—	—	—	—	—	—	—	—	1,000,000	99%	—	—
Polychlorinated dibenzofurans:																	
2,3,7,8-Tetra	5.7	90	55%	200	55%	200	54%	300	54%	—	—	200	49%	400	49%	—	—
Total Tetra	5.7	400	55%	800	55%	1,000	54%	1,000	54%	300	62%	1,000	49%	7,000	49%	90	54%
1,2,3,7,8-Penta	6.1	—	—	—	—	—	—	—	—	—	—	90	71%	—	—	—	—
2,3,4,7,8-Penta	6.1	—	—	—	—	—	—	—	—	—	—	—	—	100	71%	—	—
Total Penta	6.1	200	76%	300	75%	300	75%	600	75%	—	—	600	71%	1,000	71%	—	—
1,2,3,4,7,8-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,7,8,9-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2,3,4,6,7,8-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	7.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,7,8,9-Hepta	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hepta	6.8	—	—	—	—	—	—	1,000	93%	—	—	900	91%	1,000	91%	—	—
Octa	7.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 7. Estimated total concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during low-flow conditions in the Columbia River Basin, 1997—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in femtograms (10^{-15} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
Organic Carbon (mg/L)		1.50		2.00		2.70		2.20		5.15		1.25		1.50	
Polychlorinated dibenzo-*p*-dioxins:															
2,3,7,8-Tetra	6.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Tetra	6.4	400	80%	—	—	7,000	88%	800	85%	—	—	—	—	—	—
1,2,3,7,8-Penta	6.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Penta	6.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,7,8-Hexa	7.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	7.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,7,8,9-Hexa	7.6[d]	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hexa	7.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	7.6[d]	10,000	98%	—	—	90,000	99%	—	—	—	—	—	—	—	—
Total Hepta	7.6	—	—	—	—	200,000	99%	—	—	—	—	—	—	—	—
Octa	7.8	—	—	—	—	1,000,000	99%	—	—	—	—	—	—	—	—
Polychlorinated dibenzofurans:															
2,3,7,8-Tetra	5.7	100	44%	50	51%	90	58%	100	53%	—	—	—	—	—	—
Total Tetra	5.7	500	44%	200	51%	800	58%	600	53%	—	—	200	39%	80	44%
1,2,3,7,8-Penta	6.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2,3,4,7,8-Penta	6.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Penta	6.1	100	66%	—	—	700	78%	—	—	—	—	—	—	—	—
1,2,3,4,7,8-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,7,8,9-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2,3,4,6,7,8-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	7.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,7,8,9-Hepta	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hepta	6.8	—	—	—	—	1,000	94%	—	—	—	—	—	—	—	—
Octa	7.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[a]K_{oc} values were estimated using the approximation $K_{oc} = 0.411K_{ow}$ (Karickhoff, 1981); except where noted otherwise, K_{ow} values were taken from Gale *et al.* (1997); K_{ow} values for homolog totals were estimated from the average K_{ow} values of the individual congeners quantified.

[b]Value from high-flow deployment period.

[c]Approximation based on values from sites 3 and 4.

[d]K_{ow} values from Mackay *et al*. (1992) (value for 1,2,3,4,7,8-hexachloro congener was used to approximate value for 1,2,3,6,7,8-hexachloro congener).

Table 8. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, all information required for calculation is not available; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)			Columbia City (82)	Lake River (87)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
			Duplicates		RD			Duplicates		RD		
	Site 01	Site 02	Site 03			Site 04	Site 05	Site 06			Site 08	Site 07
4 & 10	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
7 & 9	ND	ND	ND	ND	[—]	ND	NQ	ND	ND	[—]	ND	ND
6	ND	ND	ND	NQ	[—]	ND	0.43	1.2	1.9	[45]	ND	ND
5 & 8	ND	ND	ND	NQ	[—]	NQ	NQ	ND	ND	[—]	0.86	NQ
19	ND	0.96	0.82	1.4	[52]	1.8	1.9	5.1	3.1	[49]	0.44	ND
18	2.0	3.8	3.4	3.9	[14]	4.9	6.6	9.8	6.	[48]	5.8	NQ
17 & 15	1.7	2.8	3.2	3.2	[<1]	3.5	5.	6.9	5.	[32]	3.5	0.75
24 & 27	0.35	0.56	0.84	0.86	[2]	0.73	1.5	1.3	0.9	[36]	0.58	NQ
16 & 32	1.3	2.4	3.1	3.5	[12]	3.5	6.	7.1	4.5	[45]	3.1	NQ
29	ND	ND	ND	ND	[—]	ND	0.85	0.49	ND	[—]	6.4	ND
26	0.86	1.3	1.5	1.7	[13]	1.4	2.9	2.8	1.7	[49]	1.7	0.23
25	NQ	ND	NQ	1.1	[—]	NQ	2.1	NQ	NQ	[—]	NQ	ND
31	NQ	2.2	2.7	3.3	[20]	3.4	4.9	6.	3.7	[47]	4.	NQ
28	2.4	4.7	5.6	6.1	[9]	7.2	8.	12.	7.6	[45]	6.4	NQ
20 & 33	NQ	NQ	NQ	NQ	[—]	NQ	1.5	2.	NQ	[—]	2.2	NQ
53	1.1	0.95	2.	2.6	[26]	2.9	3.1	7.3	3.8	[63]	3.9	NQ
51	0.76	0.5	1.1	1.	[10]	1.3	1.3	4.5	3.4	[28]	0.72	0.1
22	0.77	0.87	1.6	1.3	[21]	1.1	2.	2.	1.8	[11]	2.2	NQ
45	ND	1.3	1.8	1.9	[5]	2.7	2.6	4.9	3.1	[45]	2.2	NQ
46	ND	0.86	0.95	0.71	[29]	1.2	1.2	2.7	2.3	[16]	0.85	NQ
52	5.6	10.	13.	15.	[14]	19.	20.	36.	22.	[48]	100.	2.7
43	ND	0.5	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
49	4.0	7.1	10.	11.	[10]	13.	17.	25.	16.	[44]	26.	1.4
47	2.6	5.3	7.0	6.7	[4]	8.4	11.	15.	11.	[31]	6.2	0.79
48	0.88	1.6	1.9	2.4	[23]	4.1	3.6	8.3	4.9	[52]	4.8	0.73
44	2.8	5.6	6.8	7.8	[14]	11.	9.7	22.	12.	[59]	41.	NQ
42	1.8	4.0	5.2	5.3	[2]	6.5	6.9	14.	9.4	[39]	7.	0.62
41	1.2	2.5	4.3	4.5	[5]	5.1	8.4	9.7	6.6	[38]	6.	0.74
64	1.6	3.0	4.0	4.6	[14]	6.	5.6	10.	5.6	[56]	10.	NQ
40	0.76	1.2	2.3	2.0	[14]	2.8	2.1	5.1	3.5	[37]	4.6	NQ
67	0.24	0.43	0.55	0.62	[12]	0.75	ND	1.4	0.99	[34]	1.4	0.11
63	0.33	0.54	0.67	0.46	[37]	0.46	0.66	0.73	1.3	[56]	0.52	0.67
74	1.4	3.1	4.0	4.1	[2]	4.9	5.2	8.1	6.6	[20]	7.6	0.45
70 & 76	2.6	5.2	6.6	7.2	[9]	9.5	9.	15.	10.	[40]	32.	NQ
66	3.2	6.6	8.9	8.6	[3]	10.	11.	18.	13.	[32]	14.	NQ
95	3.4	5.7	6.7	7.7	[14]	13.	7.3	21.	13.	[47]	70.	1.5

Table 8. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, all information required for calculation is not available; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)			Columbia City (82)	Lake River (87)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
			Duplicates		RD			Duplicates		RD		
91	0.75	1.4	2.0	2.7	[30]	3.8	2.6	6.	4.3	[33]	14.	0.5
056 & 60	0.96	1.9	2.6	2.9	[11]	3.3	4.2	5.9	4.	[38]	3.9	0.39
92	0.73	1.8	1.2	1.4	[15]	2.8	0.89	4.	2.7	[39]	15.	0.46
84	2.2	1.7	5.2	5.4	[4]	8.1	4.7	13.	7.3	[56]	24.	1.4
101	3.3	6.0	7.4	7.6	[3]	13.	9.3	22.	14.	[44]	67.	1.8
99	1.8	3.5	4.1	4.0	[2]	5.3	4.6	9.3	8.1	[14]	21.	0.79
119	ND	ND	ND	ND	[—]	ND	ND	NQ	ND	[—]	NQ	ND
83	0.23	0.46	0.57	0.87	[42]	1.2	0.68	1.6	0.92	[54]	4.5	NQ
97	1.0	1.9	2.4	2.0	[18]	4.	3.6	6.8	5.2	[27]	20.	0.45
87	1.1	2.0	2.8	2.8	[<1]	5.2	2.4	7.1	5.3	[29]	25.	NQ
136	0.77	0.91	1.8	1.3	[32]	2.3	0.63	1.3	0.7	[60]	4.2	0.19
110	2.2	3.9	5.3	5.4	[2]	9.5	3.7	13.	9.2	[34]	44.	NQ
82	NQ	0.35	0.57	2.5	[126]	2.9	1.2	2.5	1.5	[50]	7.	0.52
151	0.58	0.89	1.2	1.2	[<1]	2.7	0.61	3.9	2.5	[44]	13.	NQ
135 & 144 & 124	NQ	NQ	0.81	1.5	[60]	2.3	0.48	2.8	1.9	[38]	10.	0.44
147	NQ	0.15	0.18	1.2	[148]	1.4	0.6	0.54	0.44	[20]	2.4	0.22
107	NQ	0.17	0.22	0.27	[20]	0.74	0.22	1.4	0.63	[76]	3.4	ND
123 & 149	1.4	2.2	3.	2.9	[3]	6.5	1.6	8.8	6.5	[30]	32.	NQ
118	NQ	1.8	2.7	3.6	[29]	6.3	2.4	7.7	5.5	[33]	23.	NQ
134	NQ	NQ	0.15	NQ	[—]	0.11	ND	0.13	0.65	[133]	2.8	ND
114	ND	ND	NQ	ND	[—]	ND	ND	ND	0.48	[—]	ND	ND
131 & 122	ND	NQ	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
146	0.33	0.2	0.48	0.49	[2]	1.1	0.25	1.6	1.4	[13]	4.9	0.12
153	ND	ND	ND	NQ	[—]	NQ	ND	NQ	NQ	[—]	18.	ND
132	1.5	2.1	4.4	1.9	[79]	5.9	1.6	7.4	7.7	[4]	25.	NQ
105	NQ	NQ	1.1	2.6	[81]	2.6	1.3	2.7	1.2	[77]	10.	NQ
141	NQ	NQ	0.48	0.54	[12]	1.2	NQ	1.7	1.2	[34]	8.6	NQ
179	NQ	NQ	0.28	0.68	[83]	1.	NQ	1.2	0.78	[42]	5.8	NQ
137	NQ	NQ	NQ	ND	[—]	NQ	ND	0.4	0.23	[54]	1.2	ND
176	NQ	NQ	0.11	ND	[—]	ND	ND	ND	0.22	[—]	ND	ND
130	ND	ND	NQ	ND	[—]	ND	ND	NQ	NQ	[—]	1.9	ND
138	ND	NQ	NQ	5.8	[—]	10.	NQ	7.2	NQ	[—]	31.	ND
158	0.13	NQ	0.27	NQ	[—]	0.26	0.22	0.96	0.36	[91]	4.8	NQ
129	NQ	NQ	0.15	ND	[—]	0.19	ND	0.27	0.23	[16]	1.7	ND
178	NQ	NQ	NQ	ND	[—]	0.3	NQ	0.3	0.24	[22]	2.1	ND

Table 8. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, all information required for calculation is not available; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)			Columbia City (82)	Lake River (87)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
			Duplicates		RD			Duplicates		RD		
182 & 187	ND	ND	ND	ND	[—]	ND	ND	NQ	ND	[—]	9.7	ND
183	0.13	0.13	0.25	0.16	[44]	0.61	NQ	0.72	ND	[—]	4.9	NQ
128	0.26	0.36	0.18	0.49	[93]	0.95	0.26	1.1	0.79	[33]	5.1	NQ
167	NQ	0.39	0.43	0.65	[41]	0.66	0.26	0.72	0.34	[72]	2.	NQ
185	ND	NQ	NQ	NQ	[—]	NQ	ND	0.15	0.11	[31]	1.	ND
174	0.22	0.3	0.37	0.43	[15]	1.1	NQ	1.5	0.96	[44]	8.6	NQ
177	0.22	0.3	0.47	0.24	[65]	0.6	NQ	0.78	0.47	[50]	4.9	NQ
171 & 202	ND	NQ	0.32	0.69	[73]	1.1	NQ	1.4	0.6	[80]	2.8	NQ
156	NQ	0.25	0.32	0.24	[29]	0.48	NQ	0.44	1.1	[86]	1.8	ND
173	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	0.25	ND
201	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	0.78	ND
157	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	0.51	ND
172	ND	ND	ND	ND	[—]	0.19	ND	0.13	ND	[—]	1.	ND
197	ND	ND	ND	ND	[—]	ND	0.7	ND	ND	[—]	ND	ND
180	NQ	NQ	ND	NQ	[—]	NQ	ND	1.4	0.83	[51]	6.6	NQ
193	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	NQ	ND
191	ND	ND	ND	ND	[—]	NQ	ND	0.57	ND	[—]	0.37	ND
200	ND	ND	NQ	0.15	[—]	NQ	ND	0.14	ND	[—]	0.43	ND
170 & 190	ND	ND	NQ	ND	[—]	0.29	ND	1.1	0.39	[95]	8.8	0.51
198	ND	ND	ND	ND	[—]	ND	0.16	ND	ND	[—]	0.19	ND
199	NQ	NQ	0.11	NQ	[—]	0.24	0.12	0.34	0.25	[31]	2.1	NQ
196 & 203	NQ	NQ	NQ	NQ	[—]	0.24	NQ	0.31	0.24	[25]	1.9	NQ
189	ND	0.13	ND	ND	[—]	ND	ND	ND	ND	[—]	0.18	ND
208 & 195	ND	ND	ND	ND	[—]	NQ	ND	ND	NQ	[—]	0.67	ND
207	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	NQ	ND
194	ND	ND	ND	ND	[—]	0.13	ND	0.15	ND	[—]	1.4	ND
205	ND	ND	ND	ND	[—]	0.11	ND	ND	ND	[—]	0.2	ND
206	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
209	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
Sum of quantified *ortho*-substituted PCBs	63.	120.	160.	190.	[17]	260.	220.	440.	290.	[41]	890.	19.

Table 8. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, all information required for calculation is not available; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Yakima River (335)			Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)		
					Duplicates	RD					Duplicates	RD
	Site 09	Site 10	Site 13	Site 11			Site 14	Site 12	Site 15	Site 16		
4 & 10	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
7 & 9	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
6	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
5 & 8	ND	ND	ND	ND	ND	[—]	ND	ND	7.1	ND	NQ	[—]
19	ND	NQ	ND	ND	ND	[—]	ND	ND	1.3	ND	0.55	[—]
18	3.	NQ	ND	ND	NQ	[—]	3.6	5.	56.	ND	2.2	[—]
17 & 15	1.7	0.59	NQ	0.78	0.88	[12]	2.4	ND	30.	NQ	1.7	[—]
24 & 27	0.17	NQ	NQ	NQ	NQ	[—]	0.26	ND	4.5	ND	0.26	[—]
16 & 32	2.	NQ	ND	NQ	NQ	[—]	1.3	ND	38.	ND	1.8	[—]
29	ND	ND	ND	ND	ND	[—]	ND	ND	1.9	0.2	ND	[—]
26	0.85	0.28	0.12	0.29	0.15	[64]	1.	0.11	12.	NQ	0.56	[—]
25	NQ	ND	ND	ND	ND	[—]	NQ	ND	6.7	ND	ND	[—]
31	3.1	NQ	ND	NQ	NQ	[—]	3.2	ND	35.	ND	NQ	[—]
28	5.2	1.8	ND	NQ	NQ	[—]	7.5	ND	56.	ND	3.	[—]
20 & 33	2.8	NQ	ND	NQ	ND	[—]	2.1	ND	45.	ND	NQ	[—]
53	NQ	ND	ND	ND	ND	[—]	1.1	ND	7.2	ND	1.6	[—]
51	0.18	ND	NQ	ND	ND	[—]	0.18	ND	2.4	NQ	1.	[—]
22	1.9	0.54	NQ	0.62	0.55	[12]	2.2	ND	25.	NQ	0.52	[—]
45	1.3	0.38	ND	ND	ND	[—]	1.5	NQ	8.5	NQ	1.3	[—]
46	0.28	0.18	ND	ND	ND	[—]	3.1	ND	4.4	ND	0.32	[—]
52	11.	3.3	NQ	4.3	4.6	[7]	14.	ND	42.	ND	8.6	[—]
43	ND	ND	ND	NQ	ND	[—]	NQ	ND	2.6	ND	ND	[—]
49	6.	1.8	NQ	1.3	1.3	[<1]	8.2	ND	35.	ND	6.	[—]
47	3.6	1.1	0.69	1.6	1.7	[6]	4.5	NQ	16.	NQ	3.8	[—]
48	2.9	0.79	0.55	1.3	0.73	[56]	3.4	NQ	19.	NQ	1.7	[—]
44	5.9	NQ	NQ	2.3	NQ	[—]	11.	ND	34.	ND	4.8	[—]
42	1.6	0.79	0.77	1.4	NQ	[—]	7.7	NQ	28.	ND	3.	[—]
41	2.3	0.65	NQ	0.6	NQ	[—]	2.	NQ	17.	NQ	2.6	[—]
64	3.2	NQ	NQ	NQ	NQ	[—]	4.2	ND	18.	ND	2.2	[—]
40	1.6	0.58	0.39	0.86	1.4	[48]	1.3	0.16	9.	ND	1.1	[—]
67	2.7	0.26	0.98	1.9	ND	[—]	0.8	ND	2.5	ND	0.62	[—]
63	1.	0.61	NQ	0.26	0.11	[81]	1.1	ND	2.3	ND	0.34	[—]
74	2.3	0.77	0.41	0.9	NQ	[—]	6.8	ND	20.	NQ	2.9	[—]
70 & 76	6.1	1.9	NQ	2.5	2.7	[8]	9.7	NQ	35.	NQ	4.1	[—]

Table 8. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, all information required for calculation is not available; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Yakima River (335)			Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)		
					Duplicates	RD					Duplicates	RD
	Site 09	Site 10	Site 13	Site 11			Site 14	Site 12	Site 15	Site 16		
66	5.3	1.6	NQ	NQ	NQ	[—]	12.	NQ	47.	ND	5.2	[—]
95	6.4	2.4	2.	3.4	3.5	[3]	8.2	NQ	10.	NQ	5.3	[—]
91	ND	0.63	0.68	1.	0.83	[19]	0.4	ND	3.2	NQ	1.3	[—]
56 & 60	2.	0.55	0.44	0.55	0.74	[29]	3.5	ND	18.	NQ	1.5	[—]
92	0.77	0.63	0.72	2.4	1.9	[23]	5.	ND	2.	0.3	1.	[108]
84	8.2	2.9	2.7	14.	17.	[19]	18.	ND	9.	NQ	2.5	[—]
101	7.7	2.3	2.4	4.2	6.7	[46]	12.	ND	13.	NQ	5.5	[—]
99	1.2	1.2	1.3	2.3	3.	[26]	1.2	2.	3.6	0.71	2.8	[119]
119	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
83	0.55	ND	NQ	0.18	ND	[—]	1.	ND	0.96	NQ	0.38	[—]
97	2.5	0.67	0.54	0.94	0.13	[151]	5.4	NQ	5.9	0.35	2.3	[147]
87	2.4	0.73	NQ	0.78	1.1	[34]	2.	ND	3.7	NQ	2.	[—]
136	0.69	0.92	0.38	ND	3.2	[—]	1.6	ND	NQ	0.21	0.94	[127]
110	3.7	1.3	1.3	3.	2.7	[11]	3.1	ND	5.1	NQ	3.7	[—]
82	2.8	ND	ND	ND	ND	[—]	0.47	ND	1.6	ND	0.69	[—]
151	0.97	NQ	NQ	1.9	1.9	[<1]	0.59	ND	NQ	ND	1.	[—]
135 & 144 & 124	1.7	0.8	ND	0.73	0.47	[43]	NQ	ND	NQ	ND	0.66	[—]
147	1.7	NQ	ND	6.	6.7	[11]	0.42	NQ	0.18	ND	0.15	[—]
107	0.3	ND	NQ	0.33	0.21	[44]	0.21	NQ	0.35	ND	0.16	[—]
123 & 149	2.5	0.92	0.94	4.2	4.	[5]	1.6	ND	1.	NQ	2.7	[—]
118	3.4	NQ	NQ	2.3	ND	[—]	2.2	ND	3.4	ND	1.9	[—]
134	ND	ND	ND	ND	ND	[—]	0.32	ND	0.11	0.15	0.28	[60]
114	ND	ND	ND	ND	ND	[—]	NQ	ND	ND	NQ	NQ	[—]
131 & 122	ND	ND	ND	ND	ND	[—]	ND	ND	ND	NQ	ND	[—]
146	0.39	NQ	0.21	1.2	1.2	[<1]	0.24	NQ	NQ	NQ	0.56	[—]
153	NQ	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
132	2.2	0.89	1.9	4.6	9.3	[68]	2.2	ND	4.9	1.4	2.3	[49]
105	2.	NQ	NQ	3.7	3.	[21]	NQ	ND	1.1	ND	NQ	[—]
141	NQ	NQ	ND	0.83	0.79	[5]	NQ	ND	NQ	ND	0.52	[—]
179	0.93	0.36	NQ	0.9	0.59	[42]	NQ	ND	ND	NQ	0.31	[—]
137	ND	NQ	NQ	0.34	NQ	[—]	NQ	ND	NQ	ND	NQ	[—]
176	ND	ND	ND	ND	ND	[—]	NQ	ND	ND	NQ	NQ	[—]
130	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
138	NQ	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	NQ	[—]
158	0.21	NQ	0.27	2.9	3.7	[24]	0.26	NQ	0.15	NQ	0.21	[—]
129	ND	NQ	NQ	0.1	ND	[—]	NQ	ND	ND	ND	0.12	[—]

Table 8. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, all information required for calculation is not available; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Yakima River (335)			Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)		
					Duplicates	RD					Duplicates	RD
	Site 09	Site 10	Site 13	Site 11			Site 14	Site 12	Site 15	Site 16		
178	ND	NQ	NQ	0.43	0.64	[39]	NQ	ND	ND	ND	NQ	[—]
182 & 187	ND	ND	ND	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
183	0.13	NQ	0.11	0.84	0.97	[14]	ND	ND	ND	NQ	ND	[—]
128	0.36	NQ	0.18	0.66	0.68	[3]	ND	ND	0.35	NQ	0.3	[—]
167	0.39	0.24	0.34	0.32	0.85	[91]	0.33	NQ	NQ	ND	0.28	[—]
185	NQ	ND	ND	0.33	0.43	[26]	ND	ND	ND	ND	NQ	[—]
174	0.32	0.26	NQ	1.	0.84	[17]	0.23	ND	NQ	NQ	0.41	[—]
177	0.21	NQ	NQ	0.66	0.63	[5]	NQ	ND	NQ	ND	0.23	[—]
171 & 202	0.52	NQ	ND	0.52	0.64	[21]	NQ	ND	NQ	ND	NQ	[—]
156	0.24	NQ	NQ	NQ	0.36	[—]	0.21	ND	NQ	NQ	NQ	[—]
173	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
201	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
157	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
172	ND	ND	ND	0.27	0.3	[11]	ND	ND	ND	ND	0.15	[—]
197	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
180	0.66	ND	ND	0.71	0.63	[12]	ND	ND	ND	ND	NQ	[—]
193	ND	ND	ND	ND	NQ	[—]	ND	ND	ND	ND	ND	[—]
191	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
200	ND	ND	NQ	0.47	0.52	[10]	ND	ND	ND	ND	ND	[—]
170 & 190	ND	ND	ND	0.49	0.48	[2]	ND	ND	ND	ND	0.29	[—]
198	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
199	NQ	NQ	NQ	0.3	0.32	[6]	NQ	ND	NQ	NQ	0.13	[—]
196 & 203	NQ	NQ	ND	0.19	0.22	[15]	NQ	ND	ND	ND	NQ	[—]
189	ND	ND	ND	NQ	ND	[—]	NQ	ND	ND	ND	NQ	[—]
208 & 195	ND	ND	ND	0.12	0.13	[8]	ND	ND	ND	ND	ND	[—]
207	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
194	ND	NQ	ND	0.17	0.16	[6]	ND	ND	ND	ND	ND	[—]
205	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	NQ	[—]
206	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
209	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Sum of quantified *ortho*-substituted PCBs	140.	36.	20.	91.	98.	[7]	190.	7.3	750.	3.3	100.	[187]

[a]Percent relative difference between two values, V_1 and V_2, is calculated as

$$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2)/2} \right| \cdot 100$$

[b]SPMD's at the Snake River site were periodically exposed to air due to fluctuating river stage and were thus compromised; analytical results are presented for informational purposes only.

Table 9. *Ortho*-substituted polychlorinated biphenyls in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributary); concentrations, reported in nanograms (10^{-9} grams) per gram of sediment (dry weight), are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary site; see Appendix A for general chemical structures of congeners]

Congener No.	Beaver Army Terminal (54)	Willamette River (101)	Warrendale (141)
	Site 02	Site 06	Site 09
4 & 10	0.23	0.32	NQ
7 & 9	NQ	ND	ND
6	NQ	ND	NQ
5 & 8	ND	ND	NQ
19	0.08	0.1	0.17
18	NQ	ND	ND
17 & 15	ND	ND	ND
24 & 27	NQ	0.8	ND
16 & 32	NQ	ND	ND
29	ND	0.11	ND
26	ND	ND	ND
25	ND	NQ	ND
31	0.3	NQ	NQ
28	NQ	NQ	ND
20 & 33	NQ	NQ	NQ
53	NQ	NQ	ND
51	0.09	0.34	ND
22	0.17	0.21	NQ
45	0.18	0.11	ND
46	0.09	0.11	ND
52	NQ	NQ	ND
43	0.08	0.46	0.06
49	0.83	0.45	0.13
47	NQ	ND	ND
48	0.34	0.33	NQ
44	0.82	NQ	ND
42	NQ	ND	ND
41	NQ	NQ	ND
64	0.35	NQ	ND
40	0.3	NQ	NQ
67	0.03	0.11	ND
63	0.09	0.69	NQ
74	0.48	ND	ND
70 & 76	NQ	ND	ND
66	NQ	NQ	NQ
95	0.39	0.4	NQ
91	0.23	0.67	NQ
56 & 60	0.39	NQ	NQ
92	NQ	0.32	NQ

Table 9. *Ortho*-substituted polychlorinated biphenyls in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributary); concentrations, reported in nanograms (10^{-9} grams) per gram of sediment (dry weight), are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary site; see Appendix A for general chemical structures of congeners]

Congener No.	Beaver Army Terminal (54)	Willamette River (101)	Warrendale (141)
	Site 02	Site 06	Site 09
84	NQ	NQ	NQ
101	NQ	NQ	NQ
99	NQ	2.4	NQ
119	NQ	0.11	0.06
83	0.06	0.34	0.02
97	NQ	NQ	NQ
87	NQ	NQ	NQ
136	NQ	0.31	NQ
110	NQ	NQ	NQ
82	0.16	NQ	NQ
151	NQ	0.34	NQ
135 & 144 & 124	NQ	0.28	NQ
147	ND	NQ	ND
107	NQ	NQ	NQ
123 & 149	NQ	NQ	NQ
118	NQ	NQ	ND
134	NQ	0.14	NQ
114	0.06	0.35	0.05
131 & 122	0.12	1.1	NQ
146	NQ	NQ	ND
153	NQ	NQ	ND
132	NQ	0.84	NQ
105	NQ	ND	ND
141	NQ	0.23	ND
179	0.06	0.11	NQ
137	NQ	NQ	NQ
176	NQ	0.11	NQ
130	0.05	0.11	0.04
138	NQ	NQ	ND
158	NQ	NQ	ND
129	NQ	0.1	NQ
178	0.04	0.04	NQ
182 & 187	NQ	NQ	ND
183	NQ	0.23	ND
128	NQ	NQ	NQ
167	0.07	0.11	0.02
185	ND	0.11	ND
174	NQ	0.32	ND
177	0.15	0.22	NQ

Table 9. *Ortho*-substituted polychlorinated biphenyls in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributary); concentrations, reported in nanograms (10^{-9} grams) per gram of sediment (dry weight), are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary site; see Appendix A for general chemical structures of congeners]

Congener No.	Beaver Army Terminal (54)	Willamette River (101)	Warrendale (141)
	Site 02	Site 06	Site 09
171 & 202	0.07	0.31	ND
156	0.05	0.08	NQ
173	ND	0.01	0.01
201	ND	0.02	0.04
157	ND	0.05	0.03
172	NQ	NQ	NQ
197	ND	ND	ND
180	NQ	ND	ND
193	ND	ND	ND
191	ND	0.11	NQ
200	ND	NQ	NQ
170 & 190	ND	ND	ND
198	ND	ND	ND
199	NQ	0.18	NQ
196 & 203	0.06	0.34	0.01
189	ND	NQ	0.1
208 & 195	ND	NQ	0.53
207	ND	ND	NQ
194	NQ	0.13	NQ
205	ND	0.03	0.05
206	ND	ND	ND
209	ND	NQ	ND
Sum of quantified *ortho*-substituted PCBs	6.4	15.	1.3

the next downstream site (Hayden Island and Umatilla, respectively). Within the main stem, concentrations were highest in SPMDs from the Columbia City site, just downstream of the Portland-Vancouver urban area, but decreased in SPMDs from more downstream sites.

For most sites sampled, the tetra- and pentachlorobiphenyls accounted for the majority of the *ortho*-substituted PCB mass quantified in SPMDs (table 8). However, SPMDs from Johnson Creek and the Yakima River also were relatively abundant in hexa-, hepta-, and octachlorobiphenyls, and those from the Wenatchee River had relatively high concentrations of trichlorobiphenyls.

In general, the site-to-site pattern of non-*ortho*-substituted PCB concentrations in SPMDs (table 10) was similar to that observed for *ortho*-substituted PCBs. However, elevated concentrations in SPMDs from Johnson Creek were much less pronounced for non-*ortho* than for *ortho*-substituted PCB, and SPMDs from the Wenatchee River site had considerably elevated concentrations of congeners 37 and 77 relative to other sites. In contrast to SPMDs, the highest sediment concentrations of non-*ortho*-substituted PCBs (table 11) were from the Beaver Army Terminal site.

Estimated dissolved and total concentrations in river water.—PCBs were estimated to be present in the dissolved phase at femtogram- or picogram-per-liter levels (tables 12 and 13). The highest dissolved concentrations of PCBs were estimated for tributary sites in the Portland-Vancouver urban area—Johnson Creek, Willamette River and Lake River—and the Wenatchee River site (figures 6 and 7). Within the main stem, patterns of

Table 10. Non-*ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)			Columbia City (82)	Lake River (87)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
			Duplicates		RD			Duplicates		RD		
	Site 01	Site 02	Site 03			Site 04	Site 05	Site 06			Site 08	Site 07
37	0.30	0.52	0.48	0.53	[10]	0.79	0.47	1.3	0.88	[39]	0.85	NQ
81	NQ	NQ	0.015	0.013	[14]	0.018	NQ	0.027	0.021	[25]	0.024	ND
77	0.12	0.23	0.33	0.29	[13]	0.44	0.24	0.67	0.53	[23]	0.71	0.025
126	NQ	NQ	NQ	NQ	[—]	0.017	NQ	0.021	0.017	[21]	0.084	ND
169	ND	ND	NQ	NQ	[—]	NQ	ND	ND	ND	[—]	0.004	ND

	Warrendale (141)	Umatilla (289)	Snake Riverb (324)	Yakima River (335)			Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)		
				Duplicates		RD				Duplicates		RD
	Site 09	Site 10	Site 13	Site 11			Site 14	Site 12	Site 15	Site 16		
37	0.27	NQ	ND	NQ	NQ	[—]	0.61	ND	7.11	ND	0.29	[—]
81	NQ	NQ	ND	NQ	NQ	[—]	0.009	ND	0.072	ND	NQ	[—]
77	0.11	0.036	0.022	0.083	0.077	[8]	0.22	NQ	1.53	0.016	0.18	[167]
126	NQ	ND	ND	NQ	0.016	[—]	NQ	ND	NQ	ND	NQ	[—]
169	NQ	ND	ND	NQ	NQ	[—]	NQ	ND	ND	ND	ND	[—]

[a]Percent relative difference between two values, V_1 and V_2, is calculated as

$$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2)/2} \right| \cdot 100$$

[b]SPMD's at the Snake River site were periodically exposed to air due to fluctuating river stage and were thus compromised; analytical results are presented for informational purposes only.

Table 11. Non-*ortho*-substituted polychlorinated biphenyls in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributary); concentrations, reported in nanograms (10^{-9} grams) per gram of sediment (dry weight), are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary site; see Appendix A for general chemical structures of congeners]

Congener No.	Beaver Army Terminal (54)	Willamette River (101)	Warrendale (141)
	Site 02	Site 06	Site 09
37	0.030	0.008	NQ
81	0.003	ND	ND
77	0.065	0.020	0.008
126	0.003	NQ	ND
169	ND	ND	ND

dissolved concentration estimates were very similar to those observed for SPMD concentrations.

Estimates of total (sorbed plus dissolved) concentrations of PCBs (tables 14-15) varied considerably more among sites than estimates of dissolved concentrations (tables 12-13). For a particular PCB congener, equation 5 shows that such differences result directly from differences in available organic carbon among sites. However, considering the sum of PCB congeners, site-to-site differences in total concentrations are governed largely by the K_{oc} values of the individual congeners that predominate at each site.

At most sites, considering the sums of individual congeners, estimates of total PCB concentrations were approximately 100 to 200 percent greater than dissolved concentration estimates. However, at the Johnson Creek and Yakima River sites, because of the predominance of the very hydrophobic hexa-, hepta-, and octachloro congeners, the sums of total concentrations were 300 to 500 percent greater than the sums of dissolved concentrations. In contrast, at the Wenatchee River site, the sum of total concentrations was only about 50 percent greater than the sum of dissolved concentrations. The relatively small proportion of sorbed PCB mass at the Wenatchee River site was due partly to the low concentrations of organic carbon available compared to other sites, but a more important factor was the predominance of trichlorobiphenyls, which have relatively low K_{oc} values.

Organochlorine Pesticides

In the United States, the use of many OC pesticides was either banned or severely restricted in the 1970s. However, because of their stability, these compounds are still frequently observed in the environment.

During the 1997 low-flow deployment, *p,p'*-DDE and *p,p'*-DDD—both metabolites of *p,p'*-DDT—were the predominant OC pesticide compounds detected in SPMDs (table 16). Overall, spatial patterns of OC Pesticides deployed in the Columbia River main stem were similar to patterns of PCBs. Moderate levels of OC pesticides were measured in SPMDs from the Vernita, Warrendale, Columbia City, and Longview sites, but levels were lower in SPMDs from intermediate sites and those from more downstream sites. Only very low levels of OC pesticides were measured in streambed sediment from the three sites that were sampled (table 17).

The Yakima River drains land that has been in agricultural use for several decades, and concentrations of OC pesticides in SPMDs from the Yakima River site were high compared to those from other sites. In particular, the concentration of *p,p'*-DDE measured in SPMDs from the Yakima site was considerably higher than from any other site measured. At other tributary sites, moderate levels of OC pesticides were measured in SPMDs deployed in the urban area (Johnson Creek and the Willamette River) and in the Snake and Wenatchee Rivers, both located in the agricultural area of Eastern Washington.

In contrast, OC pesticide levels measured in SPMDs deployed in Lower Crab Creek were quite low; Gruber and Munn (1996) analyzed streambed sediment from the same site on Lower Crab Creek and detected no OC pesticides. Although Lower Crab Creek drains an agricultural area, it is possible that historical use of this class of pesticides was limited in this particular drainage and residues have already been flushed from the system. However, our 1997 deployment period was late in the

Table 12. Estimated dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations are reported for individually quantified congeners, to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients, sampling rates, and equations used to calculate dissolved concentrations are summarized in table C2; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Lake River (87)	Wil-lamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Yakima River (335)	Vernita Bridge (388)	Lower Crab Creek (411)	Wenatche e River (468)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 08	Site 07	Site 09	Site 10	Site 11	Site 14	Site 12	Site 15	Site 16
6	—	—	—	—	3	8	—	—	—	—	—	—	—	—	—
19	—	9	8	20	20	50	4	—	—	—	—	—	—	10	—
18	10	20	20	30	40	50	30	—	20	—	—	20	30	300	—
26	4	6	7	7	10	10	8	1	4	1	1	5	0.5	60	—
25	—	—	—	—	10	—	—	—	—	—	—	—	—	30	—
31	—	9	10	10	20	20	20	—	10	—	—	10	—	100	—
28	8	20	20	20	30	40	20	—	20	6	—	30	—	200	—
53	6	6	10	20	20	40	20	—	—	—	—	6	—	40	—
51	4	3	6	8	7	30	4	0.6	1	—	—	1	—	10	—
22	4	4	8	5	10	10	10	—	9	2	3	10	—	100	—
45	—	5	6	10	9	20	8	—	5	1	—	5	—	30	—
46	—	6	6	8	8	20	5	—	2	1	—	20	—	30	—
52	30	50	60	90	90	200	500	10	50	10	20	60	—	200	—
43	—	2	—	—	—	—	—	—	—	—	—	—	—	10	—
49	20	40	50	70	90	100	100	7	30	9	7	40	—	200	—
47	10	20	30	30	40	60	20	3	10	4	6	20	—	60	—
48	7	10	20	30	30	70	40	6	20	6	10	30	—	200	—
44	10	20	30	40	40	80	200	—	20	—	9	40	—	100	—
42	8	20	20	30	30	60	30	3	7	3	6	40	—	100	—
41	6	10	20	20	40	40	30	3	10	3	3	9	—	80	—
64	6	10	20	20	20	40	40	—	10	—	—	20	—	70	—
40	3	5	10	10	9	20	20	—	7	2	4	6	0.7	40	—
67	1	2	3	4	—	8	8	0.6	10	1	10	4	—	10	—
63	2	3	4	2	3	4	3	3	5	3	1	6	—	10	—
74	6	10	20	20	20	40	30	2	10	3	4	30	—	90	—
66	20	40	50	50	60	100	80	—	30	8	—	60	—	300	—
95	20	30	30	60	30	100	300	7	30	10	20	40	—	50	—
91	5	9	10	20	20	40	90	3	—	4	6	3	—	20	—

Table 12. Estimated dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations are reported for individually quantified congeners, to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients, sampling rates, and equations used to calculate dissolved concentrations are summarized in table C2; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Lake River (87)	Wil-lamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Yakima River (335)	Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 08	Site 07	Site 09	Site 10	Site 11	Site 14	Site 12	Site 15	Site 16
92	4	10	6	20	5	20	80	2	4	3	10	30	—	10	2
84	10	10	30	50	30	80	200	9	50	20	90	100	—	60	—
101	20	30	30	60	40	100	300	8	30	10	20	60	—	60	—
99	10	20	30	30	30	60	100	5	8	7	10	8	10	20	5
119	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
83	1	3	3	7	4	9	30	—	3	—	1	6	—	6	—
97	6	10	20	30	20	40	100	3	20	4	6	30	—	40	2
87	6	10	20	30	10	40	100	—	10	4	4	10	—	20	—
136	4	5	10	10	3	7	20	1	4	5	—	9	—	—	1
110	10	20	30	50	20	60	200	—	20	6	10	20	—	30	—
82	—	2	4	20	8	20	50	3	20	—	—	3	—	10	—
151	3	5	6	10	3	20	70	—	5	—	10	3	—	—	—
107	—	0.9	1	4	1	8	20	—	2	—	2	1	—	2	—
118	—	10	20	40	10	50	100	—	20	—	10	10	—	20	—
134	—	—	0.9	0.6	—	0.8	20	—	—	—	—	2	—	0.7	0.9
114	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
146	2	1	3	6	1	9	30	0.7	2	—	7	1	—	—	—
153	—	—	—	—	—	—	100	—	—	—	—	—	—	—	—
105	—	—	8	20	9	20	70	—	10	—	30	—	—	8	—
141	—	—	3	7	—	10	50	—	—	—	5	—	—	—	—
179	—	—	4	10	—	20	70	—	10	4	10	—	—	—	—
137	—	—	—	—	—	3	10	—	—	—	3	—	—	—	—
176	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
130	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—
138	—	—	—	60	—	40	200	—	—	—	—	—	—	—	—
158	1	—	2	2	2	8	40	—	2	—	20	2	—	1	—
129	—	—	1	2	—	2	10	—	—	—	0.8	—	—	—	—
178	—	—	—	3	—	3	20	—	—	—	4	—	—	—	—
183	1	1	2	6	—	7	50	—	1	—	8	—	—	—	—

Table 12. Estimated dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations are reported for individually quantified congeners, to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients, sampling rates, and equations used to calculate dissolved concentrations are summarized in table C2; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Lake River (87)	Wil-lamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Yakima River (335)	Vernita Bridge (388)	Lower Crab Creek (411)	Wenatche e River (468)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 08	Site 07	Site 09	Site 10	Site 11	Site 14	Site 12	Site 15	Site 16
128	2	2	1	6	2	7	30	—	2	—	4	—	—	2	—
174	2	3	3	10	—	10	80	—	3	2	9	2	—	—	—
177	2	3	4	6	—	7	50	—	2	—	6	—	—	—	—
156	—	3	3	5	—	5	20	—	3	—	—	2	—	—	—
201	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—
157	—	—	—	—	—	—	5	—	—	—	—	—	—	—	—
172	—	—	—	4	—	3	20	—	—	—	6	—	—	—	—
180	—	—	—	—	—	20	70	—	7	—	8	—	—	—	—
199	—	—	2	4	2	5	30	—	—	—	5	—	—	—	—
207	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
194	—	—	—	3	—	3	30	—	—	—	4	—	—	—	—
Sum of quantified *ortho*-substituted PCBs	300	500	700	1,000	900	2,000	4,000	80	600	100	400	800	40	3,000	10

Table 13. Estimated dissolved concentrations of non-*ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); dissolved concentrations were calculated using equation (3) and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients and sampling rates used in calculations are summarized in table C3; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Lake River (87)	Willamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Yakima River (335)	Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 08	Site 07	Site 09	Site 10	Site 11	Site 14	Site 12	Site 15	Site 16
37	1	2	2	4	2	6	4	—	1	—	—	3	—	30	—
81	—	—	0.09	0.1	—	0.2	0.1	—	—	—	—	0.05	—	0.4	—
77	0.7	1	2	3	1	4	4	0.1	0.6	0.2	0.5	1	—	9	0.09
126	—	—	—	0.1	—	0.2	0.7	—	—	—	—	—	—	—	—
169	—	—	—	—	—	—	0.05	—	—	—	—	—	—	—	—

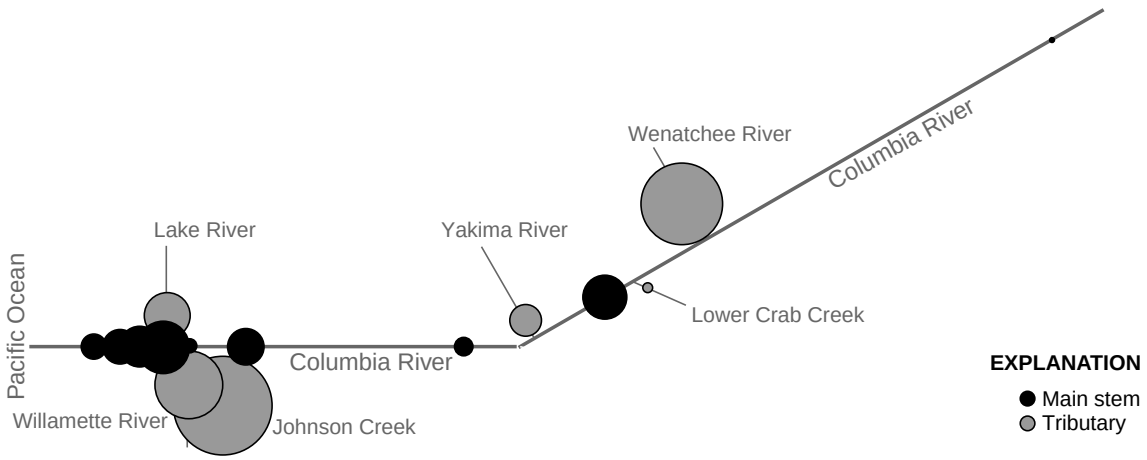

Figure 6. Sum of estimated dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997. (Areas of symbols are proportional to the sum of concentrations reported in table 12; note that symbols in figures 6 and 7 are not based on the same concentration scale.)

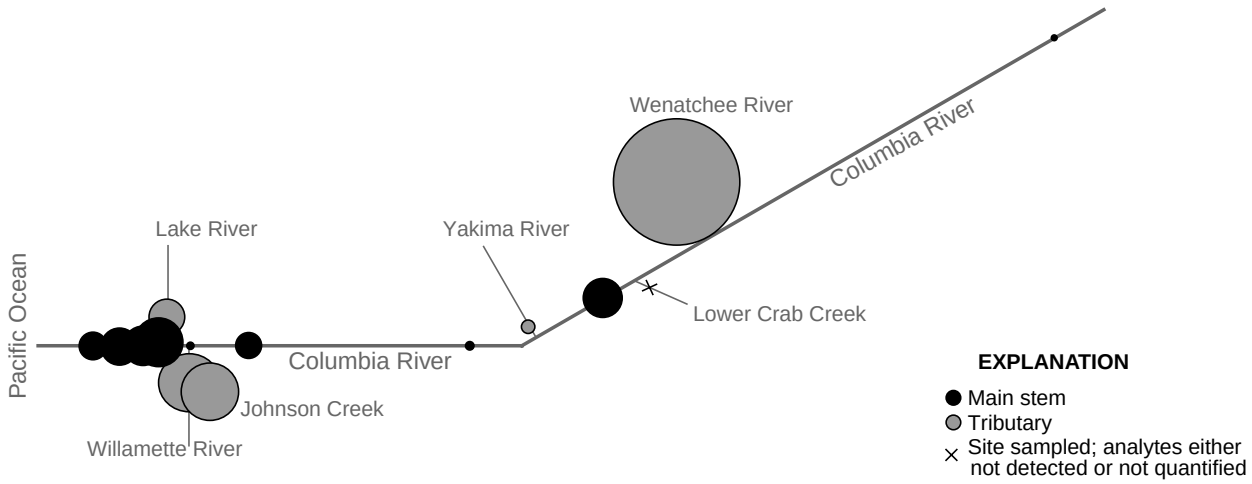

Figure 7. Sum of estimated dissolved concentrations of non-ortho-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997. (Areas of symbols are proportional to the sum of concentrations reported in table 13; note that symbols in figures 6 and 7 are not based on the same concentration scale.)

irrigation season and it is possible that higher levels of OC pesticides are carried into the stream during periods of more intense irrigation.

Estimated dissolved and total concentrations in river water.—Estimates of the dissolved concentrations of OC pesticides were generally at picogram-per-liter levels (table 18). The spatial pattern of dissolved concentrations of OC pesticides was generally similar to the pattern of SPMD concentrations (fig. 8), but the wide range of K_{SPMD} values for these compounds resulted in some important differences. For example, due to its high K_{SPMD} value, the elevated concentration of *p,p*'-DDE measured in SPMDs from the Yakima River was less pronounced in the dissolved concentration estimate. In contrast, the low K_{SPMD} value for Lindane resulted in relatively high dissolved concentration estimates for this compound, which was particularly apparent at the Warrendale site.

The K_{oc} values for the OC pesticides (table 19) cover a wide range. Considering the overall sum of OC pesticides, this resulted in considerable site-to-site variation in estimates of total (sorbed plus dissolved) concentration, depending on which compounds predominated at each site. For most compounds, total concentration estimates exceeded dissolved concentration estimates by approximately 50 to 150 percent. However, for compounds with the highest K_{oc} values, such as *p,p*'-DDE and *o,p*'-DDT, differences between estimates of total and dissolved concentrations were greater. This effect was particularly pronounced at the Yakima River site where high concentrations of the most

Table 14. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log Koca	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.40		2.35		2.30		2.30		3.10[b]		1.85		1.85		2.30[c]	
6	4.7	—	—	—	—	—	—	—	—	3	13%	8	8%	—	—	—	—
19	4.6	—	—	10	9%	8	9%	20	9%	20	12%	50	7%	4	7%	—	—
18	4.9	10	15%	20	14%	20	14%	30	14%	40	18%	60	12%	40	12%	—	—
26	5.3	6	31%	9	31%	10	30%	10	30%	20	37%	20	26%	10	26%	2	30%
25	5.3	—	—	—	—	—	—	—	—	20	37%	—	—	—	—	—	—
31	5.3	—	—	10	31%	20	31%	20	31%	30	37%	30	26%	20	26%	—	—
28	5.3	10	32%	20	31%	30	31%	40	31%	40	37%	60	26%	30	26%	—	—
53	5.2	9	29%	8	29%	20	28%	20	28%	30	35%	60	24%	30	24%	—	—
51	5.2	6	30%	4	29%	9	29%	10	29%	10	35%	30	24%	6	24%	1	29%
22	5.2	5	27%	6	27%	10	26%	7	26%	10	33%	10	22%	10	22%	—	—
45	5.1	—	—	6	25%	8	24%	10	24%	10	30%	20	20%	10	20%	—	—
46	5.1	—	—	7	25%	8	24%	10	24%	10	30%	20	20%	7	20%	—	—
52	5.5	40	41%	80	40%	100	40%	100	40%	200	47%	300	34%	700	34%	20	40%
43	5.4	—	—	4	35%	—	—	—	—	—	—	—	—	—	—	—	—
49	5.5	40	41%	60	41%	90	40%	100	40%	200	47%	200	35%	200	35%	10	40%
47	5.5	20	41%	30	41%	40	40%	50	40%	80	47%	90	35%	40	35%	5	40%
48	5.4	10	37%	20	37%	20	36%	50	36%	50	43%	100	31%	60	31%	9	36%
44	5.4	20	36%	30	35%	40	35%	60	35%	60	42%	100	30%	200	30%	—	—
42	5.4	10	36%	30	36%	40	35%	50	35%	50	42%	90	30%	50	30%	4	35%
41	5.3	8	33%	20	32%	30	32%	30	32%	60	38%	60	27%	40	27%	5	32%
64	5.6	10	47%	20	46%	30	46%	40	46%	40	53%	60	40%	60	40%	—	—
40	5.3	5	31%	7	31%	10	30%	20	30%	10	37%	30	26%	30	26%	—	—
67	5.8	3	61%	6	60%	7	60%	10	60%	—	—	20	55%	20	55%	1	60%
63	5.8	4	59%	7	59%	9	58%	6	58%	10	65%	8	53%	6	53%	8	58%

Table 14. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log Koca	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.40		2.35		2.30		2.30		3.10[b]		1.85		1.85		2.30[c]	
74	5.8	20	61%	40	60%	50	60%	60	60%	70	67%	80	55%	80	55%	5	60%
66	5.8	40	61%	90	60%	100	60%	100	60%	200	67%	200	55%	200	55%	—	—
95	5.7	40	57%	60	57%	70	56%	100	56%	90	63%	200	51%	700	51%	20	56%
91	5.7	10	57%	20	57%	30	56%	60	56%	40	63%	80	51%	200	51%	7	56%
92	6.0	10	69%	30	68%	20	68%	50	68%	20	74%	60	63%	200	63%	7	68%
84	5.7	30	52%	20	51%	70	51%	100	51%	70	58%	200	45%	300	45%	20	51%
101	6.0	50	70%	90	70%	100	69%	200	69%	200	75%	300	65%	900	65%	30	69%
99	6.0	40	71%	80	70%	90	70%	100	70%	100	76%	200	65%	400	65%	20	70%
119	6.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
83	5.9	4	64%	7	64%	9	63%	20	63%	10	70%	20	58%	60	58%	—	—
97	5.9	20	66%	40	65%	40	65%	70	65%	80	71%	100	60%	300	60%	8	65%
87	5.9	20	66%	30	65%	40	65%	80	65%	40	71%	90	60%	300	60%	—	—
136	5.8	10	62%	10	62%	20	61%	30	61%	10	68%	20	56%	50	56%	3	61%
110	6.1	40	75%	80	74%	100	74%	200	74%	90	79%	200	70%	700	70%	—	—
82	5.8	—	—	6	60%	9	60%	50	60%	20	67%	40	55%	100	55%	8	60%
151	6.3	20	81%	20	81%	30	80%	70	80%	20	85%	90	77%	300	77%	—	—
107	6.3	—	—	5	83%	7	83%	20	83%	9	87%	40	80%	90	80%	—	—
118	6.4	—	—	70	84%	100	84%	200	84%	100	88%	200	81%	700	81%	—	—
134	6.2	—	—	—	—	4	77%	3	77%	—	—	3	73%	60	73%	—	—
114	6.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
146	6.5	20	88%	10	88%	20	88%	50	88%	20	91%	60	86%	200	86%	6	88%
153	6.5	—	—	—	—	—	—	—	—	—	—	—	—	1,000	86%	—	—
105	6.3	—	—	—	—	40	81%	100	81%	60	85%	80	77%	300	77%	—	—
141	6.4	—	—	—	—	20	86%	50	86%	—	—	60	83%	300	83%	—	—
179	6.3	—	—	—	—	20	84%	80	84%	—	—	80	80%	400	80%	—	—

Table 14. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log Koca	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.40		2.35		2.30		2.30		3.10[b]		1.85		1.85		2.30[c]	
137	6.4	—	—	—	—	—	—	—	—	—	—	20	84%	60	84%	—	—
176	6.4	—	—	—	—	9	84%	—	—	—	—	—	—	—	—	—	—
130	6.4	—	—	—	—	—	—	—	—	—	—	—	—	80	83%	—	—
138	6.4	—	—	—	—	—	—	400	86%	—	—	300	84%	1,000	84%	—	—
158	6.6	10	91%	—	—	20	91%	20	91%	20	93%	70	89%	300	89%	—	—
129	6.3	—	—	—	—	7	84%	9	84%	—	—	10	80%	70	80%	—	—
178	6.8	—	—	—	—	—	—	40	93%	—	—	30	91%	200	91%	—	—
183	6.8	20	94%	20	94%	40	94%	90	94%	—	—	90	92%	600	92%	—	—
128	6.4	10	84%	10	84%	7	84%	40	84%	10	88%	40	81%	200	81%	—	—
174	6.7	30	93%	40	93%	40	92%	100	92%	—	—	100	91%	900	91%	—	—
177	6.7	30	92%	30	92%	50	92%	70	92%	—	—	70	90%	500	90%	—	—
156	6.8	—	—	40	94%	50	93%	80	93%	—	—	60	92%	200	92%	—	—
201	6.9	—	—	—	—	—	—	—	—	—	—	—	—	200	93%	—	—
157	6.8	—	—	—	—	—	—	—	—	—	—	—	—	70	92%	—	—
172	6.9	—	—	—	—	—	—	90	95%	—	—	50	94%	400	94%	—	—
180	7.0	—	—	—	—	—	—	—	—	—	—	300	95%	1,000	95%	—	—
199	7.2	—	—	—	—	70	98%	200	98%	100	98%	200	97%	1,000	97%	—	—
207	7.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
194	7.4	—	—	—	—	—	—	200	98%	—	—	200	98%	1,000	98%	—	—
Sum of quantified *ortho*-substituted PCBs		700		1,000		2,000		4,000		2,000		5,000		20,000		200	

Table 14. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
Organic Carbon (mg/L)		1.50		2.00		2.70		2.20		5.15		1.25		1.50	
6	4.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19	4.6	—	—	—	—	—	—	—	—	—	—	10	5%	—	—
18	4.9	20	10%	—	—	—	—	20	14%	40	27%	300	8%	—	—
26	5.3	5	22%	2	27%	2	34%	7	29%	1	49%	80	19%	—	—
25	5.3	—	—	—	—	—	—	—	—	—	—	40	19%	—	—
31	5.3	20	22%	—	—	—	—	20	30%	—	—	200	19%	—	—
28	5.3	20	22%	8	28%	—	—	40	30%	—	—	200	19%	—	—
53	5.2	—	—	—	—	—	—	9	27%	—	—	50	18%	—	—
51	5.2	1	21%	—	—	—	—	1	28%	—	—	20	18%	—	—
22	5.2	10	19%	3	24%	4	30%	10	26%	—	—	200	16%	—	—
45	5.1	5	17%	2	22%	—	—	7	23%	—	—	40	15%	—	—
46	5.1	2	17%	1	22%	—	—	30	23%	—	—	30	15%	—	—
52	5.5	70	30%	20	36%	30	43%	100	38%	—	—	300	26%	—	—
43	5.4	—	—	—	—	—	—	—	—	—	—	20	22%	—	—
49	5.5	40	30%	10	37%	10	44%	70	39%	—	—	300	27%	—	—
47	5.5	20	30%	6	37%	10	44%	30	39%	—	—	90	27%	—	—
48	5.4	30	27%	9	33%	20	40%	40	35%	—	—	200	24%	—	—
44	5.4	30	26%	—	—	10	38%	60	34%	—	—	200	22%	—	—
42	5.4	10	26%	5	32%	10	39%	50	34%	—	—	200	23%	—	—
41	5.3	10	23%	4	29%	4	35%	10	31%	—	—	100	20%	—	—
64	5.6	20	35%	—	—	—	—	30	45%	—	—	100	31%	—	—
40	5.3	9	22%	3	27%	6	34%	8	29%	1	49%	50	19%	—	—
67	5.8	30	49%	3	57%	30	64%	10	59%	—	—	30	45%	—	—
63	5.8	10	48%	7	55%	4	62%	10	57%	—	—	20	43%	—	—
74	5.8	20	49%	8	57%	10	64%	80	59%	—	—	200	45%	—	—

Table 14. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
Organic Carbon (mg/L)		1.50		2.00		2.70		2.20		5.15		1.25		1.50	
66	5.8	50	49%	20	57%	—	—	200	59%	—	—	500	45%	—	—
95	5.7	50	45%	20	53%	40	60%	80	55%	—	—	80	41%	—	—
91	5.7	—	—	8	53%	20	60%	6	55%	—	—	40	41%	—	—
92	6.0	10	58%	9	65%	40	71%	80	67%	—	—	20	53%	4	58%
84	5.7	90	40%	30	47%	200	55%	200	50%	—	—	90	36%	—	—
101	6.0	90	60%	30	66%	70	73%	200	68%	—	—	100	55%	—	—
99	6.0	20	60%	20	67%	60	73%	20	69%	80	84%	50	56%	10	60%
119	6.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
83	5.9	7	53%	—	—	3	67%	20	62%	—	—	10	48%	—	—
97	5.9	30	55%	10	62%	20	68%	100	64%	—	—	80	50%	5	55%
87	5.9	30	55%	9	62%	10	68%	30	64%	—	—	40	50%	—	—
136	5.8	7	51%	10	58%	—	—	20	60%	—	—	—	—	2	51%
110	6.1	50	65%	20	71%	60	77%	60	73%	—	—	70	61%	—	—
82	5.8	30	49%	—	—	—	—	7	59%	—	—	20	45%	—	—
151	6.3	20	73%	—	—	60	83%	20	80%	—	—	—	—	—	—
107	6.3	7	76%	—	—	10	85%	6	82%	—	—	7	72%	—	—
118	6.4	80	77%	—	—	100	86%	80	83%	—	—	80	74%	—	—
134	6.2	—	—	—	—	—	—	8	76%	—	—	2	65%	3	69%
114	6.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
146	6.5	10	83%	—	—	70	90%	10	88%	—	—	—	—	—	—
153	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
105	6.3	50	73%	—	—	200	83%	—	—	—	—	30	70%	—	—
141	6.4	—	—	—	—	40	88%	—	—	—	—	—	—	—	—
179	6.3	50	77%	20	82%	80	86%	—	—	—	—	—	—	—	—
137	6.4	—	—	—	—	20	88%	—	—	—	—	—	—	—	—

Table 14. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
Organic Carbon (mg/L)		1.50		2.00		2.70		2.20		5.15		1.25		1.50	
176	6.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
130	6.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
138	6.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
158	6.6	10	87%	—	—	300	92%	20	90%	—	—	8	84%	—	—
129	6.3	—	—	—	—	6	86%	—	—	—	—	—	—	—	—
178	6.8	—	—	—	—	60	94%	—	—	—	—	—	—	—	—
183	6.8	10	91%	—	—	100	95%	—	—	—	—	—	—	—	—
128	6.4	10	77%	—	—	30	86%	—	—	—	—	9	74%	—	—
174	6.7	30	89%	30	91%	100	93%	30	92%	—	—	—	—	—	—
177	6.7	20	88%	—	—	90	93%	—	—	—	—	—	—	—	—
156	6.8	30	90%	—	—	—	—	30	93%	—	—	—	—	—	—
201	6.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
157	6.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
172	6.9	—	—	—	—	100	96%	—	—	—	—	—	—	—	—
180	7.0	100	93%	—	—	200	96%	—	—	—	—	—	—	—	—
199	7.2	—	—	—	—	200	98%	—	—	—	—	—	—	—	—
207	7.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
194	7.4	—	—	—	—	300	99%	—	—	—	—	—	—	—	—
Sum of quantified *ortho*-substituted PCBs		1,000		300		3,000		2,000		100		4,000		20	

[a]K_{oc} values were estimated from K_{ow} values of Meadows *et al*. (1998) using the approximation $K_{oc} = 0.411K_{ow}$ (Karickhoff, 1981).
[b]Value from high-flow deployment period.
[c]Approximation based on values from sites 3 and 4.

Table 15. Estimated total concentrations of non-*ortho*-substituted polychlorinated biphenyls during low-flow conditions in the Columbia River Basin, 1997

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.40		2.35		2.30		2.30		3.10[b]		1.85		1.85		2.30[c]	
37	5.4	2	40%	4	40%	4	39%	6	39%	4	46%	9	34%	6	34%	—	—
81	6.0	—	—	—	—	0.3	68%	0.3	68%	—	—	0.4	64%	0.4	64%	—	—
77	6.0	2	69%	4	69%	6	68%	8	68%	5	74%	10	64%	10	64%	0.4	68%
126	6.5	—	—	—	—	—	—	1	88%	—	—	1	86%	5	86%	—	—
169	7.0	—	—	—	—	—	—	—	—	—	—	—	—	1	95%	—	—

Congener No.	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
Organic Carbon (mg/L)		1.50		2.00		2.70		2.20		5.15		1.25		1.50	
37	5.4	2	29%	—	—	—	—	5	38%	—	—	50	26%	—	—
81	6.0	—	—	—	—	—	—	0.2	67%	—	—	0.9	54%	—	—
77	6.0	2	59%	0.6	65%	2	72%	4	67%	—	—	20	54%	0.2	59%
126	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
169	7.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[a]K_{oc} values were estimated from K_{ow} values of Hawker and Connell (1988) using the approximation $K_{oc} = 0.411K_{ow}$ (Karickhoff, 1981).
[b]Value from high-flow deployment period.
[c]Approximation based on values from sites 3 and 4.

Table 16. Organochlorine pesticides and related transformation products accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)			Columbia City (82)	Lake River (87)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
			Duplicates		RD			Duplicates		RD		
	Site 01	Site 02	Site 03			Site 04	Site 05	Site 06			Site 08	Site 07
Hexachlorobenzene	11.	21.	29.	27.	[7]	33.	9.1	23.	26.	[12]	31.	NQ
Pentachloroanisole	10.	11.	8.7	8.3	[5]	25.	5.1	39.	27.	[36]	58.	3.1
alpha-hexachlorocyclohexane	1.3	1.5	2.3	1.6	[36]	2.2	1.3	2.1	1.3	[47]	ND	NQ
Lindane	NQ	NQ	NQ	NQ	[—]	1.8	NQ	5.8	3.6	[47]	NQ	3.4
beta-hexachlorocyclohexane	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
Heptachlor	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
delta-hexachlorocyclohexane	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
Aldrin	NQ	ND	NQ	NQ	[—]	1.3	NQ	3.6	3.0	[18]	4.6	ND
Dacthal	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
Oxychlordane	ND	ND	NQ	NQ	[—]	NQ	ND	NQ	NQ	[—]	5.8	ND
Heptachlor Epoxide	1.8	1.6	2.1	2.1	[<1]	1.4	2.3	NQ	NQ	[—]	5.0	NQ
trans-Chlordane	NQ	NQ	NQ	NQ	[—]	7.2	NQ	11.	7.5	[38]	29.	9.5
trans-Nonachlor	NQ	3.2	3.5	3.7	[6]	5.4	NQ	9.0	5.9	[42]	35.	3.5
o,p'-DDE	2.4	1.6	2.7	3.6	[29]	4.0	NQ	2.2	4.6	[71]	4.4	NQ
cis-Chlordane	7.0	7.5	9.5	10.	[5]	13.	5.7	16.	13.	[21]	48.	8.3
p,p'-DDE	40.	70.	130.	120.	[8]	120.	33.	70.	52.	[30]	64.	21.
Dieldrin	7.2	7.0	7.9	9.8	[21]	12.	7.4	19.	12.	[45]	100.	5.0
o,p'-DDD	8.3	9.7	13.	14.	[7]	17.	6.6	35.	24.	[37]	13.	4.7
Endrin	ND	NQ	NQ	NQ	[—]	ND	ND	NQ	NQ	[—]	4.8	ND
o,p'-DDT	NQ	1.8	2.3	2.0	[14]	3.8	NQ	1.6	6.7	[123]	6.8	2.1
cis-Nonachlor	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	6.9	ND
p,p'-DDD	29.	39.	53.	57.	[7]	58.	26.	84.	61.	[32]	43.	20.
p,p'-DDT	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
Methoxychlor	ND	NQ	NQ	NQ	[—]	NQ	ND	NQ	NQ	[—]	ND	ND
Mirex	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND

Table 16. Organochlorine pesticides and related transformation products accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]

	Warrendale (141)	Umatilla (289)	Snake Riverb (324)	Yakima River (335)			Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)		
				Duplicates		RD				Duplicates		RD
	Site 09	Site 10	Site 13	Site 11			Site 14	Site 12	Site 15	Site 16		
Hexachlorobenzene	28.	15.	33.	9.0	9.5	[5]	9.3	ND	NQ	NQ	9.2	[—]
Pentachloroanisole	7.0	1.8	3.7	11.	6.6	[50]	3.5	0.4	2.1	3.5	11.	[103]
alpha-hexachlorocyclohexane	3.0	NQ	NQ	ND	ND	[—]	3.0	NQ	ND	1.8	2.0	[11]
Lindane	14.	ND	ND	2.3	1.5	[42]	NQ	ND	NQ	ND	1.5	[—]
beta-hexachlorocyclohexane	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Heptachlor	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
delta-hexachlorocyclohexane	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Aldrin	ND	ND	NQ	3.1	3.0	[3]	ND	NQ	2.6	ND	NQ	[—]
Dacthal	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Oxychlordane	NQ	ND	NQ	NQ	NQ	[—]	ND	ND	ND	ND	ND	[—]
Heptachlor Epoxide	2.3	1.5	2.4	2.5	1.9	[27]	NQ	NQ	ND	ND	NQ	[—]
trans-Chlordane	24.	NQ	6.1	6.8	NQ	[—]	NQ	NQ	ND	NQ	NQ	[—]
trans-Nonachlor	9.9	NQ	2.9	9.0	5.1	[55]	NQ	NQ	ND	ND	NQ	[—]
o,p'-DDE	5.0	2.4	2.7	13.	5.0	[89]	7.3	ND	2.0	ND	1.4	[—]
cis-Chlordane	26.	8.8	23.	31.	18.	[53]	24.	9.2	10.	NQ	5.7	[—]
p,p'-DDE	150.	71.	70.	780.	920.	[16]	240.	NQ	150.	ND	16.	[—]
Dieldrin	15.	6.1	22.	110.	81.	[30]	4.0	16.	NQ	ND	4.6	[—]
o,p'-DDD	26.	11.	6.9	37.	27.	[31]	43.	ND	6.3	ND	7.6	[—]
Endrin	ND	ND	ND	ND	ND	[—]	ND	ND	1.4	ND	ND	[—]
o,p'-DDT	5.7	1.6	1.5	28.	16.	[55]	4.2	NQ	9.7	ND	2.1	[—]
cis-Nonachlor	NQ	ND	ND	4.8	NQ	[—]	ND	ND	ND	ND	ND	[—]
p,p'-DDD	120.	47.	20.	130.	100.	[26]	170.	NQ	21.	ND	20.	[—]
p,p'-DDT	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Methoxychlor	ND	ND	NQ	15.	8.9	[51]	ND	ND	ND	ND	ND	[—]
Mirex	ND	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]

[a]Percent relative difference between two values, V_1 and V_2, is calculated as

$$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2)/2} \right| \cdot 100$$

[b]SPMD's at the Snake River site were periodically exposed to air due to fluctuating river stage and were thus compromised; analytical results are presented for informational purposes only.

Table 17. Organochlorine pesticides and related transformation products in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributary); concentrations, reported in nanograms (10^{-9} grams) per gram of sediment (dry weight), are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded column indicates tributary site]

	Beaver Army Terminal (54)	Willamette River (101)	Warrendale (141)
	Site 02	Site 06	Site 09
Hexachlorobenzene	ND	ND	ND
Pentachloroanisole	ND	ND	ND
alpha-hexachlorocyclohexane	ND	ND	ND
Lindane	NQ	ND	ND
beta-hexachlorocyclohexane	ND	ND	ND
Heptachlor	ND	ND	ND
delta-hexachlorocyclohexane	ND	ND	ND
Aldrin	ND	ND	ND
Dacthal	ND	ND	ND
Oxychlordane	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND
trans-Chlordane	NQ	0.2	NQ
trans-Nonachlor	ND	0.2	ND
o,p'-DDE	NQ	0.4	NQ
cis-Chlordane	ND	NQ	ND
p,p'-DDE	NQ	1.8	NQ
Dieldrin	NQ	0.5	NQ
o,p'-DDD	NQ	1.5	0.2
Endrin	ND	ND	ND
o,p'-DDT	ND	ND	ND
cis-Nonachlor	ND	NQ	ND
p,p'-DDD	0.8	3.9	1.0
p,p'-DDT"	ND	2.8	ND
Methoxychlor	ND	ND	ND
Mirex	ND	ND	ND

hydrophobic OC pesticides were coupled with relatively high concentrations of organic carbon.

Polycyclic Aromatic Hydrocarbons

PAH compounds result from the burning of organic materials and are present in fossil fuels. Common outdoor sources of these compounds include combustion engine exhaust (especially diesel engines), coal burning, and wood burning.

During the 1997 low-flow period, the lowest PAH concentrations were measured in SPMDs from the main-stem sites in the upper basin (table 20). SPMDs from upper-basin tributary sites had concentrations somewhat higher than those from upper-basin main-stem sites. The highest levels were detected in SPMDs deployed in the Portland-Vancouver urban area—at the Willamette River and Johnson Creek sites—and at the Warrendale site. However, PAH concentrations in SPMDs deployed at the Hayden Island site were considerably lower than in those deployed at Warrendale, and SPMDs deployed downstream of the urban area had variable but generally lower levels lower than those deployed in the Willamette Basin.

Concentrations of PAH compounds in streambed sediment did not necessarily reflect patterns in SPMDs. Although levels were elevated in streambed sediment

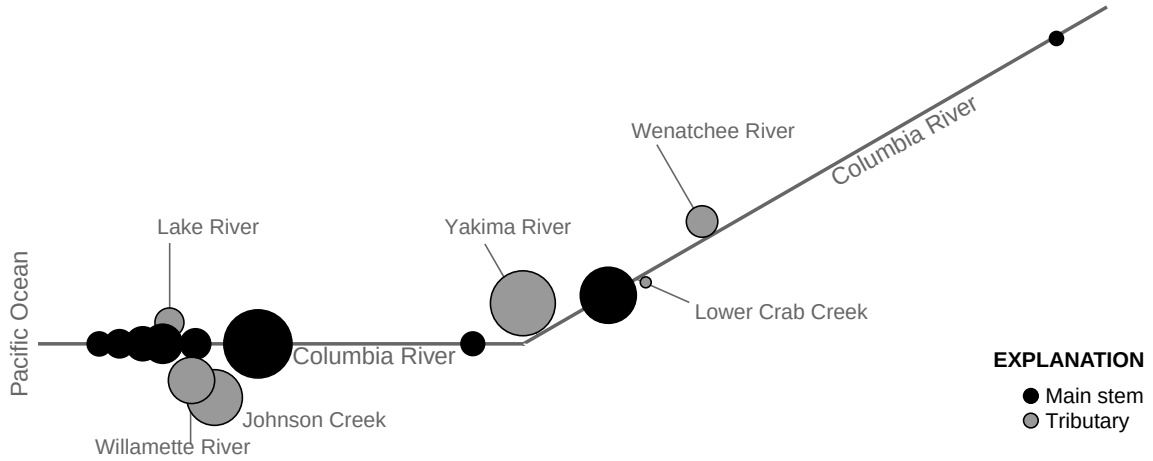

Figure 8. Sum of estimated dissolved concentrations of organochlorine pesticides and related transformation products during low-flow conditions in the Columbia River Basin, 1997. (Areas of symbols are proportional to the sum of concentrations reported in table 18.)

from the Willamette River site, concentrations were considerably lower in sediment from the Warrendale site (table 21).

Estimated dissolved and total concentrations in river water.—Dissolved PAH compounds were estimated to be present at nanogram- or picogram-per-liter levels (table 22), and generally showed the same relative spatial distribution as SPMD concentrations—dissolved concentration estimates were highest for the Willamette River, Johnson Creek and Warrendale sites, and lowest for sites in the upper basin (fig. 9).

Because the PAH compounds most frequently detected are only moderately hydrophobic (log K_{oc} < 5), differences between dissolved and total concentrations were smaller for PAHs than for other compounds measured. In many cases, estimated total concentrations (table 23) exceeded estimated dissolved concentrations by less than 10 percent. However, for more hydrophobic compounds (log K_{oc}'s greater than about 5.5), estimated total concentrations exceeded estimated dissolved concentrations by more than 100 percent.

ACKNOWLEDGMENTS

We thank Tom Edwards of the USGS-WRD, Portland, Oregon, for many productive, enjoyable, and safe hours on the water. We are grateful to Jim Huckins, CERC, USGS-BRD, Columbia, Missouri, for insightful discussions and unyielding moral support and encouragement. Many thanks go also to Ann Allert, CERC, USGS-BRD, Columbia, Missouri, and Jeremy Buck and Stephen Zylstra, USFWS, Portland, Oregon, for able field assistance. Finally, we wish to thank Tiffany Meissner and Bernadine Bonn, USGS-WRD, Portland, Oregon, for invaluable contributions toward completion of this report.

Table 18. Estimated dissolved concentrations of organochlorine pesticides and related transformation products during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients, sampling rates, and equations used to calculate dissolved concentrations are summarized in table C4; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Lake River (87)	Willamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Yakima River (335)	Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)
	Site 01	**Site 02**	**Site 03**	**Site 04**	**Site 05**	**Site 06**	**Site 08**	**Site 07**	**Site 09**	**Site 10**	**Site 11**	**Site 14**	**Site 12**	**Site 15**	**Site 16**
Hexachlorobenzene	60	100	100	200	100	100	200	—	300	70	50	70	—	—	—
Pentachloroanisole	40	50	40	100	30	200	300	20	40	7	50	20	2	10	20
alpha-hexachlorocyclohexane	100	200	200	200	100	200	—	—	300	—	—	300	—	—	200
Lindane	—	—	—	200	—	800	—	400	2,000	—	300	—	—	—	—
beta-hexachlorocyclohexane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
delta-hexachlorocyclohexane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	10	10	20	10	30	—	60	—	30	10	20	—	—	—	—
trans-Chlordane	—	—	—	30	—	50	300	80	200	—	30	—	—	—	—
trans-Nonachlor	—	20	20	30	—	50	400	30	90	—	50	—	—	—	—
o,p'-DDE	10	7	10	20	—	10	30	—	40	10	60	60	—	20	—
cis-Chlordane	30	40	40	60	40	70	500	70	200	40	100	200	40	100	—
p,p'-DDE	100	200	400	300	200	200	300	90	700	200	2,000	1,000	—	600	—
Dieldrin	40	40	40	70	100	100	700	50	100	30	600	30	90	—	—
o,p'-DDD	40	50	70	90	60	200	100	40	200	50	200	400	—	60	—
Endrin	—	—	—	—	—	—	40	—	—	—	—	—	—	10	—
o,p'-DDT	—	10	10	20	—	10	50	20	50	9	200	30	—	70	—
cis-Nonachlor	—	—	—	—	—	—	70	—	—	—	30	—	—	—	—
p,p'-DDD	100	200	200	300	200	400	300	200	1,000	200	600	1,000	—	200	—
p,p'-DDT	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Methoxychlor	—	—	—	—	—	—	—	—	—	—	100	—	—	—	—
Mirex	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 19. Estimated total concentrations of organochlorine pesticides and related transformation products during low-flow conditions in the Columbia River Basin, 1997

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.40		2.35		2.30		2.30		3.10[b]		1.85		1.85		2.30[c]	
Hexachlorobenzene	5.3	90	35%	200	34%	200	34%	300	34%	200	41%	200	29%	300	29%	—	—
Pentachloroanisole	5.1	60	22%	60	21%	50	21%	100	21%	40	26%	200	18%	400	18%	20	21%
alpha-hexachlorocyclohexane	3.4	100	1%	200	1%	200	1%	200	1%	100	1%	200	<1%	—	—	—	—
Lindane	3.3	—	—	—	—	—	—	200	<1%	—	—	800	<1%	—	—	400	<1%
beta-hexachlorocyclohexane	3.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	5.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
delta-hexachlorocyclohexane	3.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	6.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	4.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	4.6	20	9%	10	8%	20	8%	10	8%	40	11%	—	—	60	7%	—	—
trans-Chlordane	5.8	—	—	—	—	—		90	61%	—	—	100	56%	600	56%	200	61%
trans-Nonachlor	6.0	—	—	50	68%	60	68%	90	68%	—	—	100	63%	1,000	63%	90	68%
o,p'-DDE	5.6	20	50%	10	49%	20	49%	40	49%	—	—	20	43%	60	43%	—	—
cis-Chlordane	5.7	70	55%	80	55%	100	54%	100	54%	100	62%	100	49%	1,000	49%	200	54%
p,p'-DDE	6.1	500	76%	800	76%	1,000	75%	1,000	75%	900	80%	700	71%	900	71%	400	75%
Dieldrin	5.0	50	20%	50	20%	50	19%	80	19%	200	24%	100	16%	900	16%	60	19%
o,p'-DDD	5.5	80	42%	90	42%	100	41%	200	41%	100	49%	300	36%	200	36%	70	41%
Endrin	4.8	—	—	—	—	—	—	—	—	—	—	—	—	40	11%	—	—
o,p'-DDT	6.4	—	—	80	86%	100	85%	200	85%	—	—	60	82%	300	82%	100	85%
cis-Nonachlor	5.7	—	—	—	—	—	—	—	—	—	—	—	—	100	48%	—	—
p,p'-DDD	5.6	300	51%	400	50%	500	50%	500	50%	500	57%	700	44%	600	44%	300	50%
p,p'-DDT	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Methoxychlor	4.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mirex	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 19. Estimated total concentrations of organochlorine pesticides and related transformation products during low-flow conditions in the Columbia River Basin, 1997—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table D1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
Organic Carbon (mg/L)		1.50		2.00		2.70		2.20		5.15		1.25		1.50	
Hexachlorobenzene	5.3	300	25%	100	31%	70	37%	100	33%	—	—	—	—	—	—
Pentachloroanisole	5.1	50	15%	9	19%	60	24%	30	20%	3	37%	10	13%	20	15%
alpha-hexachlorocyclohexane	3.4	300	<1%	—	—	—	—	300	1%	—	—	—	—	200	<1%
Lindane	3.3	2,000	<1%	—	—	300	1%	—	—	—	—	—	—	—	—
beta-hexachlorocyclohexane	3.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	5.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
delta-hexachlorocyclohexane	3.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	6.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	4.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	4.6	30	6%	10	7%	20	10%	—	—	—	—	—	—	—	—
trans-Chlordane	5.8	400	51%	—	—	90	65%	—	—	—	—	—	—	—	—
trans-Nonachlor	6.0	200	58%	—	—	200	71%	—	—	—	—	—	—	—	—
o,p'-DDE	5.6	60	38%	20	45%	100	53%	100	47%	—	—	20	34%	—	—
cis-Chlordane	5.7	400	44%	80	51%	300	58%	500	53%	200	73%	200	39%	—	—
p,p'-DDE	6.1	2,000	67%	700	73%	10,000	78%	4,000	75%	—	—	2,000	62%	—	—
Dieldrin	5.0	200	13%	40	17%	800	22%	40	19%	100	35%	—	—	—	—
o,p'-DDD	5.5	300	31%	90	38%	400	45%	600	40%	—	—	80	28%	—	—
Endrin	4.8	—	—	—	—	—	—	—	—	—	—	10	8%	—	—
o,p'-DDT	6.4	200	79%	60	84%	1,000	87%	200	85%	—	—	300	76%	—	—
cis-Nonachlor	5.7	—	—	—	—	70	57%	—	—	—	—	—	—	—	—
p,p'-DDD	5.6	2,000	39%	400	46%	1,000	54%	2,000	49%	—	—	200	35%	—	—
p,p'-DDT	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Methoxychlor	4.7	—	—	—	—	200	12%	—	—	—	—	—	—	—	—
Mirex	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[a]K_{oc} values were estimated from K_{ow} values using the approximation $K_{oc} = 0.411K_{ow}$ (Karickhoff, 1981); K_{ow} values were obtained from Environmental Science Center Syracuse Research Corporation on-line database (accessed October 20, 1998, at http://esc.syrres.com/~esc1/kowexpdb.htm).

[b]Value from high-flow deployment period.

[c]Approximation based on values from sites 3 and 4.

Table 20. Polycyclic aromatic hydrocarbon compounds accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)			Columbia City (82)	Lake River (87)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
			Duplicates		RD			Duplicates		RD		
	Site 01	Site 02	Site 03			Site 04	Site 05	Site 06			Site 08	Site 07
Acenaphthylene	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	NQ	ND
Acenaphthene	NQ	ND	ND	ND	[—]	NQ	NQ	66	57	[15]	110	NQ
Fluorene	NQ	22	NQ	NQ	[—]	NQ	61	96	69	[33]	170	38
Phenanthrene	NQ	110	61	59	[3]	85	270	360	410	[13]	910	200
Anthracene	NQ	30	24	23	[4]	NQ	33	110	85	[26]	120	23
Fluoranthene	270	550	290	500	[53]	580	500	1,700	2,000	[17]	1,300	300
Pyrene	530	720	390	580	[39]	1,400	350	3,800	3,900	[2]	1,100	240
Benz[*a*]anthracene	NQ	230	130	83	[44]	170	43	340	340	[<1]	NQ	18
Chrysene	230	390	310	270	[14]	460	100	650	460	[34]	380	61
Benzo[*b*]fluoranthene	NQ	160	100	160	[46]	210	45	190	320	[51]	190	NQ
Benzo[*k*]fluoranthene	31	110	69	NQ	[—]	NQ	NQ	160	NQ	[—]	NQ	NQ
Benzo[*a*]pyrene	NQ	44	NQ	16	[—]	92	ND	100	110	[10]	27	ND
Indeno[*1,2,3,c,d*]pyrene	ND	NQ	ND	ND	[—]	NQ	ND	NQ	NQ	[—]	NQ	ND
Dibenz[*a,h*]anthracene	ND	ND	ND	ND	[—]	ND	ND	ND	ND	[—]	ND	ND
Benzo[*g,h,i*]perylene	ND	NQ	NQ	NQ	[—]	24	ND	50	40	[21]	29	ND

Table 20. Polycyclic aromatic hydrocarbon compounds accumulated in SPMDs during low-flow conditions in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Yakima River (335)			Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)		
					Duplicates	RD					Duplicates	RD
	Site 09	Site 10	Site 13	Site 11			Site 14	Site 12	Site 15	Site 16		
Acenaphthylene	NQ	NQ	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Acenaphthene	80	ND	ND	42	48	[13]	ND	NQ	NQ	ND	NQ	[—]
Fluorene	120	NQ	NQ	74	81	[9]	ND	NQ	56	NQ	33	[—]
Phenanthrene	850	NQ	65	300	320	[6]	ND	520	270	95	210	[75]
Anthracene	37	NQ	NQ	NQ	NQ	[—]	ND	NQ	7	NQ	50	[—]
Fluoranthene	2,100	160	150	300	330	[10]	290	640	290	170	490	[97]
Pyrene	1,200	110	76	190	200	[5]	140	320	100	81	1,100	[173]
Benz[*a*]anthracene	82	10	NQ	NQ	NQ	[—]	28	NQ	10	8	170	[182]
Chrysene	310	43	27	68	68	[<1]	120	NQ	49	39	270	[150]
Benzo[*b*]fluoranthene	76	NQ	ND	NQ	NQ	[—]	37	ND	ND	ND	62	[—]
Benzo[*k*]fluoranthene	NQ	NQ	NQ	NQ	NQ	[—]	27	ND	NQ	NQ	48	[—]
Benzo[*a*]pyrene	NQ	ND	ND	ND	ND	[—]	ND	ND	ND	ND	38	[—]
Indeno[*1,2,3,c,d*]pyrene	NQ	ND	ND	ND	ND	[—]	ND	ND	ND	ND	ND	[—]
Dibenz[*a,h*]anthracene	NQ	ND	ND	ND	ND	[—]	ND	NQ	ND	ND	NQ	[—]
Benzo[*g,h,i*]perylene	NQ	ND	ND	ND	ND	[—]	ND	ND	ND	ND	NQ	[—]

[a]Percent relative difference between two values, V_1 and V_2, is calculated as

$$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2)/2} \right| \cdot 100$$

[b]SPMD's at the Snake River site were periodically exposed to air due to fluctuating river stage and were thus compromised; analytical results are presented for informational purposes only.

Table 21. Polycyclic aromatic hydrocarbon compounds in streambed sediment collected during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributary); concentrations, reported in nanograms (10^{-9} grams) per gram of sediment (dry weight), are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded column indicates tributary site]

	Beaver Army Terminal (54)	**Willamette River (101)**	**Warrendale (141)**
	Site 02	**Site 06**	**Site 09**
Acena4phthylene	NQ	3	ND
Acenaphthene	3	14	3
Fluorene	5	16	4
Phenanthrene	21	79	14
Anthracene	2	21	1
Fluoranthene	24	98	11
Pyrene	24	120	10
Benz[*a*]anthracene	9	36	5
Chrysene	18	61	8
Benzo[*b*]fluoranthene	14	46	8
Benzo[*k*]fluoranthene	14	60	6
Benzo[*a*]pyrene	16	63	7
Indeno[*1,2,3,c,d*]pyrene	11	70	5
Dibenz[*a,h*]anthracene	3	14	ND
Benzo[*g,h,i*]perylene	16	110	6

Table 22. Estimated dissolved concentrations of polycyclic aromatic hydrocarbon compounds during low-flow conditions in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients, sampling rates, and equations used to calculate dissolved concentrations are summarized in table C5; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Lake River (87)	Wil-lamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Yakima River (335)	Vernita Bridge (388)	Lower Crab Creek (411)	Wenatche e River (468)	Northport (735)
	Site 01	**Site 02**	**Site 03**	**Site 04**	**Site 05**	**Site 06**	**Site 08**	**Site 07**	**Site 09**	**Site 10**	**Site 11**	**Site 14**	**Site 12**	**Site 15**	**Site 16**
Acenaphthylene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Acenaphthene	—	—	—	—	—	2,000	3,000	—	2,000	—	1,000	—	—	—	—
Fluorene	—	400	—	—	1,000	2,000	4,000	700	2,000	—	1,000	—	—	1,000	—
Phenanthrene	—	1,000	700	900	3,000	4,000	10,000	2,000	10,000	—	3,000	—	6,000	3,000	1,000
Anthracene	—	200	200	—	300	800	1,000	200	300	—	—	—	—	60	—
Fluoranthene	2,000	4,000	2,000	4,000	3,000	10,000	8,000	2,000	10,000	1,000	2,000	2,000	5,000	2,000	1,000
Pyrene	2,000	3,000	2,000	6,000	2,000	20,000	6,000	1,000	6,000	400	800	800	1,000	600	400
Benz[*a*]anthracene	—	1,000	800	1,000	300	2,000	—	100	600	60	—	200	—	80	60
Chrysene	1,000	2,000	1,000	2,000	700	3,000	2,000	400	2,000	200	300	700	—	300	200
Benzo[*b*]fluoranthene	—	1,000	800	2,000	400	2,000	2,000	—	600	—	—	300	—	—	—
Benzo[*k*]fluoranthene	200	600	400	—	—	900	—	—	—	—	—	200	—	—	—
Benzo[*a*]pyrene	—	300	—	500	—	600	200	—	—	—	—	—	—	—	—
Indeno[1,2,3-*cd*]pyrene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dibenz[*a,h*]anthracene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Benzo[*g,h,i*]perylene	—	—	—	300	—	600	300	—	—	—	—	—	—	—	—

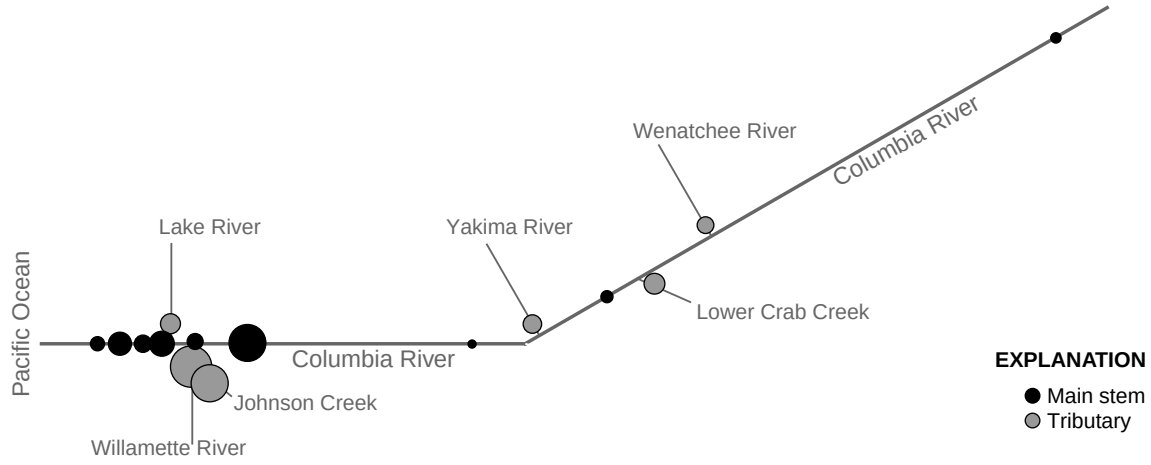

Figure 9. Sum of estimated dissolved concentrations of polynuclear aromatic hydrocarbon compounds during low-flow conditions in the Columbia River Basin, 1997. (Areas of symbols are proportional to the sum of concentrations reported in table 22.)

Table 23. Estimated total concentrations of polycyclic aromatic hydrocarbon compounds during low-flow conditions in the Columbia River Basin, 1997

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period; organic carbon data are given in table D1; total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.40		2.35		2.30		2.30		3.10[b]		1.85		1.85		2.30[c]	
Acenaphthylene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Acenaphthene	3.5	—	—	—	—	—	—	—	—	—	—	2,000	1%	3,000	1%	—	—
Fluorene	3.8	—	—	400	1%	—	—	—	—	1,000	2%	2,000	1%	4,000	1%	700	1%
Phenanthrene	4.1	—	—	1,000	3%	700	3%	1,000	3%	3,000	4%	4,000	2%	10,000	2%	2,000	3%
Anthracene	4.1	—	—	200	3%	200	3%	—	—	300	4%	900	2%	1,000	2%	200	3%
Fluoranthene	4.6	2,000	10%	4,000	9%	2,000	9%	5,000	9%	4,000	12%	10,000	8%	9,000	8%	2,000	9%
Pyrene	4.6	3.000	9%	3,000	8%	2,000	8%	7,000	8%	2,000	11%	20,000	7%	6,000	7%	1,000	8%
Benz[*a*]anthracene	5.2	—	—	2,000	29%	1,000	29%	1,000	29%	500	35%	3,000	24%	—	—	200	29%
Chrysene	5.2	1,000	30%	3,000	29%	2,000	29%	3,000	29%	1,000	35%	4,000	24%	3,000	24%	500	29%
Benzo[*b*]fluoranthene	5.8	—	—	3,000	61%	2,000	61%	4,000	61%	1,000	67%	3,000	55%	4,000	55%	—	—
Benzo[*k*]fluoranthene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Benzo[*a*]pyrene	5.7	—	—	500	51%	—	—	1,000	51%	—	—	1,000	45%	300	45%	—	—
Indeno[1,2,3-*cd*]pyrene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dibenz[*a,h*]anthracene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Benzo[*g,h,i*]perylene	6.4	—	—	—	—	—	—	2,000	85%	—	—	3,000	82%	2,000	82%	—	—

REFERENCES

Anthony, R.G., Garrett, M.G., and Schuler, C.A., 1993, Environmental contaminants in bald eagles in the Columbia River Estuary: Journal of Wildlife Management v., 57, p. 10-19.

Bonn, B.A., 1998, Polychlorinated dibenzo-p-dioxin and dibenzofuran concentration profiles in sediment and fish tissue of the Willamette Basin, Oregon, Environmental Science and Technology, v. 32, no. 6, p. 729-735.

Chiou, C.T., Porter, P.E., and Schmedding, D.W., 1983, Partition equilibria of nonionic organic compounds between soil organic matter and water: Environmental Science and Technology, v. 17, no. 4, p. 227-231.

Curtis, L.R., Carpenter, H.M., Donohoe, R.M., Williams, D.E., Hedstrom, O.R., Deinzer, M.L., Bellstein, M.A., Foster, Eugene, Gates, Richard, 1993, Sensitivity of cytochrome P450-1A1 induction in fish as a biomarker for distribution of TCDD and TCDF in the Willamette River, Oregon: Environmental Science and Technology, v. 27, no. 10, p. 2149-2157.

Edwards, T.K., 1992, Water-quality and flow data for Johnson Creek Basin, Oregon, April 1988 to January 1990: U.S. Geological Survey Open-File Report 92-73, 29 p.

Elliott, J.E., Norstrom, R.J., Lorenzen, A., Hart, L.E., Philibert, H., Kennedy, S.W., Stegeman, J.J., Bellward, G. D., and Cheng, K.M., 1996, Biological effects of polychlorinated dibenzo-p-dioxins, dibenzofurans and biphenyls in eggs of bald eagle (*Haliaeetus leucocephalus*) chicks: Environmental Toxicology and Chemistry, v. 15, p. 782-793.

Elliott, J.D., Henny, C.J., Harris, M.L., Wilson, L.K., and Norstrom, R.J., in press, Chlorinated hydrocarbons in livers of American mink (*Mustela vison*) and river otter (*Lutra canadensis*) from the Columbia and Fraser River basins, 1990-1992: Environmental Monitoring and Assessment, v. 53, p. 1-25.

Elliott, J.E., Norstrom, R.J., and Smith, G.E.J., 1996, Patterns, trends, and toxicological significance of chlorinated hydrocarbon and mercury contaminants in bald eagles eggs from the Pacific Coast of Canada, 1990-1994: Archives of Environmental Contamination and Toxicology, v. 31, p. 354-367.

Embrey, S.S., and Block, E.K., 1995, Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the Columbia Basin Project, Washington, 1991-92: U.S. Geological Survey Water-Resources Investigations Report 95-4007, 144 p.

Fattore, Elena, Benfenati, Emilio, Mariani, Giulio, and Fanelli, Robert, 1997, Patters and sources of polychlorinated dibenzo-p-dioxins and dibenzofurans in sediments from the Venice Lagoon, Italy: Environmental Science and Technology, v. 31, no. 6, p. 1777-1784.

Fuhrer, G.J. 1989, Quality of bottom material and elutriates in the lower Willamette River, Portland Harbor, Oregon: U.S. Geological Survey Water-Resources Investigations Report 89-4005, 30 p.

Fuhrer, G.J., Tanner, D.Q., Morace, J.L., McKenzie, S.W., and Skach, K.A., 1996, Water quality of the Lower Columbia River Basin—Analysis of current and historical water-quality data through 1994: U.S. Geological Survey Water-Resources Investigations Report 95-4294, 157 p.

Gale, R.W., Huckins, J.N., Petty, J.D., Peterman, P.H., Williams, L.L., Morse, Douglas, Schwartz, T.R., and Tillitt, D.E., 1997, Comparison of the uptake of dioxin-like compounds by caged channel catfish and semipermeable membrane devices in the Saginaw River, Michigan: Environmental Science and Technology, v. 31, no. 1, p.178-187.

Gale, R.W., and Orazio, C.E., 1998, Contaminant monitoring in the Lower Columbia River Estuary using semipermeable membrane devices, Part 1. Summer-fall 1997 sampling period: U.S. Geological Survey Columbia Environmental Research Center, Report No.: FY-98-31-21, 44 p., 31 tables.

Gawlik, B.M., Sotiriou, N., Feicht, E.A., Schulte-Hostede, S., and Kettrup, A., 1997, Alternatives for the determination of the soil adsorption coefficient, KOC, of non-ionicorganic compounds—A review: Chemosphere, v. 34, no. 12, p. 2525-2551.

Giesy, J.P., Bowerman, W.W., Mora, M.A., Verbrugge, D.A. Othoudt, R.A., Newsted, J.L., Summer, C.L., Aulerich, R.J., Bursian, S.J., Ludwig, J.P., Dawson, G.A., Kubiak, T.J., Best. D.A., and Tillitt. D.E., 1995, Contaminants in fishes from the Great Lakes-influenced sections and above dams of three Michigan rivers: III. Implications for health of bald eagles: Archives of Environmental Contamination and Toxicology v. 29, p. 309-321.

Gruber, S.J., and Munn, M.D., 1996, Organochlorine pesticides and PCBs in aquatic ecosystems of the Central Columbia Plateau: U.S. Geological Survey Fact Sheet 170-96, 4 p.

Harrison, H.E., Anderson, C.W., Rinella, F.A., Gasser, T.M., and Pogue, T.R. Jr., 1995, Analytical data from phases I and II of the Willamette River Basin water quality study, Oregon, 1992-94: U.S. Geological Survey Open-File Report 95-373, 171 p.

Hawker, D.W., and Connell, D.W., 1988, Octanol-water partition coefficients of polychlorinated biphenyl congeners: Environmental Science and Technology, v. 22, no. 4, p. 382-387.

Henny, C.J., Grove, R.A., and Hedstrom, O.R., 1996, A field evaluation of mink and river otter on the Lower Columbia River and the influence of environmental contaminants, National Biological Service Final Report Submitted to The Lower Columbia River Bi-State Water Quality Program; Oregon Department of Environmental Quality Contract No. 143-94, Washington State Department of Ecology Contract No. C9500038: Corvallis, Oregon, unpaged. [Available from Forest and Rangeland Ecosystem Science Center, U.S. Geological Survey Biological Resources Division, 3080 SE Clearwater Drive, Corvallis, OR 97333]

Hubbard, L.E., Herrett, T.A., Poole, J.E., Ruppert, G.P., and Courts, M.L., 1998, Water Resources Data, Oregon, Water Year 1997: U.S. Geological Survey Water-Data Report OR-97-1, 416 p.

Huckins, J.N., Manuweera, G.K., Petty, J.D., Mackay, Donald., Lebo, J.A., 1993, Lipid-containing semipermeable membrane devices for monitoring organic contaminants in water: Environmental Science and Technology, v. 27, no. 12, p. 2489-2496.

Huckins, J.N., Petty, J.D., Lebo, J.A., Orazio, C.E., Clark, R.C., and Gibson, V.L., 1998, SPMD technology—A tutorial: Columbia, Missouri, 90 p. [Available from Columbia Environmental Research Center, U.S. Geological Survey Biological Resources Division, 4200 New Haven Road, Columbia, MO 65201]

Huckins, J.N., Petty, J.D., Prest, H.F., Lebo, J.A., Orazio, C.E., and Gale, R.W., 1997, Important considerations in semipermeable membrane device (SPMD) design, application, performance and data comparability: Abstracts, 18th Annual Meeting, Society of Environmental Toxicology and Chemistry, San Francisco, CA, November 16-20, p. 206.

Huckins, J.N., Petty, J.D., Prest, H.F., Orazio, C.E., and Clark, R.C., 1999, A guide for the use of semipermeable membrane devices (SPMDs) as samplers of waterborne hydrophobic organic contaminants: American Petroleum Institute Publication No. 4690.

Karickhoff, S.W., 1981, Semi-empirical estimation of sorption of hydrophobic pollutants on natural sediments and soils: Chemosphere, v. 10, no. 8, p. 833-846.

Lower Columbia River Bi-State Steering Committee, 1996, Lower Columbia River Bi-State water quality program—Final executive summary and steering committee recommendations— June 1996: 20 p. [Available from the Lower Columbia River Estuary Program, 811 SW Sixth Avenue, Portland, OR 97204, Phone: 503-229-5247, E-mail: lcrep@deq.state.or.us]

Mackay, Donald, Shiu, Wan Ying, and Ma, Kuo Ching, 1992, Illustrated handbook of physical-chemical properties and environmental fate for organic chemicals—Volume II—Polynuclear aromatic hydrocarbons, polychlorinated dioxins, and dibenzofurans: Chelsea, Michigan, Lewis Publishers, 597 p.

McFarland, V.A., and Clarke, J.U., 1989, Environmental occurrence, abundance and potential toxicity of polychlorinated bipehnyl congeners—Considerations for a congener-specific analysis: Environmental Health Perspectives, v. 81, 225-239.

Meadows, J.C., Echols, K.R., Huckins, J.N., Borsuk, F.A., Carline, R.F., and Tillitt, D.E., 1998, Estimation of uptake rate constants for PCB Congeners accumulated by semipermeable membrane devices and brown trout (Salmo Trutta): Environmental Science and Technology, v. 32, no. 12, p. 1847-1852.

Munn, M.D., and Gruber, S.J., 1997, The relationship between land use and organochlorine compounds in streambed sediment and fish in the Central Columbia Plateau, Washington and Idaho, USA: Environmental Toxicology and Chemistry, v. 16, no 9, p. 1877-1887

Onuska, F.I., 1989, Analysis of polycyclic aromatic hydrocarbons in environmental samples, *in* Afghan, B.K., and Chau, A.S.Y., editors, Analysis of trace organics in the aquatic environment: Boca Raton, Florida, CRC Press, p. 205-241.

Petty, J.D., Huckins, J.N., Orazio, C.E., Lebo, J.A., Clark, R.C., and Gibson, V.L., 1994, Laboratory studies of the use of semipermeable membrane devices (SPMDs) as passive water samplers of polyaromatic hydrocarbon (PAH) priority pollutants—Final report to the American Petroleum Institute on Grant 93-045, National Biological Survey: Columbia, Missouri, unpaged. [Available from Columbia Environmental Research Center, U.S. Geological Survey Biological Resources Division, 4200 New Haven Road, Columbia, MO 65201]

Pirkey, K.D., and Glodt, S.R., 1998, Quality control at the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Fact Sheet FS-026-98, 4 p.

Rinella, F.A., 1993, Evaluation of organic compounds and trace elements in Amazon Creek Basin, Oregon, September, 1990: U.S. Geological Survey Water-Resources Investigations Report 93-4041, 41 p.

Rinella, J.F., McKenzie, S.W., Crawford, J.K., Foreman, W.T., Gates, P.M., Fuhrer, G.J., and Janet, M.L., 1992, Surface-water-quality assessment of the Yakima River Basin, Washington—Pesticide and other trace-organic-compound data for water, sediment, soil, and aquatic biota, 1987-91:U.S. Geological Survey Open-File Report 92-644, 154 p.

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

Tillitt, D.E., Giesy, J.P., and Ankley, G.T., 1991, Characterization of the H4IIE rat hepatoma cell bioassay as a tool for assessing toxic potency of planar halogenated hydrocarbons in environmental samples: Environmental Science and Technology, v. 25, no. 1, p.87-92.

Wagner, R.J., Ebbert, J.C., Roberts, L.M., and Ryker, S.J., 1995, Agricultural pesticide applications and observed concentrations in surface waters from four drainage basins in the Central Columbia Plateau, Washington and Idaho, 1993-94: U.S. Geological Survey Water-Resources Investigations Report 95-4285, 50 p.

Wentz, D.A., Bonn, B.A., Carpenter, K.D., Hinkle, S.R., Janet, M.L., Rinella, F.A., Uhrich, M.A., Waite, I R., Laenen, Antonius, and Bencala, K.E., 1998, Water quality in the Willamette Basin, Oregon, 1991-95: U.S. Geological Survey Circular 1161, 34 p.

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

Wiemeyer, S.N., Bunck, C.M., and Stafford, C.J., 1993, Environmental contaminants in bald eagle eggs—1980-84—and further interpretations of relationships to productivity and shell thickness: Archives of Environmental Contamination and Toxicology, v. 24, p. 213-227.

Wiggins, W.D., Ruppert, G.P., Smith, R.R., Reed, L.L., Hubbard, L.E., and Courts, M.L., 1998, Water Resources Data, Washington, Water Year 1997: U.S. Geological Survey Water-Data Report WA-97-1

Williamson, A.K., Munn, M.D., Ryker, S.J., Wagner, R.J., Ebbert, J.C., and Vanderpool, A.M., 1998, Water quality in the Central Columbia Plateau, Washington and Idaho, 1992-95: U.S. Geological Survey Circular 1144, 35 p.

APPENDIX A

General Chemical Structures of Polychlorinated Dibenzo-*p*-dioxins, Polychlorinated Dibenzofurans, and Polychlorinated Biphenyls

APPENDIX A

The positions of the chlorine substituents in PCDD, PCDF, and PCB molecules are identified by numbers, as shown in figure A1. PCDDs and PCDFs may contain from 1 to 8 chlorine atoms, and PCBs may contain from 1 to 10 chlorine atoms. Individual PCB congeners are also identified by congener numbers (table A1).

numbers indicate the ortho positions for PCBs.)

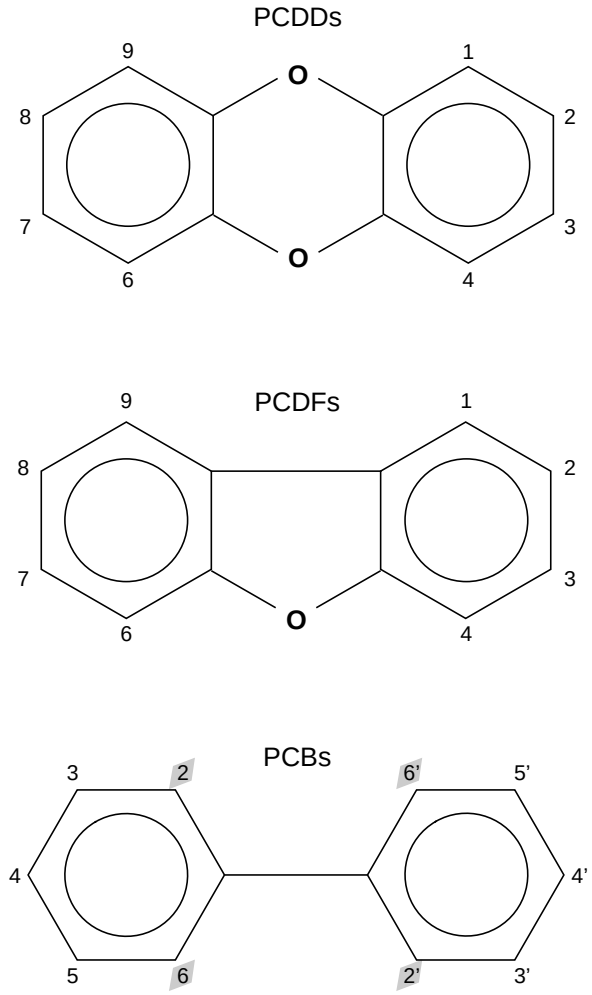

Figure A1. General chemical structures of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polychlorinated biphenyls (PCBs). (Shaded numbers indicate the ortho positions for PCBs.)

Table A1. Congener number and chlorine positions for polychlorinated biphenyls (McFarland and Clarke, 1989)

[Chlorine positions indicate positions of chlorine atoms as illustrated in figure A1]

Congener No.	Chlorine Positions	Congener No.	Chlorine Positions	Congener No.	Chlorine Positions	Congener No.	Chlorine Positions	Congener No.	Chlorine Positions
Monochlorobiphenyls		Tetrachlorobiphenyls		Pentachlorobiphenyls		Hexachlorobiphenyls		Heptachlorobiphenyls	
1	2	40	2,2',3,3'	82	2,2',3,3',4	128	2,2',3,3',4,4'	170	2,2',3,3',4,4',5
2	3	41	2,2',3,4	83	2,2',3,3',5	129	2,2',3,3',4,5	171	2,2',3,3',4,4',6
3	4	42	2,2',3,4'	84	2,2',3,3',6	130	2,2',3,3',4,5'	172	2,2',3,3',4,5,5'
		43	2,2',3,5	85	2,2',3,4,4'	131	2,2',3,3',4,6	173	2,2',3,3',4,5,6
Dichlorobiphenyls		44	2,2',3,5'	86	2,2',3,4,5	132	2,2',3,3',4,6'	174	2,2',3,3',4,5,6'
4	2,2'	45	2,2',3,6	87	2,2',3,4,5'	133	2,2',3,3',5,5'	175	2,2',3,3',4,5',6
5	2,3	46	2,2',3,6'	88	2,2',3,4,6	134	2,2',3,3',5,6	176	2,2',3,3',4,6,6'
6	2,3'	47	2,2',4,4'	89	2,2',3,4,6'	135	2,2',3,3',5,6'	177	2,2',3,3',4',5,6
7	2,4	48	2,2',4,5	90	2,2',3,4',5	136	2,2',3,3',6,6'	178	2,2',3,3',5,5',6
8	2,4'	49	2,2',4,5'	91	2,2',3,4',6	137	2,2',3,4,4',5	179	2,2',3,3',5,6,6'
9	2,5	50	2,2',4,6	92	2,2',3,5,5'	138	2,2',3,4,4',5'	180	2,2',3,4,4',5,5'
10	2,6	51	2,2',4,6'	93	2,2',3,5,6	139	2,2',3,4,4',6	181	2,2',3,4,4',5,6
11	3,3'	52	2,2',5,5'	94	2,2',3,5,6'	140	2,2',3,4,4',6'	182	2,2',3,4,4',5,6'
12	3,4	53	2,2',5,6'	95	2,2',3,5',6	141	2,2',3,4,5,5'	183	2,2',3,4,4',5',6
13	3,4'	54	2,2',6,6'	96	2,2',3,6,6'	142	2,2',3,4,5,6	184	2,2',3,4,4',6,6'
14	3,5	55	2,3,3',4	97	2,2',3',4,5	143	2,2',3,4,5,6'	185	2,2',3,4,5,5',6
15	4,4'	56	2,3,3',4'	98	2,2',3',4,6	144	2,2',3,4,5',6	186	2,2',3,4,5,6,6'
		57	2,3,3',5	99	2,2',4,4',5	145	2,2',3,4,6,6'	187	2,2',3,4',5,5',6
Trichlorobiphenyls		58	2,3,3',5'	100	2,2',4,4',6	146	2,2',3,4',5,5'	188	2,2',3,4',5,6,6'
16	2,2',3	59	2,3,3',6	101	2,2',4,5,5'	147	2,2',3,4',5,6	189	2,3,3',4,4',5,5'
17	2,2',4	60	2,3,4,4'	102	2,2',4,5,6'	148	2,2',3,4',5,6'	190	2,3,3',4,4',5,6
18	2,2',5	61	2,3,4,5	103	2,2',4,5',6	149	2,2',3,4',5',6	191	2,3,3',4,4',5',6
19	2,2',6	62	2,3,4,6	104	2,2',4,6,6'	150	2,2',3,4',6,6'	192	2,3,3',4,5,5',6
20	2,3,3'	63	2,3,4',5	105	2,3,3',4,4'	151	2,2',3,5,5',6	193	2,3,3',4,',5,5',6
21	2,3,4	64	2,3,4',6	106	2,3,3',4,5	152	2,2',3,5,6,6'		
22	2,3,4'	65	2,3,5,6	107	2,3,3',4',5	153	2,2',4,4',5,5'	Octachlorobiphenyls	
23	2,3,5	66	2,3',4,4'	108	2,3,3',4,5'	154	2,2',4,4',5,6'	194	2,2',3,3',4,4',5,5'
24	2,3,6	67	2,3',4,5	109	2,3,3',4,6	155	2,2',4,4',6,6'	195	2,2',3,3',4,4',5,6
25	2,3',4	68	2,3',4,5'	110	2,3,3',4',6	156	2,3,3',4,4',5	196	2,2',3,3',4,4',5,6'
26	2,3',5	69	2,3',4,6	111	2,3,3',5,5'	157	2,3,3',4,4',5'	197	2,2',3,3',4,4',6,6'
27	2,3',6	70	2,3',4',5	112	2,3,3',5,6	158	2,3,3',4,4',6	198	2,2',3,3',4,5,5',6
28	2,4,4'	71	2,3',4',6	113	2,3,3',5',6	159	2,3,3',4,5,5'	199	2,2',3,3',4,5,5',6'
29	2,4,5	72	2,3',5,5'	114	2,3,4,4',5	160	2,3,3',4,5,6	200	2,2',3,3',4,5,6,6'
30	2,4,6	73	2,3',5',6	115	2,3,4,4',6	161	2,3,3',4,5',6	201	2,2',3,3',4,5',6,6'
31	2,4',5	74	2,4,4',5	116	2,3,4,5,6	162	2,3,3',4',5,5'	202	2,2',3,3',5,5',6,6'
32	2,4',6	75	2,4,4',6	117	2,3,4',5,6	163	2,3,3',4',5,6	203	2,2',3,4,4',5,5',6
33	2',3,4	76	2',3,4,5	118	2,3',4,4',5	164	2,3,3',4',5',6	204	2,2',3,4,4',5,6,6'
34	2',3,5	77	3,3',4,4'	119	2,3',4,4',6	165	2,3,3',5,5',6	205	2,3,3',4,4',5,5',6
35	3,3',4	78	3,3',4,5	120	2,3',4,5,5'	166	2,3,4,4',5,6		
36	3,3',5	79	3,3',4,5'	121	2,3',4,5',6	167	2,3',4,4',5,5'	Nonachlorobiphenyls	
37	3,4,4'	80	3,3',5,5'	122	2',3,3',4,5	168	2,3',4,4',5',6	206	2,2',3,3',4,4',5,5',6
38	3,4,5	81	3,4,4',5	123	2',3,4,4',5	169	3,3',4,4',5,5'	207	2,2',3,3',4,4',5,6,6'
39	3,4',5			124	2',3,4,5,5'			208	2,2',3,3',4,5,5',6,6'
				125	2',3,4,5,6'				
				126	3,3',4,4',5			Decachlorobiphenyl	
				127	3,3',4,5,5'			209	2,2',3,3',4,4',5,5',6,6'

APPENDIX B

Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds Accumulated in Field Blanks During Low-Flow Conditions, 1997

Table B1. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in picograms (10^{-12} grams) per SPMD, are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary sites]

	Willamette River (101)	Umatilla (289)	Lower Crab Creek (411)	Northport (735)
	Site 06	Site 10	Site 12	Site 16
Polychlorinated dibenzo-*p*-dioxins:				
2,3,7,8-Tetra	ND	ND	ND	ND
Total Tetra	ND	ND	ND	ND
1,2,3,7,8-Penta	ND	ND	ND	ND
Total Penta	ND	ND	ND	ND
1,2,3,4,7,8-Hexa	ND	ND	ND	ND
1,2,3,6,7,8-Hexa	ND	ND	ND	ND
1,2,3,7,8,9-Hexa	ND	ND	ND	ND
Total Hexa	ND	ND	ND	ND
1,2,3,4,6,7,8-Hepta	ND	ND	ND	NQ
Total Hepta	NQ	NQ	NQ	NQ
Octa	NQ	NQ	NQ	NQ
Polychlorinated dibenzofurans:				
2,3,7,8-Tetra	ND	ND	ND	ND
Total Tetra	NQ	ND	ND	ND
1,2,3,7,8-Penta	ND	ND	ND	ND
2,3,4,7,8-Penta	ND	ND	ND	ND
Total Penta	ND	ND	ND	ND
1,2,3,4,7,8-Hexa	ND	ND	ND	ND
1,2,3,6,7,8-Hexa	ND	ND	ND	ND
1,2,3,7,8,9-Hexa	ND	ND	ND	ND
2,3,4,6,7,8-Hexa	ND	ND	ND	ND
Total Hexa	ND	ND	ND	ND
1,2,3,4,6,7,8-Hepta	ND	ND	ND	ND
1,2,3,4,7,8,9-Hepta	ND	ND	ND	ND
Total Hepta	NQ	ND	ND	NQ
Octa	9.9	9.9	27.	12.

Table B2. *Ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary sites; see Appendix A for general chemical structures of congeners]

Congener No.	Willamette River (101)	Umatilla (289)	Lower Crab Creek (411)	Northport (735)
	Site 06	Site 10	Site 12	Site 16
4 & 10	ND	ND	2.5	NQ
7 & 9	NQ	ND	ND	NQ
6	ND	ND	ND	ND
5 & 8	ND	ND	ND	ND
19	NQ	ND	ND	ND
18	0.73	0.64	1.1	0.67
17 & 15	0.40	0.35	NQ	0.36
24 & 27	NQ	ND	ND	NQ
16 & 32	0.46	0.46	0.79	0.47
29	ND	NQ	ND	ND
26	NQ	NQ	ND	NQ
25	0.12	NQ	0.43	NQ
31	0.48	0.40	0.96	0.40
28	0.76	0.67	1.2	0.65
20 & 33	0.62	0.55	0.98	0.55
53	0.25	NQ	ND	NQ
51	ND	ND	ND	ND
22	0.28	0.25	0.42	0.25
45	NQ	0.15	ND	NQ
46	ND	NQ	ND	ND
52	0.76	0.63	1.4	0.59
43	ND	ND	ND	ND
49	0.48	0.40	0.86	0.39
47	0.25	0.23	NQ	NQ
48	0.34	0.30	NQ	0.31
44	0.59	0.45	1.3	0.50
42	0.19	0.24	0.41	0.24
41	0.22	0.19	NQ	0.17
64	0.29	0.27	0.64	0.24
40	NQ	NQ	ND	NQ
67	ND	ND	ND	ND
63	ND	ND	ND	ND
74	0.12	0.13	0.23	0.12
70 & 76	0.40	0.41	0.93	0.31
66	NQ	NQ	NQ	NQ
95	NQ	NQ	NQ	NQ
91	ND	ND	ND	ND

Table B2. *Ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary sites; see Appendix A for general chemical structures of congeners]

Congener No.	Willamette River (101)	Umatilla (289)	Lower Crab Creek (411)	Northport (735)
	Site 06	Site 10	Site 12	Site 16
56 & 60	NQ	NQ	NQ	NQ
92	0.12	NQ	NQ	NQ
84	NQ	NQ	NQ	NQ
101	0.42	NQ	NQ	NQ
99	ND	NQ	ND	NQ
119	ND	ND	ND	ND
83	ND	ND	ND	ND
97	NQ	NQ	ND	NQ
87	0.13	NQ	0.36	NQ
136	ND	ND	ND	ND
110	0.25	0.16	0.61	0.17
82	ND	NQ	ND	ND
151	NQ	NQ	NQ	NQ
135 & 144 & 124	NQ	ND	NQ	ND
147	ND	NQ	ND	ND
107	ND	ND	ND	ND
123 & 149	0.15	0.14	0.42	0.12
118	NQ	NQ	NQ	NQ
134	ND	ND	ND	ND
114	NQ	NQ	NQ	NQ
131 & 122	ND	0.66	ND	0.77
146	ND	ND	ND	ND
153	ND	ND	ND	ND
132	0.09	0.22	0.32	ND
105	NQ	ND	NQ	ND
141	NQ	ND	NQ	NQ
179	ND	ND	ND	NQ
137	ND	ND	ND	ND
176	ND	ND	ND	ND
130	ND	ND	ND	ND
138	NQ	ND	NQ	ND
158	ND	ND	ND	ND
129	ND	ND	ND	ND
178	ND	ND	ND	ND
182 & 187	ND	ND	ND	ND
183	ND	ND	ND	ND
128	ND	ND	ND	ND
167	ND	ND	ND	ND

Table B2. *Ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary sites; see Appendix A for general chemical structures of congeners]

Congener No.	Willamette River (101)	Umatilla (289)	Lower Crab Creek (411)	Northport (735)
	Site 06	Site 10	Site 12	Site 16
185	ND	ND	ND	ND
174	ND	ND	ND	NQ
177	ND	ND	ND	ND
171 & 202	ND	ND	ND	ND
156	ND	ND	ND	ND
173	ND	ND	ND	ND
201	ND	ND	ND	ND
157	ND	ND	ND	ND
172	ND	ND	ND	ND
197	ND	ND	ND	ND
180	NQ	NQ	NQ	ND
193	ND	ND	ND	ND
191	ND	ND	ND	ND
200	ND	ND	ND	ND
170 & 190	ND	ND	ND	ND
198	ND	NQ	ND	ND
199	ND	ND	ND	ND
196 & 203	ND	ND	ND	ND
189	ND	ND	ND	ND
208 & 195	ND	ND	ND	ND
207	ND	ND	ND	ND
194	ND	ND	ND	ND
205	ND	ND	ND	ND
206	ND	ND	ND	ND
209	0.24	0.18	2.4	NQ
Total quantified *ortho*-substituted PCBs	9.1	8.0	18.	7.2

Table B3. Non-*ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in picograms (10^{-12} grams) per SPMD, are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary sites; see Appendix A for general chemical structures of congeners]

Congener No.	Willamette River (101)	Umatilla (289)	Lower Crab Creek (411)	Northport (735)
	Site 06	Site 10	Site 12	Site 16
37	34	77	35	53
81	NQ	NQ	ND	NQ
77	10	11	ND	9.6
126	ND	NQ	NQ	NQ
169	ND	ND	ND	ND

Table B4. Organochlorine pesticides and related transformation products accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary sites]

	Willamette River (101)	Umatilla (289)	Lower Crab Creek (411)	Northport (735)
	Site 06	Site 10	Site 12	Site 16
Hexachlorobenzene	ND	ND	ND	ND
Pentachloroanisole	NQ	NQ	ND	NQ
alpha-hexachlorocyclohexane	ND	ND	ND	ND
Lindane	ND	NQ	ND	NQ
beta-hexachlorocyclohexane	ND	ND	ND	ND
Heptachlor	0.8	0.4	NQ	0.6
delta-hexachlorocyclohexane	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND
Dacthal	ND	ND	ND	ND
Oxychlordane	NQ	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND
trans-Chlordane	0.7	1.8	2.1	2.2
trans-Nonachlor	0.3	0.5	NQ	0.7
o,p'-DDE	ND	ND	ND	NQ
cis-Chlordane	1.4	1.5	1.6	2.2
p,p'-DDE	NQ	NQ	ND	NQ
Dieldrin	NQ	NQ	NQ	NQ
o,p'-DDD	ND	ND	ND	ND
Endrin	ND	ND	ND	ND
o,p'-DDT	ND	NQ	ND	0.4
cis-Nonachlor	ND	ND	ND	ND
p,p'-DDD	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND
Mirex	ND	ND	ND	ND

Table B5. Polycyclic aromatic hydrocarbon compounds accumulated in field blanks exposed during low-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1997

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries and procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded columns indicate tributary sites]

	Willamette River (101)	Umatilla (289)	Lower Crab Creek (411)	Northport (735)
	Site 06	Site 10	Site 12	Site 16
Acenaphthylene	ND	ND	ND	2
Acenaphthene	ND	ND	ND	NQ
Fluorene	ND	NQ	ND	5
Phenanthrene	20	26	30	24
Anthracene	NQ	ND	NQ	2
Fluoranthene	10	7	13	11
Pyrene	9	6	11	10
Benz[*a*]anthracene	NQ	1	ND	NQ
Chrysene	NQ	1	NQ	1
Benzo[*b*]fluoranthene	ND	ND	ND	ND
Benzo[*k*]fluoranthene	ND	ND	ND	ND
Benzo[*a*]pyrene	ND	ND	ND	ND
Indeno[*1,2,3,c,d*]pyrene	ND	ND	ND	ND
Dibenz[*a,h*]anthracene	ND	ND	ND	ND
Benzo[*g,h,i*]perylene	ND	ND	ND	ND

APPENDIX C

Partition Coefficients, Sampling Rates, and Equations used to Estimate Dissolved Concentrations of Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds During Low-Flow Conditions, 1997

Table C1. Partition coefficients and sampling rates used for estimating dissolved concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during low-flow and high-flow conditions in the Columbia River Basin, 1997 and 1998

[K_{SPMD}, SPMD-water partition coefficient; R, sampling rate in liters per day, based on a linear regression[a] of PCB field data (Meadows *et al*., 1998)]]

Congener No.	log K_{SPMD}[b]	R
Polychlorinated dioxins:		
2,3,7,8-Tetra	6.3	3.8
Total Tetra	6.3	3.8
1,2,3,7,8-Penta	6.8	2.6
Total Penta	6.8	2.6
1,2,3,4,7,8-Hexa	7.5	0.8
1,2,3,6,7,8-Hexa	7.5	0.8
1,2,3,7,8,9-Hexa	7.5	0.8
Total Hexa	7.5	0.8
1,2,3,4,6,7,8-Hepta	7.5	0.8
Total Hepta	7.5	0.8
Octa	7.7	0.3
Polychlorinated dibenzofurans:		
2,3,7,8-Tetra	5.6	5.5
Total Tetra	5.6	5.5
1,2,3,7,8-Penta	6.0	4.5
2,3,4,7,8-Penta	6.0	4.5
Total Penta	6.0	4.5
1,2,3,4,7,8-Hexa	6.5	3.3
1,2,3,6,7,8-Hexa	6.5	3.3
1,2,3,7,8,9-Hexa	6.5	3.3
2,3,4,6,7,8-Hexa	6.5	3.3
Total Hexa	6.5	3.3
1,2,3,4,6,7,8-Hepta	6.9	2.3
1,2,3,4,7,8,9-Hepta	6.4	3.6
Total Hepta	6.6	2.9
Octa	7.1	1.8

[a] $R = -2.5\ log(K_{ow}) + 20.7$; K_{ow} values for hexa- and heptachloro dibenzo-*p*-dioxin congeners were taken from Mackay *et al*. (1992); value for 1,2,3,4,7,8-hexachloro congener was used to approximate value for 1,2,3,6,7,8-hexachloro congener; K_{ow} values for other congeners were taken from Gale *et al*. (1997); K_{ow} values for homolog totals were estimated from the average K_{ow} values of the individual congeners quantified.

[b] K_{SPMD} values were estimated from K_{ow} values of Hawker and Connell (1988) using the approximation $K_{SPMD} = 0.3K_{ow}$ (Huckins *et al*., 1993).

Table C2. Partition coefficients, sampling rates, and equations for estimating dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during low-flow and high-flow conditions in the Columbia River Basin, 1997 and 1998

[K_{SPMD}, SPMD-water partition coefficient; R, sampling rate in liters per day, based on field data (Meadows *et al*., 1998); see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{SPMD}[a]	R	Equation Used	Congener No.	Log K_{SPMD}[a]	R	Equation Used	Congener No.	Log K_{SPMD}[a]	R	Equation Used
6	4.5	12.9	(1)	63	5.6	5.3	(3)	105	6.1	4.0	(3)
19	4.5	5.3	(1)	74	5.7	6.2	(3)	141	6.3	4.9	(3)
18	4.7	9.3	(1)	66	5.7	5.3	(3)	179	6.2	2.2	(3)
26	5.1	5.8	(3)	95	5.6	6.2	(3)	137	6.3	3.6	(3)
25	5.1	5.8	(3)	91	5.6	4.4	(3)	176	6.2	2.2	(3)
31	5.1	7.1	(3)	92	5.8	5.3	(3)	130	6.3	4.0	(3)
28	5.1	8.4	(3)	84	5.5	4.4	(3)	138	6.3	4.9	(3)
53	5.1	4.9	(3)	101	5.9	6.2	(3)	158	6.5	3.6	(3)
51	5.1	4.9	(3)	99	5.9	4.4	(3)	129	6.2	3.6	(3)
22	5.1	5.8	(3)	119	6.1	4.4	(3)	178	6.6	3.1	(3)
45	5.0	8.0	(3)	83	5.7	4.9	(3)	183	6.7	3.1	(3)
46	5.0	4.4	(3)	97	5.8	4.4	(3)	128	6.2	4.4	(3)
52	5.3	6.2	(3)	87	5.8	5.3	(3)	174	6.6	3.1	(3)
43	5.2	6.2	(3)	136	5.7	5.3	(3)	177	6.6	3.1	(3)
49	5.3	5.3	(3)	110	6.0	5.8	(3)	156	6.7	2.7	(3)
47	5.3	7.5	(3)	82	5.7	4.4	(3)	201	6.7	1.8	(3)
48	5.3	3.6	(3)	151	6.1	5.3	(3)	157	6.7	2.7	(3)
44	5.2	7.5	(3)	107	6.2	5.3	(3)	172	6.8	1.3	(3)
42	5.2	6.2	(3)	118	6.2	4.9	(3)	180	6.8	2.7	(3)
41	5.2	6.2	(3)	134	6.0	4.9	(3)	199	7.1	1.8	(3)
64	5.4	7.5	(3)	114	6.1	4.4	(3)	207	7.2	0.3	(3)
40	5.1	6.7	(3)	146	6.4	4.9	(3)	194	7.3	1.3	(3)
67	5.7	5.3	(3)	153	6.4	3.6	(3)				

[a]K_{SPMD} values were estimated from K_{ow} values using the approximation $K_{SPMD} = 0.3K_{ow}$ (Huckins *et al*., 1993); K_{ow} values were obtained from Environmental Science Center Syracuse Research Corporation on-line database (accessed October 20, 1998, at http://esc.syrres.com/~esc1/kowexpdb.htm).

Table C3. Partition coefficients and sampling rates used for estimating dissolved concentrations of non-*ortho*-substituted polychlorinated biphenyls during low-flow and high-flow conditions in the Columbia River Basin, 1997 and 1998

[K_{SPMD}, SPMD-water partition coefficient; R, sampling rate in liters per day, based on a linear regression[a] of *ortho*-substituted PCB field data (Meadows *et al*., 1998); see Appendix A for general chemical structures of congeners]

Congener No.	log K_{SPMD}[b]	R
37	5.3	6.2
81	5.8	4.9
77	5.8	4.9
126	6.4	3.6
169	6.9	2.3

[a]K_{SPMD} values were estimated from K_{ow} values using the approximation $K_{SPMD} = 0.3K_{ow}$ (Huckins *et al*., 1993); K_{ow} values were obtained from Environmental Science Center Syracuse Research Corporation on-line database (accessed October 20, 1998, at http://esc.syrres.com/~esc1/kowexpdb.htm).

Table C4. Partition coefficients, sampling rates, and equations for estimating dissolved concentrations of organochlorine pesticides and related transformation products during low-flow conditions in the Columbia River Basin, 1997

[K_{SPMD}, SPMD-water partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); R, temperature-dependent sampling rate in liters per day, based on laboratory data (Huckins *et al*., 1999); shaded columns indicate tributary sites; —, all information required for calculation is not available]

		Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
	log K_{SPMD}[a]	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
Hexachlorobenzene	5.2	5.6	(3)	5.6	(3)	5.6	(3)	5.6	(3)	2.6	(3)	5.6	(3)	3.6	(3)	3.1	(3)
Pentachloroanisole	4.9	9.5	(1)	9.5	(1)	9.5	(1)	9.5	(1)	5.1	(3)	9.5	(1)	4.9	(3)	5.0	(3)
alpha-hexachlorocyclohexane	3.3	2.7	(4)	2.7	(4)	2.7	(4)	2.7	(4)	0.9	(4)	2.7	(4)	1.4	(4)	1.2	(4)
Lindane	3.2	1.7	(4)	1.7	(4)	1.7	(4)	1.7	(4)	0.7	(4)	1.7	(4)	1.1	(4)	0.9	(4)
beta-hexachlorocyclohexane	3.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	5.6	—	—	—	—	—	—	—	—	3.6	(3)	—	—	—	—	—	—
delta-hexachlorocyclohexane	3.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	6.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	3.9	1.9	(1)	1.9	(1)	1.9	(1)	1.9	(1)	0.6	(3)	1.9	(1)	1.8	(1)	1.2	(1)
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	4.5	8.3	(1)	8.3	(1)	8.3	(1)	8.3	(1)	2.9	(1)	8.3	(1)	3.6	(1)	3.3	(1)
trans-Chlordane	5.7	6.1	(3)	6.1	(3)	6.1	(3)	6.1	(3)	3.5	(3)	6.1	(3)	3.1	(3)	3.3	(3)
trans-Nonachlor	5.8	5.7	(3)	5.7	(3)	5.7	(3)	5.7	(3)	3.6	(3)	5.7	(3)	2.8	(3)	3.2	(3)
o,p'-DDE	5.5	6.3	(3)	6.3	(3)	6.3	(3)	6.3	(3)	3.3	(3)	6.3	(3)	3.7	(3)	3.5	(3)
cis-Chlordane	5.6	6.1	(3)	6.1	(3)	6.1	(3)	6.1	(3)	3.8	(3)	6.1	(3)	2.8	(3)	3.3	(3)
p,p'-DDE	6.0	10.5	(3)	10.5	(3)	10.5	(3)	10.5	(3)	5.5	(3)	10.5	(3)	6.9	(3)	6.2	(3)
Dieldrin	4.9	5.2	(3)	5.2	(3)	5.2	(3)	5.2	(3)	1.8	(3)	5.2	(3)	4.0	(3)	2.9	(3)
o,p'-DDD	5.4	5.5	(3)	5.5	(3)	5.5	(3)	5.5	(3)	3.3	(3)	5.5	(3)	3.3	(3)	3.3	(3)
Endrin	4.7	7.8	(1)	7.8	(1)	7.8	(1)	7.8	(1)	3.1	(3)	7.8	(1)	4.9	(1)	4.0	(3)
o,p'-DDT	6.3	4.5	(3)	4.5	(3)	4.5	(3)	4.5	(3)	2.2	(3)	4.5	(3)	4.3	(3)	3.3	(3)
cis-Nonachlor	5.6	4.9	(3)	4.9	(3)	4.9	(3)	4.9	(3)	2.8	(3)	4.9	(3)	3.0	(3)	2.9	(3)
p,p'-DDD	5.5	6.3	(3)	6.3	(3)	6.3	(3)	6.3	(3)	3.1	(3)	6.3	(3)	3.8	(3)	3.5	(3)
p,p'-DDT	6.4	5.6	(3)	5.6	(3)	5.6	(3)	5.6	(3)	3.2	(3)	5.6	(3)	5.6	(3)	4.4	(3)
Methoxychlor	4.6	4.5	(1)	4.5	(1)	4.5	(1)	4.5	(1)	1.5	(3)	4.5	(1)	6.2	(1)	3.9	(1)
Mirex	6.4	7.6	(3)	7.6	(3)	7.6	(3)	7.6	(3)	4.7	(3)	7.6	(3)	5.0	(3)	4.9	(3)

Table C4. Partition coefficients, sampling rates, and equations for estimating dissolved concentrations of organochlorine pesticides and related transformation products during low-flow conditions in the Columbia River Basin, 1997—Continued

[K_{SPMD}, SPMD-water partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); R, temperature-dependent sampling rate in liters per day, based on laboratory data (Huckins *et al*., 1999); shaded columns indicate tributary sites; —, all information required for calculation is not available]

		Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
	log K_{SPMD}[a]	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
Hexachlorobenzene	5.2	3.1	(3)	5.6	(3)	5.6	(3)	3.6	(3)	5.6	(3)	3.6	(3)	3.6	(3)
Pentachloroanisole	4.9	5.0	(3)	9.5	(1)	9.5	(1)	4.9	(3)	9.5	(1)	4.9	(3)	4.9	(3)
alpha-hexachlorocyclohexane	3.3	1.2	(4)	2.7	(4)	2.7	(4)	1.4	(4)	2.7	(4)	1.4	(4)	1.4	(4)
Lindane	3.2	0.9	(4)	1.7	(4)	1.7	(4)	1.1	(4)	1.7	(4)	1.1	(4)	1.1	(4)
beta-hexachlorocyclohexane	3.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	5.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
delta-hexachlorocyclohexane	3.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	6.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	3.9	1.2	(1)	1.9	(1)	1.9	(1)	1.8	(1)	1.9	(1)	1.8	(1)	1.8	(1)
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	4.5	3.3	(1)	8.3	(1)	8.3	(1)	3.6	(1)	8.3	(1)	3.6	(1)	3.6	(1)
trans-Chlordane	5.7	3.3	(3)	6.1	(3)	6.1	(3)	3.1	(3)	6.1	(3)	3.1	(3)	3.1	(3)
trans-Nonachlor	5.8	3.2	(3)	5.7	(3)	5.7	(3)	2.8	(3)	5.7	(3)	2.8	(3)	2.8	(3)
o,p'-DDE	5.5	3.5	(3)	6.3	(3)	6.3	(3)	3.7	(3)	6.3	(3)	3.7	(3)	3.7	(3)
cis-Chlordane	5.6	3.3	(3)	6.1	(3)	6.1	(3)	2.8	(3)	6.1	(3)	2.8	(3)	2.8	(3)
p,p'-DDE	6.0	6.2	(3)	10.5	(3)	10.5	(3)	6.9	(3)	10.5	(3)	6.9	(3)	6.9	(3)
Dieldrin	4.9	2.9	(3)	5.2	(3)	5.2	(3)	4.0	(3)	5.2	(3)	4.0	(3)	4.0	(3)
o,p'-DDD	5.4	3.3	(3)	5.5	(3)	5.5	(3)	3.3	(3)	5.5	(3)	3.3	(3)	3.3	(3)
Endrin	4.7	4.0	(3)	7.8	(1)	7.8	(1)	4.9	(1)	7.8	(1)	4.9	(1)	4.9	(1)
o,p'-DDT	6.3	3.3	(3)	4.5	(3)	4.5	(3)	4.3	(3)	4.5	(3)	4.3	(3)	4.3	(3)
cis-Nonachlor	5.6	2.9	(3)	4.9	(3)	4.9	(3)	3.0	(3)	4.9	(3)	3.0	(3)	3.0	(3)
p,p'-DDD	5.5	3.5	(3)	6.3	(3)	6.3	(3)	3.8	(3)	6.3	(3)	3.8	(3)	3.8	(3)
p,p'-DDT	6.4	4.4	(3)	5.6	(3)	5.6	(3)	5.6	(3)	5.6	(3)	5.6	(3)	5.6	(3)
Methoxychlor	4.6	3.9	(1)	4.5	(1)	4.5	(1)	6.2	(1)	4.5	(1)	6.2	(1)	6.2	(1)
Mirex	6.4	4.9	(3)	7.6	(3)	7.6	(3)	5.0	(3)	7.6	(3)	5.0	(3)	5.0	(3)

[a]K_{SPMD} values were estimated from K_{ow} values using the approximation $K_{SPMD} = 0.3K_{ow}$ (Huckins *et al*., 1993); K_{ow} values were obtained from Environmental Science Center Syracuse Research Corporation on-line database (accessed October 20, 1998, at http://esc.syrres.com/~esc1/kowexpdb.htm).

Table C5. Partition coefficients, sampling rates, and equations for estimating dissolved concentrations of polycyclic aromatic hydrocarbon compounds during low-flow conditions in the Columbia River Basin, 1997

[K_{SPMD}, SPMD-water partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); R, temperature-dependent sampling rate in liters per day, based on laboratory data (Huckins *et al*., 1999); shaded columns indicate tributary sites; —, no value available.]

		Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
	log K_{SPMD}[a]	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used
Acenaphthylene	3.6	1.6	(1)	1.6	(1)	1.6	(1)	1.6	(1)	2.3	(4)	1.6	(1)	1.4	(1)	1.9	(4)
Acenaphthene	4.1	2.4	(1)	2.4	(1)	2.4	(1)	2.4	(1)	2.7	(1)	2.4	(1)	2.3	(1)	2.5	(1)
Fluorene	4.2	2.3	(1)	2.3	(1)	2.3	(1)	2.3	(1)	3.0	(1)	2.3	(1)	1.7	(1)	2.4	(1)
Phenanthrene	4.5	4.0	(1)	4.0	(1)	4.0	(1)	4.0	(1)	3.9	(1)	4.0	(1)	3.4	(1)	3.7	(1)
Anthracene	4.7	3.7	(3)	3.7	(3)	3.7	(3)	3.7	(3)	3.0	(3)	3.7	(3)	3.6	(3)	3.3	(3)
Fluoranthene	4.7	5.9	(1)	5.9	(1)	5.9	(1)	5.9	(1)	4.3	(3)	5.9	(1)	4.6	(3)	4.5	(3)
Pyrene	—	6.6	(3)	6.6	(3)	6.6	(3)	6.6	(3)	5.1	(3)	6.6	(3)	5.2	(3)	5.2	(3)
Benz[*a*]anthracene	—	4.6	(3)	4.6	(3)	4.6	(3)	4.6	(3)	3.6	(3)	4.6	(3)	3.6	(3)	3.6	(3)
Chrysene	—	6.3	(3)	6.3	(3)	6.3	(3)	6.3	(3)	4.0	(3)	6.3	(3)	5.1	(3)	4.6	(3)
Benzo[*b*]fluoranthene	—	3.5	(3)	3.5	(3)	3.5	(3)	3.5	(3)	3.2	(3)	3.5	(3)	3.4	(3)	3.3	(3)
Benzo[*k*]fluoranthene	—	5.1	(3)	5.1	(3)	5.1	(3)	5.1	(3)	3.4	(3)	5.1	(3)	4.0	(3)	3.7	(3)
Benzo[*a*]pyrene	—	5.0	(3)	5.0	(3)	5.0	(3)	5.0	(3)	3.5	(3)	5.0	(3)	4.3	(3)	3.9	(3)
Indeno[1,2,3-*cd*]pyrene	—	4.5	(3)	4.5	(3)	4.5	(3)	4.5	(3)	3.3	(3)	4.5	(3)	4.2	(3)	3.8	(3)
Dibenz[*a,h*]anthracene	—	3.2	(3)	3.2	(3)	3.2	(3)	3.2	(3)	2.3	(3)	3.2	(3)	3.3	(3)	2.8	(3)
Benzo[*g,h,i*]perylene	—	2.5	(3)	2.5	(3)	2.5	(3)	2.5	(3)	1.9	(3)	2.5	(3)	2.4	(3)	2.2	(3)

Table C5. Partition coefficients, sampling rates, and equations for estimating dissolved concentrations of polycyclic aromatic hydrocarbon compounds during low-flow conditions in the Columbia River Basin, 1997—Continued

[K_{SPMD}, SPMD-water partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); R, temperature-dependent sampling rate in liters per day, based on laboratory data (Huckins *et al*., 1999); shaded columns indicate tributary sites; —, no value available.]

		Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
	log K_{SPMD}[a]	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used
Acenaphthylene	3.6	1.9	(4)	1.6	(4)	1.6	(1)	1.4	(1)	1.6	(1)	1.4	(1)	1.4	(1)
Acenaphthene	4.1	2.5	(1)	2.4	(1)	2.4	(1)	2.3	(1)	2.4	(1)	2.3	(1)	2.3	(1)
Fluorene	4.2	2.4	(1)	2.3	(1)	2.3	(1)	1.7	(1)	2.3	(1)	1.7	(1)	1.7	(1)
Phenanthrene	4.5	3.7	(1)	4.0	(1)	4.0	(1)	3.4	(1)	4.0	(1)	3.4	(1)	3.4	(1)
Anthracene	4.7	3.3	(3)	3.7	(3)	3.7	(3)	3.6	(3)	3.7	(3)	3.6	(3)	3.6	(3)
Fluoranthene	4.7	4.5	(3)	5.9	(1)	5.9	(1)	4.6	(3)	5.9	(1)	4.6	(3)	4.6	(3)
Pyrene	—	5.2	(3)	6.6	(3)	6.6	(3)	5.2	(3)	6.6	(3)	5.2	(3)	5.2	(3)
Benz[*a*]anthracene	—	3.6	(3)	4.6	(3)	4.6	(3)	3.6	(3)	4.6	(3)	3.6	(3)	3.6	(3)
Chrysene	—	4.6	(3)	6.3	(3)	6.3	(3)	5.1	(3)	6.3	(3)	5.1	(3)	5.1	(3)
Benzo[*b*]fluoranthene	—	3.3	(3)	3.5	(3)	3.5	(3)	3.4	(3)	3.5	(3)	3.4	(3)	3.4	(3)
Benzo[*k*]fluoranthene	—	3.7	(3)	5.1	(3)	5.1	(3)	4.0	(3)	5.1	(3)	4.0	(3)	4.0	(3)
Benzo[*a*]pyrene	—	3.9	(3)	5.0	(3)	5.0	(3)	4.3	(3)	5.0	(3)	4.3	(3)	4.3	(3)
Indeno[1,2,3-*cd*]pyrene	—	3.8	(3)	4.5	(3)	4.5	(3)	4.2	(3)	4.5	(3)	4.2	(3)	4.2	(3)
Dibenz[*a,h*]anthracene	—	2.8	(3)	3.2	(3)	3.2	(3)	3.3	(3)	3.2	(3)	3.3	(3)	3.3	(3)
Benzo[*g,h,i*]perylene	—	2.2	(3)	2.5	(3)	2.5	(3)	2.4	(3)	2.5	(3)	2.4	(3)	2.4	(3)

[a]K_{SPMD} values from Huckins *et al*. (1999).

APPENDIX D

Suspended and Dissolved Organic Carbon During Low-Flow Conditions, 1997

Table D1. Organic carbon measured during low-flow conditions in the Columbia River Basin, 1997

[mg/L, milligrams per liter; shaded cells indicate duplicate-sample pairs]

Site Name	Site Number	Data-Collection Date	Suspended Organic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)
		Phase 1 Deployment		
Bradwood	01	08/04/1997	0.5	2.2
		09/08/1997	0.4	1.7
Beaver Army Terminal	02	08/04/1997	0.6	2.0
		08/20/1997	0.6[a]	1.9[a]
		08/20/1997	0.5[a]	1.8[a]
		09/08/1997	0.3	1.7
Longview	03	08/05/1997	0.6	2.0
		09/09/1997	0.3	1.7
Columbia City	04	08/05/1997	0.7	1.9
		09/09/1997	0.4	1.6
Willamette River	06	08/06/1997	0.6	1.4
		08/19/1997	0.6[a]	1.4[a]
		09/10/1997	0.3	1.3
		09/10/1997	0.5	1.3
Johnson Creek	08	08/06/1997	0.5	1.4
		09/10/1997	0.4	1.4
Umatilla	10	09/15/1997	0.3	1.7
Yakima River	11	08/11/1997	1.2	2.1
		09/15/1997	0.5	1.8
		09/15/1997	0.5	2.0
Lower Crab Creek	12	08/11/1997	1.9	4.1
		09/16/1997	0.3	4.0
Snake River	13	08/14/1997	0.4[a]	1.8[a]
		08/14/1997	0.4[a]	1.7[a]
		09/18/1997	0.5[a]	1.8[a]
Vernita Bridge	14	08/12/1997	0.4[a]	1.8[a]
Wenatchee River	15	08/13/1997	0.5	0.8
		09/16/1997	0.3	0.9
Northport	16	08/20/1997	0.2[a]	1.3[a]
		Phase 2 Deployment		
Warrendale	09	10/29/1997	<0.2[a]	1.4[a]

[a]data collected as part of the U.S. Geological Survey's National Stream Quality Accounting Network Program (Hubbard *et al*., 1998).

APPENDIX E

Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds Accumulated in Field Blanks During High-flow Conditions, 1998

Table E1. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in picograms (10^{-12} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural background contamination; NR, not reported; shaded columns indicates tributary site]

	Beaver Army Terminal (54)	Willamette River (101)	Vernita Bridge (388)
	Site 02	Site 06	Site 14
Polychlorinated dibenzo-*p*-dioxins:			
2,3,7,8-Tetra	NR	NR	NR
Total Tetra	NR	NR	NR
1,2,3,7,8-Penta	NR	NR	NR
Total Penta	NR	NR	NR
1,2,3,4,7,8-Hexa	NR	NR	NR
1,2,3,6,7,8-Hexa	NR	NR	NR
1,2,3,7,8,9-Hexa	NR	NR	NR
Total Hexa	NR	NR	NR
1,2,3,4,6,7,8-Hepta	NR	NR	NR
Total Hepta	NR	1.8	NR
Octa	NR	6.1	NR
Polychlorinated dibenzofurans:			
2,3,7,8-Tetra	NR	NR	NR
Total Tetra	NR	NR	NR
1,2,3,7,8-Penta	NR	NR	NR
2,3,4,7,8-Penta	NR	NR	NR
Total Penta	NR	NR	NR
1,2,3,4,7,8-Hexa	NR	NR	NR
1,2,3,6,7,8-Hexa	NR	NR	NR
1,2,3,7,8,9-Hexa	NR	NR	NR
2,3,4,6,7,8-Hexa	NR	NR	NR
Total Hexa	NR	NR	NR
1,2,3,4,6,7,8-Hepta	NR	NR	NR
1,2,3,4,7,8,9-Hepta	NR	NR	NR
Total Hepta	NR	NR	NR
Octa	NR	NR	NR

Table E2. *Ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded column indicates tributary sites; see Appendix A for general chemical structures of congeners]

Congener No.	Beaver Army Terminal (54)	Willamette River[a] (101)	Vernita Bridge (388)
	Site 02	Site 06	Site 14
4 & 10	NR	NR	NR
7 &9	NR	0.51	0.08
6	NR	NR	NR
5 & 8	0.91	NR	NR
19	NR	NR	NR
18	NR	0.84	NR
17 &15	NR	0.46	NR
24 & 27	NR	NR	NR
16 & 32	NR	0.53	NR
29	NR	NR	NR
26	NR	0.12	NR
25	NR	0.16	NR
31 & 28	NR	1.4	NR
20 & 33 & 53	NR	≥ 0.77	NR
51 & 22	NR	≥0.31	NR
45	0.64	0.14	NR
46	NR	NR	NR
52	NR	0.99	NR
43 & 49[a]	NR	0.76	NR
47 & 48	NR	0.68	NR
44	NR	0.72	NR
42	NR	0.25	NR
41 & 64	NR	0.66	NR
40	0.66	NR	NR
67	NR	NR	NR
63	NR	NR	NR
74	NR	0.17	NR
70 & 76	NR	0.47	NR
66 & 95	NR	NR	NR
91	NR	NR	NR
56 & 60	NR	0.11	NR
92	NR	0.13	NR
84	NR	NR	NR
101	NR	0.43	NR

Table E2. *Ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded column indicates tributary sites; see Appendix A for general chemical structures of congeners]

Congener No.	Beaver Army Terminal (54)	Willamette River[a] (101)	Vernita Bridge (388)
	Site 02	Site 06	Site 14
99[b]	4.7	NR	NR
119	NR	NR	NR
83	NR	NR	NR
97	NR	NR	NR
81 & 87	0.52	≥0.16	0.60
85	NR	—	NR
136	NR	NR	NR
110	NR	0.27	NR
82	NR	NR	NR
151	NR	NR	NR
135 & 144 & 124	NR	NR	NR
147 & 107	NR	NR	NR
123 & 149	NR	0.17	NR
118	NR	0.21	NR
134	NR	NR	NR
114 & 131 & 122	0.78	NR	1.0
146	NR	NR	NR
153 & 132 & 105	NR	≥0.16	NR
141 & 179	NR	NR	NR
176 & 130 & 137	NR	NR	NR
138 & 158	NR	NR	NR
129 & 178	0.52	NR	0.79
182 & 187	NR	NR	NR
183	NR	NR	NR
128	NR	NR	NR
167	NR	NR	NR
185	NR	NR	NR
174	NR	NR	NR
177	NR	NR	NR
171 & 202 & 156	NR	≥0.12	NR
173 & 201 & 157	NR	NR	NR
172 & 197	NR	NR	NR
180 & 193	NR	≥0.19	NR
191	NR	NR	NR
200	0.04	NR	0.05
170 & 190	NR	NR	NR

Table E2. *Ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural background contamination; ND, not detected; NQ, detected, but not quantified; shaded column indicates tributary sites; see Appendix A for general chemical structures of congeners]

Congener No.	Beaver Army Terminal (54)	Willamette River[a] (101)	Vernita Bridge (388)
	Site 02	Site 06	Site 14
198	NR	NR	NR
199	NR	NR	NR
196 & 203	NR	NR	NR
189	0.1	NR	NR
208 & 195	NR	NR	NR
207	0.07	NR	0.09
194	NR	NR	NR
205	NR	NR	NR
206	NR	NR	NR
209	NR	0.14	NR
Total quantified *ortho*-substituted PCBs	9.0	≥12.	2.6

[a] Suspected interference.
[b] Interference from target pesticides or surrogate compound.

Table E3. Non-*ortho*-substituted polychlorinated biphenyls accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in picograms (10^{-12} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural background contamination; NR, not reported; shaded column indicates tributary site; —, no value available; see Appendix A for general chemical structures of congeners]

Congener No.	Beaver Army Terminal (54)	Willamette River (101)	Vernita Bridge (388)
	Site 02	Site 06	Site 14
37	—	51.	—
81	NR	NR	NR
77	6.7	9.	8.7
126	NR	NR	NR
169	NR	NR	NR

Table E4. Organochlorine pesticides and related transformation products accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural background contamination; NR, not reported; shaded column indicates tributary sites]

	Beaver Army Terminal (54)	Willamette River (101)	Yakima River (335)	Vernita Bridge (388)
	Site 02	Site 06	Site 11	Site 14
Hexachlorobenzene	2.	NR	6.	NR
Pentachloroanisole	NR	NR	NR	NR
alpha-hexachlorocyclohexane	NR	NR	NR	NR
Lindane	NR	NR	NR	NR
beta-hexachlorocyclohexane	NR	NR	NR	NR
Heptachlor	NR	0.7	NR	NR
delta-hexachlorocyclohexane	NR	NR	NR	NR
Aldrin	NR	NR	NR	NR
Dacthal	NR	NR	NR	NR
Oxychlordane	NR	NR	NR	NR
Heptachlor Epoxide	NR	NR	NR	NR
trans-Chlordane	3.	2.	NR	4.
trans-Nonachlor	NR	0.7	NR	5.
o,p'-DDE	NR	NR	NR	NR
cis-Chlordane	3.	2.	NR	NR
p,p'-DDE	NR	NR	NR	3.
Dieldrin	NR	NR	NR	NR
o,p'-DDD	NR	NR	NR	NR
Endrin	NR	NR	NR	NR
o,p'-DDT	NR	NR	NR	NR
cis-Nonachlor	NR	NR	NR	NR
p,p'-DDD	NR	NR	NR	2.
p,p'-DDT	NR	NR	NR	2.
Methoxychlor	NR	NR	NR	NR
Mirex	NR	NR	NR	NR

Table E5. Polycyclic aromatic hydrocarbon compounds accumulated in field blanks exposed during high-flow deployment and retrieval of SPMDs in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural background contamination; NR, not reported; shaded columns indicate tributary sites]

	Beaver Army Terminal (54)	Willamette River (101)	Yakima River (335)	Vernita Bridge (388)
	Site 02	Site 06	Site 11	Site 14
Naphthalene	80.	72.	120.	70.
Acenaphthylene	NR	NR	NR	NR
Acenaphthene	20.	4.	NR	NR
Fluorene	20.	6.	NR	NR
Phenanthrene	50.	24.	70.	30.
Anthracene	20.	NR	80.	30.
Fluoranthene	NR	11.	NR	20.
Pyrene	NR	15.	NR	NR
Benz[*a*]anthracene	NR	NR	NR	NR
Chrysene	NR	NR	NR	NR
Benzo[b]fluoranthene	NR	NR	NR	NR
Benzo[k]fluoranthene	NR	NR	NR	NR
Benzo[*a*]pyrene	NR	NR	NR	NR
Indeno[1,2,3,*c,d*]pyrene	NR	NR	NR	NR
Dibenz[a,h]anthracene	NR	NR	NR	NR
Benzo[g,h,i]perylene	NR	NR	NR	NR

APPENDIX F

Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds Accumulated in SPMDs During High-Flow Conditions, 1998

Table F1. Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in picograms (10^{-12} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; NR, not reported; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Bradwood (39)	Beaver Army Terminal (54)			Longview (69)	Columbia City (82)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
		Duplicates		RD			Duplicates		RD		
	Site 01	Site 02			Site 03	Site 04	Site 06			Site 08	Site 07
Polychlorinated dibenzo-*p*-dioxins:											
2,3,7,8-Tetra	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Total Tetra	11.	13.	14.	[7]	NR	17.	NR	NR	[—]	NR	3.2
1,2,3,7,8-Penta	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Total Penta	1.6	2.2	3.2	[37]	NR	NR	NR	NR	[—]	NR	NR
1,2,3,4,7,8-Hexa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
1,2,3,6,7,8-Hexa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	4.8	NR
1,2,3,7,8,9-Hexa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Total Hexa	4.9	4.9	NR	[—]	NR	4.2	NR	NR	[—]	NR	NR
1,2,3,4,6,7,8-Hepta	3.9	NR	NR	[—]	NR	4.2	7.1	NR	[—]	27.	NR
Total Hepta	7.2	6.1	5.7	[6]	NR	8.6	12.	15.	[22]	45.	NR
Octa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	110.	NR
Polychlorinated dibenzofurans:											
2,3,7,8-Tetra	2.9[c]	4.9[c]	4.2[c]	[—]	2.1[c]	2.3[c]	NR	NR	[—]	NR	1.8[c]
Total Tetra	14.	30.	24.	[22]	8.5	17.	9.0	NR	[—]	15.	5.9
1,2,3,7,8-Penta	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
2,3,4,7,8-Penta	NR	0.7	NR	[—]	NR	0.8	NR	NR	[—]	NR	NR
Total Penta	1.7	11.	7.0	[44]	5.0	10.	NR	NR	[—]	NR	6.0
1,2,3,4,7,8-Hexa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
1,2,3,6,7,8-Hexa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
1,2,3,7,8,9-Hexa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
2,3,4,6,7,8-Hexa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Total Hexa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
1,2,3,4,6,7,8-Hepta	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
1,2,3,4,7,8,9-Hepta	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Total Hepta	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Octa	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR

Table F2. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)			Longview (69)	Columbia City (82)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
		Duplicates		RD			Duplicates		RD		
	Site 01	Site 02			Site 03	Site 04	Site 06			Site 08	Site 07
4 & 10	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
7 & 9	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
6	NQ	0.28	0.21	[29]	NQ	NQ	ND	ND	[—]	ND	NQ
5 & 8	NQ	4.0	NQ	[—]	NQ	NQ	NQ	NQ	[—]	ND	NQ
19	1.1	2.2	1.8	[20]	0.85	1.4	NQ	NQ	[—]	1.3	NQ
18	2.7	4.1	4.4	[7]	3.2	2.9	1.3	1.5	[14]	4	2.6
17 & 15	1.6	2.6	2.2	[17]	2.1	1.5	0.93	1	[7]	3.2	1.0
24 & 27	NQ	NQ	NQ	[—]	NQ	NQ	NQ	0.11	[—]	0.81	NQ
16 & 32	1.1	2.3	2.1	[9]	1.3	1.3	1	1.1	[10]	4.1	0.57
29	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	4.6	NQ
26	NQ	1.0	0.95	[5]	0.57	0.85	0.49	0.64	[27]	0.63	0.26
25	NQ	5.1	4.4	[15]	NQ	5.4	ND	ND	[—]	ND	NQ
31 & 28	NQ	6.6	6.1	[8]	NQ	5.1	NQ	NQ	[—]	7.8	2.2
20 & 33 & 53	NQ	2.6	2.3	[12]	NQ	1.7	NQ	NQ	[—]	2.3	0.99
51 & 22	0.54	1.1	0.94	[16]	0.53	0.89	NQ	NQ	[—]	2.22	0.35
45	NQ	NQ	NQ	[—]	NQ	NQ	0.34	0.43	[23]	1.6	NQ
46	0.86	NQ	0.72	[—]	NQ	0.90	ND	NQ	[—]	ND	0.3
52	4.3	7.8	7.6	[3]	NQ	6.1	2.8	3.5	[22]	30	1.8
43 & 49[c]	NQ b	NQ b	NQ b	[—]	NQ b	NQ b	≥1.8	≥2.2	[—]	≥10.	NQ b
47 & 48	5.0	4.6	6.8	[39]	4.1	5.1	1.17	1.44	[21]	8.4	NQ
44	2.8	4.2	4.2	[<1]	2.6	4.0	NQ	2.1	[—]	14	2.2
42	2.4	3.2	3.1	[3]	2.0	2.8	0.79	0.97	[20]	4	NQ
41 & 64	3.5	4.5	4.4	[2]	2.9	3.5	≥0.83	≥0.90	[—]	7.1	0.82
40	NQ	19	13	[38]	7.2	NQ	0.38	0.41	[8]	5.4	4.4
67	NQ	NQ	NQ	[—]	NQ	NQ	NQ	0.37	[—]	3.3	NQ
63	NQ	NQ	NQ	[—]	NQ	NQ	NQ	0.37	[—]	5.9	NQ
74	2.6	2.1	2.1	[<1]	2.0	2.2	0.57	0.58	[2]	2.6	0.48
70 & 76	2.0	2.9	2.5	[15]	1.7	2.9	NQ	NQ	[—]	11	0.94
66 & 95	2.4	3.6	2.9	[22]	1.8	3.2	≥1.5	3.4	[—]	26.6	0.97
91	NQ	NQ	0.97	[—]	NQ	NQ	0.52	0.5	[4]	4.2	NQ
56 & 60	NQ	NQ	NQ	[—]	NQ	NQ	0.42	0.48	[13]	2.3	NQ
92	NQ	NQ	NQ	[—]	NQ	NQ	0.53	0.6	[12]	4.5	NQ
84	NQ	NQ	NQ	[—]	NQ	4.2	0.85	1.1	[26]	12	2.9
101	3.2	4.8	4.6	[4]	2.1	4.1	1.8	2.2	[20]	21	1.7
99[d]	NQ a	NQ a	NQ a	[—]	NQ a	NQ a	0.78	0.88	[12]	8.1	NQ a
119	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	NQ	NQ

Table F2. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)			Longview (69)	Columbia City (82)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
		Duplicates		RD			Duplicates		RD		
	Site 01	Site 02			Site 03	Site 04	Site 06			Site 08	Site 07
83	NQ	NQ	NQ	[—]	NQ	NQ	NQ	ND	[—]	2	NQ
97	1.2	1.6	1.3	[21]	NQ	1.5	0.48	0.56	[15]	5.3	0.59
81 & 87	1.4	2.3	1.9	[19]	NQ	2.0	NQ	NQ	[—]	≥7.7	1.2
85	NQ	NQ	NQ	[—]	NQ	NQ	—	—	[—]	—	NQ
136	NQ	NQ	NQ	[—]	NQ	NQ	0.33	0.15	[75]	2.4	NQ
110	6.3	7.1	8.0	[12]	NQ	6.4	1.3	1.4	[7]	13	NQ
82	1.6	1.2	1.2	[<1]	0.61	1.1	0.41	0.43	[5]	8.9	NQ
151	1.6	2.3	2	[14]	1.0	1.5	NQ	NQ	[—]	4.2	2.3
135 & 144 & 124	1.6	NQ	NQ	[—]	NQ	NQ	NQ	NQ	[—]	5.5	NQ
147 & 107	1.8	0.70	0.48	[37]	0.69	0.63	NQ	≥0.19	[—]	2.84	0.66
123 & 149	NQ	1.1	0.59	[60]	NQ	NQ	NQ	1	[—]	9.8	NQ
118	2.0	2.5	2.6	[4]	1.3	2.2	NQ	NQ	[—]	9.8	1.3
134	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	0.27	NQ
114 & 131 & 122	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
146	NQ	NQ	1.2	[—]	NQ	NQ	NQ	NQ	[—]	1.5	NQ
153 & 132 & 105	3.3	5.5	5.5	[<1]	NQ	3.6	≥0.81	≥0.77	[—]	22.2	NQ
141 & 179	NQ	1.1	0.98	[12]	NQ	0.82	NQ	NQ	[—]	7.1	0.50
176 & 130 & 137	NQ	NQ	NQ	[—]	1.3	NQ	ND	ND	[—]	NQ	1.6
138 & 158	2.5	4.7	4.0	[16]	NQ	3.5	NQ	NQ	[—]	9.1	NQ
129 & 178	NQ	NQ	2.4	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
182 & 187	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	NQ	NQ
183	NQ	0.32	0.46	[36]	NQ	0.28	NQ	0.13	[—]	1.5	NQ
128	NQ	NQ	NQ	[—]	NQ	NQ	NQ	NQ	[—]	1.3	NQ
167	1.2	1.7	1.6	[6]	1.0	NQ	ND	NQ	[—]	0.35	0.96
185	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
174	NQ	0.44	0.27	[48]	NQ	NQ	0.22	0.28	[24]	2.5	NQ
177	NQ	0.38	0.26	[38]	NQ	0.27	NQ	NQ	[—]	2	NQ
171 & 202 & 156	0.75	1.2	1.1	[9]	0.53	0.94	≥0.30	≥0.31	[—]	1.03	0.56
173 & 201 & 157	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
172 & 197	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	≥0.22	NQ
180 & 193	NQ	NQ	NQ	[—]	NQ	NQ	NQ	≥1.4	[—]	≥2.1	NQ
191	NQ	NQ	NQ	[—]	NQ	NQ	ND	0.16	[—]	ND	NQ
200	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	1.2	NQ
170 & 190	NQ	0.27	0.24	[12]	NQ	NQ	ND	NQ	[—]	2.1	NQ
198	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	NQ	NQ
199	NQ	NQ	NQ	[—]	NQ	NQ	NQ	NQ	[—]	0.63	NQ
196 & 203	NQ	0.10	0.10	[<1]	NQ	NQ	NQ	NQ	[—]	0.53	0.10

Table F2. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)			Longview (69)	Columbia City (82)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
		Duplicates		RD			Duplicates		RD		
	Site 01	Site 02			Site 03	Site 04	Site 06			Site 08	Site 07
189	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
208 & 195	NQ	NQ	0.05	[—]	NQ	NQ	ND	ND	[—]	0.13	NQ
207	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
194	NQ	NQ	NQ	[—]	NQ	NQ	NQ	ND	[—]	0.39	NQ
205	NQ	NQ	NQ	[—]	NQ	NQ	NQ	ND	[—]	NQ	NQ
206	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
209	NQ	NQ	NQ	[—]	NQ	NQ	ND	ND	[—]	ND	NQ
Sum of quantified *ortho*-substituted PCBs	61	123	115		41	85	≥23	≥34		≥341	34

Table F2. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Vernita Bridge (388)			Wenatchee River (468)	Northport (735)
				Duplicates		RD		
	Site 09	Site 10	Site 13	Site 14			Site 15	Site 16
4 & 10	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
7 & 9	NQ	NQ	NQ	0.15	NQ	[—]	NQ	NQ
6	NQ	0.08	NQ	0.19	NQ	[—]	NQ	NQ
5 & 8	NQ	NQ	NQ	2.6	NQ	[—]	NQ	NQ
19	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
18	2.4	2.8	3.9	2.5	NQ	[—]	NQ	3.1
17 & 15	0.9	0.98	NQ	1.1	NQ	[—]	NQ	0.84
24 & 27	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
16 & 32	NQ	0.92	NQ	1.2	NQ	[—]	NQ	NQ
29	0.05	0.11	NQ	NQ	NQ	[—]	NQ	NQ
26	0.42	0.4	NQ	0.57	0.52	[9]	NQ	NQ
25	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
31 & 28	3.4	NQ	NQ	5	3.3	[41]	NQ	NQ
20 & 33 & 53	0.95	1.5	NQ	2.1	NQ	[—]	NQ	NQ
51 & 22	0.52	0.78	NQ	1	0.63	[45]	NQ	NQ
45	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
46	0.41	0.54	NQ	0.47	0.33	[35]	NQ	0.37
52	3.7	3.5	NQ	5.1	3.7	[32]	NQ	NQ
43 & 49[c]	NQ b	NQ b	NQ b	NQ b	NQ b	[—]	NQ b	NQ b
47 & 48	3.4	2.8	3.6	4.5	3.8	[17]	NQ	NQ
44	2.1	2.3	NQ	3.3	2.4	[32]	NQ	2.0
42	1.4	1.3	NQ	2.9	2.3	[23]	NQ	NQ
41 & 64	2.0	1.8	NQ	3.1	2.4	[25]	NQ	0.92
40	NQ	4.3	NQ	NQ	NQ	[—]	NQ	NQ
67	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
63	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
74	0.64	1.0	NQ	2.5	1.8	[33]	NQ	NQ
70 & 76	1.0	2.3	NQ	3.4	2.3	[39]	NQ	NQ
66 & 95	1.4	2.8	NQ	2.9	2	[37]	NQ	NQ
91	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
56 & 60	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
92	NQ	NQ	NQ	NQ	NQ	[—]	NQ	0.61
84	NQ	NQ	NQ	5.6	6	[7]	NQ	1.4
101	1.5	4.3	NQ	3.7	2.5	[39]	NQ	NQ
99[d]	NQ a	NQ a	NQ a	NQ a	NQ a	[—]	NQ a	NQ a
119	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ

Table F2. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Vernita Bridge (388)			Wenatchee River (468)	Northport (735)
				Duplicates		RD		
	Site 09	Site 10	Site 13	Site 14			Site 15	Site 16
83	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
97	0.95	1.2	0.90	1.7	1	[52]	NQ	0.54
81 & 87	1.8	2.0	NQ	2.5	NQ	[—]	NQ	NQ
85	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
136	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
110	NQ	NQ	2.7	3	NQ	[—]	NQ	2.0
82	1.4	1.4	5.0	NQ	NQ	[—]	NQ	NQ
151	2.9	4.0	5.7	1.3	NQ	[—]	NQ	1.2
135 & 144 & 124	NQ	NQ	0.73	0.78	NQ	[—]	NQ	0.65
147 & 107	1.3	1.5	1.9	0.92	0.87	[6]	NQ	0.63
123 & 149	1.0	2.4	2.8	0.93	NQ	[—]	NQ	NQ
118	2.3	2.8	1.6	2.1	1.6	[27]	NQ	0.69
134	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
114 & 131 & 122	NQ	NQ	NQ	NQ	NQ	[—]	6.8	NQ
146	NQ	NQ	0.99	NQ	NQ	[—]	NQ	NQ
153 & 132 & 105	NQ	4.6	NQ	4.1	NQ	[—]	NQ	NQ
141 & 179	NQ	1.2	NQ	0.74	NQ	[—]	NQ	NQ
176 & 130 & 137	2.3	2.9	3.8	NQ	NQ	[—]	NQ	NQ
138 & 158	2.2	2.4	3.0	1.9	NQ	[—]	NQ	1.2
129 & 178	NQ	1.6	NQ	NQ	NQ	[—]	NQ	NQ
182 & 187	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
183	0.69	NQ	0.92	NQ	NQ	[—]	NQ	NQ
128	NQ	NQ	NQ	NQ	NQ	[—]	NQ	0.68
167	2.3	2.6	4.0	1.5	1.4	[7]	NQ	0.66
185	0.07	0.17	NQ	NQ	NQ	[—]	NQ	0.05
174	NQ	0.58	NQ	0.2	NQ	[—]	NQ	NQ
177	0.25	0.57	NQ	0.16	NQ	[—]	NQ	NQ
171 & 202 & 156	0.90	1.1	0.73	0.81	0.79	[3]	NQ	0.59
173 & 201 & 157	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
172 & 197	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
180 & 193	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
191	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
200	NQ	NQ	0.21	0.18	NQ	[—]	NQ	NQ
170 & 190	NQ	0.38	NQ	0.19	NQ	[—]	NQ	0.40
198	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
199	NQ	0.13	NQ	0.09	NQ	[—]	NQ	NQ

Table F2. *Ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; ND, not detected; NQ, detected, but not quantified; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]; see Appendix A for general chemical structures of congeners]

Congener No.	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Vernita Bridge (388)			Wenatchee River (468)	Northport (735)
				Duplicates		RD		
	Site 09	Site 10	Site 13	Site 14			Site 15	Site 16
196 & 203	NQ	0.12	NQ	0.12	NQ	[—]	NQ	0.23
189	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
208 & 195	NQ	0.05	NQ	0.04	NQ	[—]	NQ	0.11
207	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
194	0.12	0.13	NQ	NQ	NQ	[—]	NQ	0.25
205	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
206	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
209	NQ	NQ	NQ	NQ	NQ	[—]	NQ	NQ
Sum of quantified *ortho*-substituted PCBs	47	68	42	77	40		7	19

[a]Percent relative difference between two values, V_1 and V_2, is calculated as

$$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2)/2} \right| \cdot 100$$

[b]SPMD's at the Snake River site were periodically exposed to air due to fluctuating river stage and were thus compromised; analytical results are presented for informational purposes only.

[c]suspected interference.

[d]interference from target pesticides or surrogate compound.

Table F3. Non-*ortho*-substituted polychlorinated biphenyls accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; NR, not reported; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)			Longview (69)	Columbia City (82)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
		Duplicates		RD			Duplicates		RD		
	Site 01	Site 02			Site 03	Site 04	Site 06			Site 08	Site 07
37	—	—	—	[—]	—	—	0.17	NR	[—]	NR	—
81	0.003	0.004	0.003	[24]	NR	0.004	NR	NR	[—]	NR	NR
77	0.052	0.086	0.076	[12]	0.039	0.079	0.043	0.042	[2]	0.19	NR
126	0.002	0.004	0.003	[15]	0.002	0.003	NR	NR	[—]	0.016	0.001
169	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR

	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Vernita Bridge (388)			Northport (388)
				Duplicates		RD	
	Site 09	Site 10	Site 13	Site 14			Site 16
37	—	—	—	—	—	[—]	—
81	NR	NR	NR	0.004	0.005	[17]	NR
77	0.037	0.039	0.049	0.065	0.082	[23]	NR
126	0.002	0.002	0.005	0.003	0.003	[25]	0.001
169	NR	NR	NR	NR	NR	[—]	NR

[a]Percent relative difference between two values, V_1 and V_2, is calculated as

$$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2)/2} \right| \cdot 100$$

[b]SPMD's at the Snake River site were periodically exposed to air due to fluctuating river stage and were thus compromised; analytical results are presented for informational purposes only

Table F4. Organochlorine pesticides and related transformation products accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; NR, not reported; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Bradwood (39)	Beaver Army Terminal (54)			Longview (69)	Columbia City (82)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
		Duplicates		RD			Duplicates		RD		
	Site 01	Site 02			Site 03	Site 04	Site 06			Site 08	Site 07
Hexachlorobenzene	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	15.	NR
Pentachloroanisole	11.	8.	8.	[<1]	4.	17.	13.	19.	[38]	110.	4.
alpha-hexachlorocyclohexane	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Lindane	NR	NR	NR	[—]	NR	NR	10.	15.	[40]	18.	NR
beta-hexachlorocyclohexane	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Heptachlor	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
delta-hexachlorocyclohexane	4.	NR	NR	[—]	3.	3.	NR	NR	[—]	NR	4.
Aldrin	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	5.3	NR
Dacthal	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Oxychlordane	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	2.2	NR
Heptachlor Epoxide	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	2.4	NR
trans-Chlordane	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	15.	NR
trans-Nonachlor	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	18.	NR
o,p'-DDE	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	8.5	NR
cis-Chlordane	NR	NR	NR	[—]	NR	NR	NR	3.8	[—]	28.	NR
p,p'-DDE	35.	60.	55.	[9]	31.	31.	11.	13.	[17]	220.	35.
Dieldrin	4.	3.	3.	[<1]	4.	6.	5.6	6.3	[12]	120.	4.
o,p'-DDD	8.	10.	9.	[11]	6.	7.	1.5	1.8	[18]	17.	6.
Endrin	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	1.7	NR
o,p'-DDT	9.	7.	5.	[33]	NR	7.	NR	NR	[—]	31.	NR
cis-Nonachlor	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
p,p'-DDD	23.	30.	26.	[14]	NR	21.	3.8	3.7	[3]	50.	21.
p,p'-DDT	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Methoxychlor	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	NR	NR
Mirex	NR	NR	NR	[—]	NR	NR	NR	NR	[—]	15.	NR

Table F4. Organochlorine pesticides and related transformation products accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; NR, not reported; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Warrendale (141)	Umatilla (289)	Snake River[b] (324)	Yakima River (335)			Vernita River[c] (388)			Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)
				Duplicates		RD	Duplicates		RD			
	Site 09	Site 10	Site 13	Site 11			Site 14			Site 12	Site 15	Site 16
Hexachlorobenzene	NR	NR	38.	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
Pentachloroanisole	4.	4.	8.	NR	NR	[—]	4.	NR	[—]	NR	NR	NR
alpha-hexachlorocyclohexane	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
Lindane	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
beta-hexachlorocyclohexane	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
Heptachlor	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
delta-hexachlorocyclohexane	NR	5.	13.	7.	NR	[—]	NR	NR	[—]	NR	NR	NR
Aldrin	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
Dacthal	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
Oxychlordane	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
Heptachlor Epoxide	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
trans-Chlordane	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
trans-Nonachlor	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
o,p'-DDE	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
cis-Chlordane	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
p,p'-DDE	79.	68.	92.	240.	250.	[4]	99.	79.	[22]	NR	26.	NR
Dieldrin	4.	4.	10.	98.	90.	[9]	NR	NR	[—]	14.	NR	NR
o,p'-DDD	12.	12.	10.	19.	17.	[11]	17.	NR	[—]	NR	NR	NR
Endrin	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
o,p'-DDT	4.	6.	NR	16.	15.	[6]	5.	NR	[—]	NR	NR	3.
cis-Nonachlor	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
p,p'-DDD	38.	32.	24.	49.	46.	[6]	56.	51.	[9]	NR	NR	NR
p,p'-DDT	NR	NR	NR	59.	58.	[2]	NR	NR	[—]	NR	NR	NR
Methoxychlor	NR	NR	NR	NR	NR	[—]	NR	NR	[—]	NR	NR	NR
Mirex	NR	NR	38.	NR	NR	[—]	NR	NR	[—]	NR	NR	NR

[a]Percent relative difference between two values, V_1 and V_2, is calculated as

$$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2)/2} \right| \cdot 100$$

[b]SPMD's at the Snake River site were periodically exposed to air due to fluctuating river stage and were thus compromised; analytical results are presented for informational purposes only.
[c]Second sample of duplicate pair was analyzed prior to final concentration step; minimum reporting limits were thus higher than for first sample of duplicate pair.

Table F5. Polycyclic aromatic hydrocarbon compounds accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; NR, not reported; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Bradwood (39)	Beaver Army Terminal (54)			Longview (69)	Columbia City (82)	Lake River (87)	Willamette River (101)			Johnson Creek (—)	Hayden Island (102)
		Duplicates		RD				Duplicates		RD		
	Site 01	Site 02			Site 03	Site 04	Site 05	Site 06			Site 08	Site 07
Naphthalene	NR	NR	NR	[—]	NR	NR	NR	NR	NR	[—]	NR	NR
Acenaphthylene	NR	NR	NR	[—]	NR	NR	NR	NR	NR	[—]	NR	NR
Acenaphthene	NR	NR	NR	[—]	NR	NR	NR	290.	140.	[70]	NR	NR
Fluorene	NR	40.	40.	[<1]	NR	NR	NR	180.	95.	[62]	NR	NR
Phenanthrene	NR	NR	NR	[—]	NR	NR	NR	530.	380.	[33]	380.	NR
Anthracene	NR	NR	NR	[—]	NR	NR	NR	130.	85.	[42]	NR	NR
Fluoranthene	430.	960.	860.	[11]	370.	380.	400.	360.	430.	[18]	690.	290.
Pyrene	360.	710.	680.	[4]	220.	490.	350.	460.	480.	[4]	2400.	180.
Benz[*a*]anthracene	NR	100.	80.	[22]	NR	40.	NR	42.	40.	[5]	150.	NR
Chrysene	100.	250.	230.	[8]	60.	110.	70.	79.	84.	[6]	580.	50.
Benzo[*b*]fluoranthene	NR	60.	60.	[<1]	NR	NR	NR	NR	35.	[—]	110.	NR
Benzo[*k*]fluoranthene	NR	40.	NR	[—]	NR	NR	NR	NR	15.	[—]	74.	NR
Benzo[*a*]pyrene	NR	NR	70.	[—]	NR	NR	NR	NR	NR	[—]	65.	NR
Indeno[*1,2,3,c,d*]pyrene	NR	NR	NR	[—]	NR	NR	NR	NR	NR	[—]	19.	NR
Dibenz[*a,h*]anthracene	NR	NR	NR	[—]	NR	NR	NR	NR	NR	[—]	NR	NR
Benzo[*g,h,i*]perylene	NR	NR	NR	[—]	NR	NR	NR	NR	NR	[—]	34.	NR

Table F5. Polycyclic aromatic hydrocarbon compounds accumulated in SPMDs during high-flow conditions in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations, reported in nanograms (10^{-9} grams) per SPMD, are corrected for surrogate recoveries (when applicable) and for procedural and field-blank background contamination; NR, not reported; —, no value; shaded columns indicate tributary sites; RD value, shown in brackets, is relative difference between duplicate pairs, in percent[a]]

	Warrendale (141)	Umatilla (289)	Yakima River (335)			Vernita Bridge (388)			Northport (735)
			Duplicates		RD	Duplicates		RD	
	Site 09	Site 10	Site 11			Site 14			Site 16
Naphthalene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Acenaphthylene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Acenaphthene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Fluorene	40	NR	100	80	[22]	NR	NR	[—]	NR
Phenanthrene	NR	NR	280	250	[11]	NR	NR	[—]	NR
Anthracene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Fluoranthene	460	200	230	210	[9]	310	290	[7]	230
Pyrene	240	110	90	90	[<1]	130	110	[17]	70
Benz[*a*]anthracene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Chrysene	90	40	NR	NR	[—]	80	60	[29]	40
Benzo[*b*]fluoranthene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Benzo[*k*]fluoranthene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Benzo[*a*]pyrene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Indeno[*1,2,3,c,d*]pyrene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Dibenz[*a,h*]anthracene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR
Benzo[*g,h,i*]perylene	NR	NR	NR	NR	[—]	NR	NR	[—]	NR

Percent relative difference between two values, V_1 and V_2, is calculated as

$$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2)/2} \right| \cdot 100$$

[b]SPMD's at the Snake River site were periodically exposed to air due to fluctuating river stage and were thus compromised; analytical results are presented for informational purposes only

APPENDIX G

Estimated Dissolved Concentrations of Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds During High-flow Conditions, 1998

Table G1. Estimated dissolved concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); dissolved concentrations were calculated using equation (3) and are reported to one significant digit, in femtograms (10^{-15} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients and sampling rates used in calculations are summarized in table C1; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Willamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Vernita Bridge (388)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 06	Site 08	Site 07	Site 09	Site 10	Site 14	Site 16
Polychlorinated dibenzo-*p*-dioxins:											
2,3,7,8-Tetra	—	—	—	—	—	—	—	—	—	—	—
Total Tetra	90	100	—	100	—	—	20	60	40	100	20
1,2,3,7,8-Penta	—	—	—	—	—	—	—	—	—	—	—
Total Penta	20	30	—	—	—	—	—	10	—	—	—
1,2,3,4,7,8-Hexa	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	—	—	—	—	—	200	—	—	—	—	—
1,2,3,7,8,9-Hexa	—	—	—	—	—	—	—	—	—	—	—
Total Hexa	200	200	—	200	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	100	—	—	200	300	1,000	—	—	—	—	—
Total Hepta	300	200	—	300	400	2,000	—	—	—	—	300
Octa	—	—	—	—	—	10,000	—	—	—	—	6,000
Polychlorinated dibenzofurans:											
2,3,7,8-Tetra	20	30	10	10	—	—	10	20	20	10	—
Total Tetra	70	200	50	100	50	80	30	100	80	80	20
1,2,3,7,8-Penta	—	—	—	—	—	—	—	—	—	—	—
2,3,4,7,8-Penta	—	5	—	5	—	—	—	—	—	—	—
Total Penta	10	70	30	70	—	—	40	80	10	30	4
1,2,3,4,7,8-Hexa	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	—	—	—	—	—	—	—	—	—	—	—
1,2,3,7,8,9-Hexa	—	—	—	—	—	—	—	—	—	—	—
2,3,4,6,7,8-Hexa	—	—	—	—	—	—	—	—	—	—	—
Total Hexa	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,7,8,9-Hepta	—	—	—	—	—	—	—	—	—	—	—
Total Hepta	—	—	—	—	—	—	—	—	—	—	—
Octa	—	—	—	—	—	—	—	—	—	—	—

Table G2. Estimated dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations are reported for individually quantified congeners, to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients, sampling rates, and equations used to calculate dissolved concentrations are summarized in table C2; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Willamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Vernita Bridge (388)	Wenatchee River (468)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 06	Site 08	Site 07	Site 09	Site 10	Site 14	Site 15	Site 16
6	—	2	—	—	—	—	—	—	0.5	1	—	—
19	10	20	8	10	—	10	—	—	—	—	—	—
18	10	20	20	20	7	20	10	10	10	10	—	20
26	—	5	3	4	2	3	1	2	2	3	—	—
25	—	30	—	30	—	—	—	—	—	—	—	—
45	—	—	—	—	1	6	—	—	—	—	—	—
46	6	—	—	6	—	—	2	3	3	3	—	2
52	20	40	—	30	10	100	8	20	10	20	—	—
44	10	20	10	20	—	50	8	8	8	10	—	8
42	10	10	9	10	4	20	—	6	6	10	—	—
40	—	80	30	—	2	20	20	—	20	—	—	—
67	—	—	—	—	—	20	—	—	—	—	—	—
63	—	—	—	—	—	30	—	—	—	—	—	—
74	10	10	9	10	3	10	2	3	4	10	—	—
91	—	—	—	—	3	30	—	—	—	—	—	—
92	—	—	—	—	3	20	—	—	—	—	—	3
84	—	—	—	30	5	80	20	—	—	40	—	9
101	10	20	10	20	8	100	8	7	20	20	—	—
99	—	—	—	—	5	50	—	—	—	—	—	—
119	—	—	—	—	—	—	—	—	—	—	—	—
83	—	—	—	—	—	10	—	—	—	—	—	—
97	8	10	—	10	3	30	4	6	7	10	—	3
85	—	—	—	—	—	—	—	—	—	—	—	—
136	—	—	—	—	2	10	—	—	—	—	—	—
110	30	40	—	30	6	60	—	—	—	10	—	10
82	10	8	4	7	3	60	—	9	8	—	—	—
151	9	10	5	8	—	20	10	20	20	7	—	6
118	10	10	8	10	—	60	7	10	20	10	—	4

Table G2. Estimated dissolved concentrations of *ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998—Continued

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations are reported for individually quantified congeners, to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients, sampling rates, and equations used to calculate dissolved concentrations are summarized in table C2; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Willamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Vernita Bridge (388)	Wenatchee River (468)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 06	Site 08	Site 07	Site 09	Site 10	Site 14	Site 15	Site 16
134	—	—	—	—	—	2	—	—	—	—	—	—
146	—	—	—	—	—	9	—	—	—	—	—	—
183	—	3	—	3	—	10	—	6	—	—	—	—
128	—	—	—	—	—	8	—	—	—	—	—	4
174	—	4	—	—	2	20	—	—	5	2	—	—
177	—	3	—	2	—	20	—	2	5	1	—	—
199	—	—	—	—	—	10	—	—	2	1	—	—
207	—	—	—	—	—	—	—	—	—	—	—	—
194	—	—	—	—	—	8	—	3	3	—	—	5
Sum of quantified *ortho*-substituted PCBs	200	300	100	300	70	1,000	100	100	200	200	0	70

Table G3. Estimated dissolved concentrations of non-*ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); dissolved concentrations were calculated using equation (3) and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients and sampling rates used in calculations are summarized in table C3; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Willamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Vernita Bridge (388)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 06	Site 08	Site 07	Site 09	Site 10	Site 14	Site 16
37	—	—	—	—	0.8	—	—	—	—	—	—
81	0.02	0.02	—	0.02	—	—	—	—	—	0.02	—
77	0.3	0.5	0.2	0.5	0.3	1	—	0.2	0.2	0.4	—
126	0.02	0.03	0.01	0.03	—	0.1	0.009	0.02	0.02	0.02	0.01
169	—	—	—	—	—	—	—	—	—	—	—

Table G4. Estimated dissolved concentrations of organochlorine pesticides and related transformation products during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients, sampling rates, and equations used to calculate dissolved concentrations are summarized in table H1; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Willamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Yakima River (335)	Vernita Bridge (388)	Lower Crab Creek (411)	Wenatchee River (468)	Northport (735)
	Site 01	Site 02	Site 03	Site 04	Site 06	Site 08	Site 07	Site 09	Site 10	Site 11	Site 14	Site 12	Site 15	Site 16
Hexachlorobenzene	—	—	—	—	—	200	—	—	—	—	—	—	—	—
Pentachloroanisole	60	50	20	100	70	600	20	20	20	—	20	—	—	—
alpha-hexachlorocyclohexane	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lindane	—	—	—	—	1,000	2,000	—	—	—	—	—	—	—	—
beta-hexachlorocyclohexane	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	—	—	—	—	—	—	—	—	—	—	—	—	—	—
delta-hexachlorocyclohexane	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	—	—	—	—	—	30	—	—	—	—	—	—	—	—
trans-Chlordane	—	—	—	—	—	100	—	—	—	—	—	—	—	—
trans-Nonachlor	—	—	—	—	—	100	—	—	—	—	—	—	—	—
o,p'-DDE	—	—	—	—	—	80	—	—	—	—	—	—	—	—
cis-Chlordane	—	—	—	—	—	200	—	—	—	—	—	—	—	—
p,p'-DDE	200	300	200	200	60	1,000	200	400	300	1,000	500	—	100	—
Dieldrin	40	30	40	60	90	2,000	40	40	30	700	—	80	—	—
o,p'-DDD	70	90	60	70	10	200	50	100	100	200	200	—	—	—
Endrin	—	—	—	—	—	20	—	—	—	—	—	—	—	—
o,p'-DDT	80	60	—	70	—	400	—	40	40	100	50	—	—	30
cis-Nonachlor	—	—	—	—	—	—	—	—	—	—	—	—	—	—
p,p'-DDD	200	300	—	200	40	500	200	300	300	400	500	—	—	—
p,p'-DDT	—	—	—	—	—	—	—	—	—	300	—	—	—	—
Methoxychlor	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mirex	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table G5. Estimated dissolved concentrations of polycyclic aromatic hydrocarbon compounds during high-flow conditions in the Columbia River Basin, 1998

[Numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); concentrations are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; partition coefficients, sampling rates, and equations used to calculate dissolved concentrations are summarized in table H2; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Bradwood (39)	Beaver Army Terminal (54)	Longview (69)	Columbia City (82)	Lake River (87)	Willamette River (101)	Johnson Creek (—)	Hayden Island (102)	Warrendale (141)	Umatilla (289)	Yakima River (335)	Vernita Bridge (388)	Northpo (735)
	Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 08	Site 07	Site 09	Site 10	Site 11	Site 14	Site 1
Acenaphthylene	—	—	—	—	—	—	—	—	—	—	—	—	—
Acenaphthene	—	—	—	—	—	6,000	—	—	—	—	—	—	—
Fluorene	—	800	—	—	—	3,000	—	—	800	—	2,000	—	—
Phenanthrene	—	—	—	—	—	6,000	4,000	—	—	—	4,000	—	—
Anthracene	—	—	—	—	—	1,000	—	—	—	—	—	—	—
Fluoranthene	3,000	6,000	3,000	3,000	3,000	2,000	5,000	2,000	3,000	1,000	2,000	2,000	2,000
Pyrene	2,000	4,000	1,000	3,000	2,000	3,000	10,000	1,000	1,000	600	500	800	400
Benz[*a*]anthracene	—	800	—	300	—	300	1,000	—	—	—	—	—	—
Chrysene	600	2,000	400	800	400	600	4,000	300	600	200	—	500	300
Benzo[*b*]fluoranthene	—	500	—	—	—	—	1,000	—	—	—	—	—	—
Benzo[*k*]fluoranthene	—	300	—	—	—	—	600	—	—	—	—	—	—
Benzo[*a*]pyrene	—	—	—	—	—	—	500	—	—	—	—	—	—
Indeno[1,2,3-*cd*]pyrene	—	—	—	—	—	—	200	—	—	—	—	—	—
Dibenz[*a,h*]anthracene	—	—	—	—	—	—	—	—	—	—	—	—	—
Benzo[*g,h,i*]perylene	—	—	—	—	—	—	500	—	—	—	—	—	—

APPENDIX H

Partition Coefficients, Sampling Rates, and Equations used to Estimate Dissolved Concentrations of Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds During High-Flow Conditions, 1998

Table H1. Partition coefficients, sampling rates, and equations for estimating dissolved concentrations of organochlorine pesticides and related transformation products during high-flow conditions in the Columbia River Basin, 1998

[K_{SPMD}, SPMD-water partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); R, temperature-dependent sampling rate in liters per day, based on laboratory data (Huckins *et al*., 1999); shaded columns indicate tributary sites; —, all information required for calculation is not available.]

		Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
	log K_{SPMD}[a]	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used
		Site 01		Site 02		Site 03		Site 04		Site 06		Site 08		Site 07	
Hexachlorobenzene	5.2	3.1	(3)	3.1	(3)	3.1	(3)	3.1	(3)	2.6	(3)	2.6	(3)	3.1	(3)
Pentachloroanisole	4.9	5.0	(3)	5.0	(3)	5.0	(3)	5.0	(3)	5.1	(3)	5.1	(3)	5.0	(3)
alpha-hexachlorocyclohexane	3.3	1.2	(4)	1.2	(4)	1.2	(4)	1.2	(4)	0.9	(4)	0.9	(4)	1.2	(4)
Lindane	3.2	0.9	(4)	0.9	(4)	0.9	(4)	0.9	(4)	0.7	(4)	0.7	(4)	0.9	(4)
beta-hexachlorocyclohexane	3.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	5.6	—	—	—	—	—	—	—	—	3.6	(3)	3.6	(3)	—	—
delta-hexachlorocyclohexane	3.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	6.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	3.9	1.2	(1)	1.2	(1)	1.2	(1)	1.2	(1)	0.6	(3)	0.6	(3)	1.2	(1)
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	4.5	3.3	(1)	3.3	(1)	3.3	(1)	3.3	(1)	2.9	(1)	2.9	(1)	3.3	(1)
trans-Chlordane	5.7	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)	3.5	(3)	3.5	(3)	3.3	(3)
trans-Nonachlor	5.8	3.2	(3)	3.2	(3)	3.2	(3)	3.2	(3)	3.6	(3)	3.6	(3)	3.2	(3)
o,p'-DDE	5.5	3.5	(3)	3.5	(3)	3.5	(3)	3.5	(3)	3.3	(3)	3.3	(3)	3.5	(3)
cis-Chlordane	5.6	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)	3.8	(3)	3.8	(3)	3.3	(3)
p,p'-DDE	6.0	6.2	(3)	6.2	(3)	6.2	(3)	6.2	(3)	5.5	(3)	5.5	(3)	6.2	(3)
Dieldrin	4.9	2.9	(3)	2.9	(3)	2.9	(3)	2.9	(3)	1.8	(3)	1.8	(3)	2.9	(3)
o,p'-DDD	5.4	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)
Endrin	4.7	4.0	(3)	4.0	(3)	4.0	(3)	4.0	(3)	3.1	(3)	3.1	(3)	4.0	(3)
o,p'-DDT	6.3	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)	2.2	(3)	2.2	(3)	3.3	(3)
cis-Nonachlor	5.6	2.9	(3)	2.9	(3)	2.9	(3)	2.9	(3)	2.8	(3)	2.8	(3)	2.9	(3)
p,p'-DDD	5.5	3.5	(3)	3.5	(3)	3.5	(3)	3.5	(3)	3.1	(3)	3.1	(3)	3.5	(3)
p,p'-DDT	6.4	4.4	(3)	4.4	(3)	4.4	(3)	4.4	(3)	3.2	(3)	3.2	(3)	4.4	(3)
Methoxychlor	4.6	3.9	(1)	3.9	(1)	3.9	(1)	3.9	(1)	1.5	(3)	1.5	(3)	3.9	(1)
Mirex	6.4	4.9	(3)	4.9	(3)	4.9	(3)	4.9	(3)	4.7	(3)	4.7	(3)	4.9	(3)

Table H1. Partition coefficients, sampling rates, and equations for estimating dissolved concentrations of organochlorine pesticides and related transformation products during high-flow conditions in the Columbia River Basin, 1998—Continued

[K_{SPMD}, SPMD-water partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); R, temperature-dependent sampling rate in liters per day, based on laboratory data (Huckins *et al*., 1999); shaded columns indicate tributary sites; —, all information required for calculation is not available.]

		Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
	log K_{SPMD}[a]	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
Hexachlorobenzene	5.2	3.1	(3)	3.6	(3)	3.6	(3)	3.1	(3)	5.6	(3)	3.1	(3)	3.1	(3)
Pentachloroanisole	4.9	5.0	(3)	4.9	(3)	4.9	(3)	5.0	(3)	9.5	(1)	5.0	(3)	5.0	(3)
alpha-hexachlorocyclohexane	3.3	1.2	(4)	1.4	(4)	1.4	(4)	1.2	(4)	2.7	(4)	1.2	(4)	1.2	(4)
Lindane	3.2	0.9	(4)	1.1	(4)	1.1	(4)	0.9	(4)	1.7	(4)	0.9	(4)	0.9	(4)
beta-hexachlorocyclohexane	3.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	5.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
delta-hexachlorocyclohexane	3.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	6.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	3.9	1.2	(1)	1.8	(1)	1.8	(1)	1.2	(1)	1.9	(1)	1.2	(1)	1.2	(1)
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	4.5	3.3	(1)	3.6	(1)	3.6	(1)	3.3	(1)	8.3	(1)	3.3	(1)	3.3	(1)
trans-Chlordane	5.7	3.3	(3)	3.1	(3)	3.1	(3)	3.3	(3)	6.1	(3)	3.3	(3)	3.3	(3)
trans-Nonachlor	5.8	3.2	(3)	2.8	(3)	2.8	(3)	3.2	(3)	5.7	(3)	3.2	(3)	3.2	(3)
o,p'-DDE	5.5	3.5	(3)	3.7	(3)	3.7	(3)	3.5	(3)	6.3	(3)	3.5	(3)	3.5	(3)
cis-Chlordane	5.6	3.3	(3)	2.8	(3)	2.8	(3)	3.3	(3)	6.1	(3)	3.3	(3)	3.3	(3)
p,p'-DDE	6.0	6.2	(3)	6.9	(3)	6.9	(3)	6.2	(3)	10.5	(3)	6.2	(3)	6.2	(3)
Dieldrin	4.9	2.9	(3)	4.0	(3)	4.0	(3)	2.9	(3)	5.2	(3)	2.9	(3)	2.9	(3)
o,p'-DDD	5.4	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)	5.5	(3)	3.3	(3)	3.3	(3)
Endrin	4.7	4.0	(3)	4.9	(1)	4.9	(1)	4.0	(3)	7.8	(1)	4.0	(3)	4.0	(3)
o,p'-DDT	6.3	3.3	(3)	4.3	(3)	4.3	(3)	3.3	(3)	4.5	(3)	3.3	(3)	3.3	(3)
cis-Nonachlor	5.6	2.9	(3)	3.0	(3)	3.0	(3)	2.9	(3)	4.9	(3)	2.9	(3)	2.9	(3)
p,p'-DDD	5.5	3.5	(3)	3.8	(3)	3.8	(3)	3.5	(3)	6.3	(3)	3.5	(3)	3.5	(3)
p,p'-DDT	6.4	4.4	(3)	5.6	(3)	5.6	(3)	4.4	(3)	5.6	(3)	4.4	(3)	4.4	(3)
Methoxychlor	4.6	3.9	(1)	6.2	(1)	6.2	(1)	3.9	(1)	4.5	(1)	3.9	(1)	3.9	(1)
Mirex	6.4	4.9	(3)	5.0	(3)	5.0	(3)	4.9	(3)	7.6	(3)	4.9	(3)	4.9	(3)

[a]K_{SPMD} values were estimated from K_{ow} values using the approximation $K_{SPMD} = 0.3K_{ow}$ (Huckins *et al*., 1993); K_{ow} values were obtained from Environmental Science Center Syracuse Research Corporation on-line database (accessed October 20, 1998, at http://esc.syrres.com/~esc1/kowexpdb.htm).

Table H2. Partition coefficients, sampling rates, and equations for estimating dissolved concentrations of polycyclic aromatic hydrocarbon compounds during high-flow conditions in the Columbia River Basin, 1998

[K_{SPMD}, SPMD-water partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); R, temperature-dependent sampling rate in liters per day, based on laboratory data (Huckins *et al*., 1999); shaded columns indicate tributary sites; —, all information required for calculation is not available]

		Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
	log K_{SPMD}[a]	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used
Acenaphthylene	3.6	1.9	(4)	1.9	(4)	1.9	(4)	1.9	(4)	1.4	(1)	2.3	(4)	2.3	(4)	1.9	(4)
Acenaphthene	4.1	2.5	(1)	2.5	(1)	2.5	(1)	2.5	(1)	2.3	(1)	2.7	(1)	2.7	(1)	2.5	(1)
Fluorene	4.2	2.4	(1)	2.4	(1)	2.4	(1)	2.4	(1)	1.7	(3)	3.0	(1)	3.0	(1)	2.4	(1)
Phenanthrene	4.5	3.7	(1)	3.7	(1)	3.7	(1)	3.7	(1)	3.4	(1)	3.9	(1)	3.9	(1)	3.7	(1)
Anthracene	4.7	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)	3.6	(3)	3.0	(3)	3.0	(3)	3.3	(3)
Fluoranthene	4.7	4.5	(3)	4.5	(3)	4.5	(3)	4.5	(3)	4.6	(3)	4.3	(3)	4.3	(3)	4.5	(3)
Pyrene	—	5.2	(3)	5.2	(3)	5.2	(3)	5.2	(3)	5.2	(3)	5.1	(3)	5.1	(3)	5.2	(3)
Benz[*a*]anthracene	—	3.6	(3)	3.6	(3)	3.6	(3)	3.6	(3)	3.6	(3)	3.6	(3)	3.6	(3)	3.6	(3)
Chrysene	—	4.6	(3)	4.6	(3)	4.6	(3)	4.6	(3)	5.1	(3)	4.0	(3)	4.0	(3)	4.6	(3)
Benzo[*b*]fluoranthene	—	3.3	(3)	3.3	(3)	3.3	(3)	3.3	(3)	3.4	(3)	3.2	(3)	3.2	(3)	3.3	(3)
Benzo[*k*]fluoranthene	—	3.7	(3)	3.7	(3)	3.7	(3)	3.7	(3)	4.0	(3)	3.4	(3)	3.4	(3)	3.7	(3)
Benzo[*a*]pyrene	—	3.9	(3)	3.9	(3)	3.9	(3)	3.9	(3)	4.3	(3)	3.5	(3)	3.5	(3)	3.9	(3)
Indeno[1,2,3-*cd*]pyrene	—	3.8	(3)	3.8	(3)	3.8	(3)	3.8	(3)	4.2	(3)	3.3	(3)	3.3	(3)	3.8	(3)
Dibenz[*a,h*]anthracene	—	2.8	(3)	2.8	(3)	2.8	(3)	2.8	(3)	3.3	(3)	2.3	(3)	2.3	(3)	2.8	(3)
Benzo[*g,h,i*]perylene	—	2.2	(3)	2.2	(3)	2.2	(3)	2.2	(3)	2.4	(3)	1.9	(3)	1.9	(3)	2.2	(3)

Table H2. Partition coefficients, sampling rates, and equations for estimating dissolved concentrations of polycyclic aromatic hydrocarbon compounds during high-flow conditions in the Columbia River Basin, 1998—Continued

[K_{SPMD}, SPMD-water partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); R, temperature-dependent sampling rate in liters per day, based on laboratory data (Huckins *et al*., 1999); shaded columns indicate tributary sites; —, all information required for calculation is not available]

		Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 16	
	log K_{SPMD}[a]	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used	R	Equation Used
Acenaphthylene	3.6	1.9	(4)	1.4	(1)	1.4	(1)	1.9	(4)	1.9	(4)
Acenaphthene	4.1	2.5	(1)	2.3	(1)	2.3	(1)	2.5	(1)	2.5	(1)
Fluorene	4.2	2.4	(1)	1.7	(1)	1.7	(1)	2.4	(1)	2.4	(1)
Phenanthrene	4.5	3.7	(1)	3.4	(1)	3.4	(1)	3.7	(1)	3.7	(1)
Anthracene	4.7	3.3	(3)	3.6	(3)	3.6	(3)	3.3	(3)	3.3	(3)
Fluoranthene	4.7	4.5	(3)	4.6	(3)	4.6	(3)	4.5	(3)	4.5	(3)
Pyrene	—	5.2	(3)	5.2	(3)	5.2	(3)	5.2	(3)	5.2	(3)
Benz[*a*]anthracene	—	3.6	(3)	3.6	(3)	3.6	(3)	3.6	(3)	3.6	(3)
Chrysene	—	4.6	(3)	5.1	(3)	5.1	(3)	4.6	(3)	4.6	(3)
Benzo[*b*]fluoranthene	—	3.3	(3)	3.4	(3)	3.4	(3)	3.3	(3)	3.3	(3)
Benzo[*k*]fluoranthene	—	3.7	(3)	4.0	(3)	4.0	(3)	3.7	(3)	3.7	(3)
Benzo[*a*]pyrene	—	3.9	(3)	4.3	(3)	4.3	(3)	3.9	(3)	3.9	(3)
Indeno[1,2,3-*cd*]pyrene	—	3.8	(3)	4.2	(3)	4.2	(3)	3.8	(3)	3.8	(3)
Dibenz[*a,h*]anthracene	—	2.8	(3)	3.3	(3)	3.3	(3)	2.8	(3)	2.8	(3)
Benzo[*g,h,i*]perylene	—	2.2	(3)	2.4	(3)	2.4	(3)	2.2	(3)	2.2	(3)

[a]K_{SPMD} values from Huckins *et al*. (1999).

APPENDIX I

Estimated Total Concentrations of Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds During High-flow Conditions, 1998

Table I1. Estimated total concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during high-flow conditions in the Columbia River Basin, 1998

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table J1); total concentrations were calculated using equation 5 and are reported to one significant digit, in femtograms (10^{-15} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.85		2.80		2.60		2.60[b]		2.60		2.90		2.60[b]	
Polychlorinated dibenzo-*p*-dioxins:															
2,3,7,8-Tetra	6.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Tetra	6.4	700	88%	800	88%	—	—	1,000	87%	—	—	—	—	200	87%
1,2,3,7,8-Penta	6.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Penta	6.9	400	96%	600	96%	—	—	—	—	—	—	—	—	—	—
1,2,3,4,7,8-Hexa	7.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	7.6	—	—	—	—	—	—	—	—	—	—	20,000	99%	—	—
1,2,3,7,8,9-Hexa	7.6[c]	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hexa	7.6	20,000	99%	20,000	99%	—	—	20,000	99%	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	7.6[c]	20,000	99%	—	—	—	—	20,000	99%	30,000	99%	100,000	99%	—	—
Total Hepta	7.6	30,000	99%	30,000	99%	—	—	40,000	99%	50,000	99%	200,000	99%	—	—
Octa	7.8	—	—	—	—	—	—	—	—	—	—	2,000,000	99%	—	—
Polychlorinated dibenzofurans:															
2,3,7,8-Tetra	5.7	40	60%	60	59%	30	57%	30	57%	—	—	—	—	20	57%
Total Tetra	5.7	200	60%	400	59%	100	57%	200	57%	100	57%	200	60%	70	57%
1,2,3,7,8-Penta	6.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2,3,4,7,8-Penta	6.1	—	—	20	78%	—	—	20	77%	—	—	—	—	—	—
Total Penta	6.1	50	79%	300	78%	100	77%	300	77%	—	—	—	—	200	77%
1,2,3,4,7,8-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,7,8,9-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2,3,4,6,7,8-Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hexa	6.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	7.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,2,3,4,7,8,9-Hepta	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Hepta	6.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Octa	7.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table I1. Estimated total concentrations of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans during high-flow conditions in the Columbia River Basin, 1998—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table J1); total concentrations were calculated using equation 5 and are reported to one significant digit, in femtograms (10^{-15} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Vernita Bridge (388)		Northport (735)	
		Site 09		Site 10		Site 14		Site 16	
Organic Carbon (mg/L)		2.60		2.60[b]		2.20		1.65	
Polychlorinated dibenzo-*p*-dioxins:									
2,3,7,8-Tetra	6.4	—	—	—	—	—	—	—	—
Total Tetra	6.4	500	87%	300	87%	600	85%	100	81%
1,2,3,7,8-Penta	6.9	—	—	—	—	—	—	—	—
Total Penta	6.9	300	96%	—	—	—	—	—	—
1,2,3,4,7,8-Hexa	7.6	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	7.6	—	—	—	—	—	—	—	—
1,2,3,7,8,9-Hexa	7.6[c]	—	—	—	—	—	—	—	—
Total Hexa	7.6	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	7.6[c]	—	—	—	—	—	—	—	—
Total Hepta	7.6	—	—	—	—	—	—	20,000	99%
Octa	7.8	—	—	—	—	—	—	600,000	99%
Polychlorinated dibenzofurans:									
2,3,7,8-Tetra	5.7	50	57%	40	57%	30	53%	—	—
Total Tetra	5.7	300	57%	200	57%	200	53%	30	46%
1,2,3,7,8-Penta	6.1	—	—	—	—	—	—	—	—
2,3,4,7,8-Penta	6.1	—	—	—	—	—	—	—	—
Total Penta	6.1	400	77%	60	77%	100	74%	10	68%
1,2,3,4,7,8-Hexa	6.6	—	—	—	—	—	—	—	—
1,2,3,6,7,8-Hexa	6.6	—	—	—	—	—	—	—	—
1,2,3,7,8,9-Hexa	6.6	—	—	—	—	—	—	—	—
2,3,4,6,7,8-Hexa	6.6	—	—	—	—	—	—	—	—
Total Hexa	6.6	—	—	—	—	—	—	—	—
1,2,3,4,6,7,8-Hepta	7.0	—	—	—	—	—	—	—	—
1,2,3,4,7,8,9-Hepta	6.5	—	—	—	—	—	—	—	—
Total Hepta	6.8	—	—	—	—	—	—	—	—
Octa	7.2	—	—	—	—	—	—	—	—

[a]K_{oc} values were estimated using the approximation $K_{oc} = 0.411K_{ow}$ (Karickhoff, 1981); except where noted otherwise, K_{ow} values were taken from Gale *et al*. (1997); K_{ow} values for homolog totals were estimated from the average K_{ow} values of the individual congeners quantified.

[b]Approximation based on values from sites 3 and 9.

[c]K_{ow} values from Mackay *et al*. (1992) (value for 1,2,3,4,7,8-hexachloro congener was used to approximate value for 1,2,3,6,7,8-hexachloro congener).

Table I2. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table J1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.85		2.80		2.60		2.60		2.60		2.90		2.60	
6	4.7	—	—	2	12%	—	—	—	—	—	—	—	—	—	—
19	4.6	10	11%	20	11%	9	10%	10	10%	—	—	10	11%	—	—
18	4.9	20	17%	30	17%	20	16%	20	16%	8	16%	30	17%	20	16%
26	5.3	—	—	8	34%	4	33%	6	33%	4	33%	5	35%	2	33%
25	5.3	—	—	40	35%	—	—	40	33%	—	—	—	—	—	—
45	5.1	—	—	—	—	—	—	—	—	2	27%	8	29%	—	—
46	5.1	8	28%	—	—	—	—	8	27%	—	—	—	—	3	27%
52	5.5	40	45%	60	44%	—	—	50	43%	20	43%	300	45%	10	43%
44	5.4	20	40%	30	39%	20	38%	20	38%	—	—	90	40%	10	38%
42	5.4	20	40%	20	40%	10	38%	20	38%	6	38%	30	41%	—	—
40	5.3	—	—	100	34%	50	33%	—	—	2	33%	40	35%	30	33%
67	5.8	—	—	—	—	—	—	—	—	—	—	50	65%	—	—
63	5.8	—	—	—	—	—	—	—	—	—	—	90	64%	—	—
74	5.8	30	65%	30	65%	20	63%	30	63%	7	63%	30	65%	6	63%
91	5.7	—	—	—	—	—	—	—	—	8	59%	70	62%	—	—
92	6.0	—	—	—	—	—	—	—	—	10	71%	90	73%	—	—
84	5.7	—	—	—	—	—	—	60	54%	10	54%	200	57%	40	54%
101	6.0	60	74%	80	73%	30	72%	70	72%	30	72%	400	74%	30	72%
99	6.0	—	—	—	—	—	—	—	—	20	72%	200	75%	—	—
119	6.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
83	5.9	—	—	—	—	—	—	—	—	—	—	40	68%	—	—
97	5.9	30	70%	30	69%	—	—	30	68%	10	68%	100	70%	10	68%
85	5.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
136	5.8	—	—	—	—	—	—	—	—	5	64%	40	66%	—	—
110	6.1	100	78%	200	78%	—	—	100	76%	30	76%	300	78%	—	—
82	5.8	30	65%	20	65%	10	63%	20	63%	7	63%	200	65%	—	—

Table I2. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table J1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.85		2.80		2.60		2.60		2.60		2.90		2.60	
151	6.3	50	84%	70	83%	30	82%	50	82%	—	—	100	84%	70	82%
118	6.4	90	87%	100	86%	50	85%	90	85%	—	—	400	87%	50	85%
134	6.2	—	—	—	—	—	—	—	—	—	—	8	81%	—	—
146	6.5	—	—	—	—	—	—	—	—	—	—	90	90%	—	—
183	6.8	—	—	60	95%	—	—	50	94%	—	—	300	95%	—	—
128	6.4	—	—	—	—	—	—	—	—	—	—	60	87%	—	—
174	6.7	—	—	60	94%	—	—	—	—	30	93%	400	94%	—	—
177	6.7	—	—	50	93%	—	—	30	93%	—	—	300	93%	—	—
199	7.2	—	—	—	—	—	—	—	—	—	—	500	98%	—	—
207	7.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
194	7.4	—	—	—	—	—	—	—	—	—	—	600	99%	—	—
Sum of quantified *ortho*-substituted PCBs		500		1,000		300		700		200		5,000		300	

Table I2. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table J1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Vernita Bridge (388)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 14		Site 15		Site 16	
Organic Carbon (mg/L)		2.60		2.60		2.20		1.70		1.65	
6	4.7	—	—	0.5	11%	1	9%	—	—	—	—
19	4.6	—	—	—	—	—	—	—	—	—	—
18	4.9	20	16%	20	16%	20	14%	—	—	20	11%
26	5.3	3	33%	3	33%	4	29%	—	—	—	—
25	5.3	—	—	—	—	—	—	—	—	—	—
45	5.1	—	—	—	—	—	—	—	—	—	—
46	5.1	3	27%	4	27%	4	23%	—	—	3	19%
52	5.5	30	43%	30	43%	40	38%	—	—	—	—
44	5.4	10	38%	10	38%	20	34%	—	—	10	28%
42	5.4	10	38%	9	38%	20	34%	—	—	—	—
40	5.3	—	—	30	33%	—	—	—	—	—	—
67	5.8	—	—	—	—	—	—	—	—	—	—
63	5.8	—	—	—	—	—	—	—	—	—	—
74	5.8	8	63%	10	63%	30	59%	—	—	—	—
91	5.7	—	—	—	—	—	—	—	—	—	—
92	6.0	—	—	—	—	—	—	—	—	8	60%
84	5.7	—	—	—	—	70	50%	—	—	20	43%
101	6.0	20	72%	60	72%	50	68%	—	—	—	—
99	6.0	—	—	—	—	—	—	—	—	—	—
119	6.2	—	—	—	—	—	—	—	—	—	—
83	5.9	—	—	—	—	—	—	—	—	—	—
97	5.9	20	68%	20	68%	30	64%	—	—	8	57%
85	5.9	—	—	—	—	—	—	—	—	—	—
136	5.8	—	—	—	—	—	—	—	—	—	—
110	6.1	—	—	—	—	60	73%	—	—	30	67%
82	5.8	20	63%	20	63%	—	—	—	—	—	—
151	6.3	90	82%	100	82%	30	80%	—	—	30	75%

Table I2. Estimated total concentrations of *ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table J1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Vernita Bridge (388)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 14		Site 15		Site 16	
Organic Carbon (mg/L)		2.60		2.60		2.20		1.70		1.65	
118	6.4	90	85%	100	85%	70	83%	—	—	20	79%
134	6.2	—	—	—	—	—	—	—	—	—	—
146	6.5	—	—	—	—	—	—	—	—	—	—
183	6.8	100	94%	—	—	—	—	—	—	—	—
128	6.4	—	—	—	—	—	—	—	—	20	79%
174	6.7	—	—	70	93%	20	92%	—	—	—	—
177	6.7	30	93%	70	93%	20	92%	—	—	—	—
199	7.2	—	—	90	98%	60	97%	—	—	—	—
207	7.4	—	—	—	—	—	—	—	—	—	—
194	7.4	200	99%	200	99%	—	—	—	—	200	98%
Sum of quantified *ortho*-substituted PCBs		600		800		500		0		400	

[a]K_{oc} values were estimated from K_{ow} values of Meadows *et al*. (1998) using the approximation $K_{oc} = 0.411K_{ow}$ (Karickhoff, 1981).
[b]Value from high-flow deployment period.
[c]Approximation based on values from sites 3 and 4.

Table I3. Estimated total concentrations of non-*ortho*-substituted polychlorinated biphenyls during high-flow conditions in the Columbia River Basin, 1998

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table J1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available; see Appendix A for general chemical structures of congeners]

Congener No.	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.85		2.80		2.60		2.60[b]		2.60		2.90		2.60[b]	
37	5.4	—	—	—	—	—	—	—	—	1	42%	—	—	—	—
81	6.0	0.06	73%	0.08	72%	—	—	0.09	71%	—	—	—	—	—	—
77	6.0	1	73%	2	72%	0.8	71%	2	71%	0.9	71%	4	73%	—	—
126	6.5	0.2	90%	0.3	90%	0.1	89%	0.2	89%	—	—	1	90%	0.08	89%
169	7.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Congener No.	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Vernita Bridge (388)		Northport (735)	
		Site 09		Site 10		Site 14		Site 16	
Organic Carbon (mg/L)		2.60		2.60[b]		2.20		1.65	
37	5.4	—	—	—	—	—	—	—	—
81	6.0	—	—	—	—	0.07	67%	—	—
77	6.0	0.8	71%	0.8	71%	1	67%	—	—
126	6.5	0.2	89%	0.2	89%	0.2	88%	0.07	84%
169	7.0	—	—	—	—	—	—	—	—

[a]K_{oc} values were estimated from K_{ow} values of Hawker and Connell (1988) using the approximation $K_{oc} = 0.411K_{ow}$ (Karickhoff, 1981).
[b]Approximation based on values from sites 3 and 9.

Table I4. Estimated total concentrations of organochlorine pesticides and related transformation products during high-flow conditions in the Columbia River Basin, 1998

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table J1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.85		2.80		2.60		2.60[b]		2.60		2.90		2.60[b]	
Hexachlorobenzene	5.3	—	—	—	—	—	—	—	—	—	—	300	—	—	—
Pentachloroanisole	5.1	90	25%	60	24%	30	23%	100	23%	100	23%	800	25%	30	23%
alpha-hexachlorocyclohexane	3.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lindane	3.3	—	—	—	—	—	—	—	—	1,000	1%	2,000	1%	—	—
beta-hexachlorocyclohexane	3.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	5.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
delta-hexachlorocyclohexane	3.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	6.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	4.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	4.6	—	—	—	—	—	—	—	—	—	—	40	10%	—	—
trans-Chlordane	5.8	—	—	—	—	—	—	—	—	—	—	400	66%	—	—
trans-Nonachlor	6.0	—	—	—	—	—	—	—	—	—	—	500	73%	—	—
o,p'-DDE	5.6	—	—	—	—	—	—	—	—	—	—	200	54%	—	—
cis-Chlordane	5.7	—	—	—	—	—	—	—	—	—	—	500	60%	—	—
p,p'-DDE	6.1	800	79%	1,000	79%	700	78%	700	78%	300	78%	6,000	79%	700	78%
Dieldrin	5.0	50	23%	40	22%	50	21%	80	21%	100	21%	3,000	23%	50	21%
o,p'-DDD	5.5	100	46%	200	46%	100	44%	100	44%	20	44%	300	47%	100	44%
Endrin	4.8	—	—	—	—	—	—	—	—	—	—	20	16%	—	—
o,p'-DDT	6.4	700	88%	500	88%	—	—	500	87%	—	—	3,000	88%	—	—
cis-Nonachlor	5.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
p,p'-DDD	5.6	400	55%	600	55%	—	—	400	53%	80	53%	1,000	56%	400	53%
p,p'-DDT	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Methoxychlor	4.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mirex	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table I4. Estimated total concentrations of organochlorine pesticides and related transformation products during high-flow conditions in the Columbia River Basin, 1998—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period (organic carbon data are given in table J1); total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Lower Crab Creek (411)		Wenatchee River (468)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 12		Site 15		Site 16	
Organic Carbon (mg/L)		2.60		2.60[b]		3.65		2.20		6.05		1.70		1.65	
Hexachlorobenzene	5.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pentachloroanisole	5.1	30	23%	30	23%	—	—	30	20%	—	—	—	—	—	—
alpha-hexachlorocyclohexane	3.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lindane	3.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
beta-hexachlorocyclohexane	3.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor	5.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
delta-hexachlorocyclohexane	3.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aldrin	6.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dacthal	4.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxychlordane	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Heptachlor Epoxide	4.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
trans-Chlordane	5.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
trans-Nonachlor	6.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
o,p'-DDE	5.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
cis-Chlordane	5.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
p,p'-DDE	6.1	2,000	78%	1,000	78%	6,000	83%	2,000	75%	—	—	400	69%	—	—
Dieldrin	5.0	50	21%	40	21%	1,000	27%	—	—	100	38%	—	—	—	—
o,p'-DDD	5.5	200	44%	200	44%	400	53%	300	40%	—	—	—	—	—	—
Endrin	4.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
o,p'-DDT	6.4	300	87%	300	87%	1,000	90%	300	85%	—	—	—	—	100	81%
cis-Nonachlor	5.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
p,p'-DDD	5.6	700	53%	500	53%	1,000	61%	1,000	49%	—	—	—	—	—	—
p,p'-DDT	6.5	—	—	—	—	4,000	92%	—	—	—	—	—	—	—	—
Methoxychlor	4.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mirex	6.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[a]K_{oc} values were estimated from K_{ow} values using the approximation $K_{oc} = 0.411K_{ow}$ (Karickhoff, 1981); K_{ow} values were obtained from Environmental Science Center Syracuse Research Corporation on-line database (accessed October 20, 1998, at http://esc.syrres.com/~esc1/kowexpdb.htm).
[b]Approximation based on values from sites 3 and 9.

Table I5. Estimated total concentrations of polycyclic aromatic hydrocarbon compounds during high-flow conditions in the Columbia River Basin, 1998

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period; organic carbon data are given in table J1; total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Bradwood (39)		Beaver Army Terminal (54)		Longview (69)		Columbia City (82)		Lake River (87)		Willamette River (101)		Johnson Creek (—)		Hayden Island (102)	
		Site 01		Site 02		Site 03		Site 04		Site 05		Site 06		Site 08		Site 07	
Organic Carbon (mg/L)		2.85		2.80		2.60		2.60[b]		3.10		2.60		2.90		2.60[b]	
Acenaphthylene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Acenaphthene	3.5	—	—	—	—	—	—	—	—	—	—	7,000	1%	—	—	—	—
Fluorene	3.8	—	—	800	2%	—	—	—	—	—	—	3,000	2%	—	—	—	—
Phenanthrene	4.1	—	—	—	—	—	—	—	—	—	—	6,000	3%	5,000	3%	—	—
Anthracene	4.1	—	—	—	—	—	—	—	—	—	—	1,000	3%	—	—	—	—
Fluoranthene	4.6	3,000	11%	7,000	11%	3,000	10%	3,000	10%	3,000	12%	3,000	10%	5,000	11%	2,000	10%
Pyrene	4.6	2,000	10%	5,000	10%	1,000	9%	3,000	9%	2,000	11%	3,000	9%	20,000	10%	1,000	9%
Benz[*a*]anthracene	5.2	—	—	1,000	33%	—	—	500	31%	—	—	500	31%	2,000	34%	—	—
Chrysene	5.2	1,000	33%	2,000	33%	600	31%	1,000	31%	700	35%	800	31%	6,000	34%	500	31%
Benzo[*b*]fluoranthene	5.8	—	—	2,000	65%	—	—	—	—	—	—	—	—	3,000	66%	—	—
Benzo[*k*]fluoranthene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Benzo[*a*]pyrene	5.7	—	—	—	—	—	—	—	—	—	—	—	—	1,000	57%	—	—
Indeno[1,2,3-*cd*]pyrene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dibenz[*a,h*]anthracene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Benzo[*g,h,i*]perylene	6.4	—	—	—	—	—	—	—	—	—	—	—	—	4,000	88%	—	—

Table I5. Estimated total concentrations of polycyclic aromatic hydrocarbon compounds during high-flow conditions in the Columbia River Basin, 1998—Continued

[K_{oc}, organic-carbon partition coefficient; numbers in parentheses below site names indicate Columbia River mile (point of entry for tributaries); mg/L, milligrams per liter; organic carbon values are the average of suspended plus dissolved organic carbon measured during the SPMD exposure period; organic carbon data are given in table J1; total concentrations were calculated using equation 5 and are reported to one significant digit, in picograms (10^{-12} grams) per liter, with estimated absolute error of approximately one order of magnitude; percentages following concentrations indicate the percent of the total concentration that is sorbed; shaded columns indicate tributary sites; the first sample of each duplicate pair was used in calculations; —, all information required for calculation is not available]

	Log K_{oc}[a]	Warrendale (141)		Umatilla (289)		Yakima River (335)		Vernita Bridge (388)		Northport (735)	
		Site 09		Site 10		Site 11		Site 14		Site 16	
Organic Carbon (mg/L)		2.60		2.60[b]		3.65		2.20		1.65	
Acenaphthylene	—	—	—	—	—	—	—	—	—	—	—
Acenaphthene	3.5	—	—	—	—	—	—	—	—	—	—
Fluorene	3.8	800	2%	—	—	3,000	2%	—	—	—	—
Phenanthrene	4.1	—	—	—	—	4,000	4%	—	—	—	—
Anthracene	4.1	—	—	—	—	—	—	—	—	—	—
Fluoranthene	4.6	3,000	10%	1,000	10%	2,000	14%	2,000	9%	2,000	7%
Pyrene	4.6	2,000	9%	700	9%	600	13%	800	8%	400	6%
Benz[*a*]anthracene	5.2	—	—	—	—	—	—	—	—	—	—
Chrysene	5.2	900	31%	300	31%	—	—	700	28%	300	22%
Benzo[*b*]fluoranthene	5.8	—	—	—	—	—	—	—	—	—	—
Benzo[*k*]fluoranthene	—	—	—	—	—	—	—	—	—	—	—
Benzo[*a*]pyrene	5.7	—	—	—	—	—	—	—	—	—	—
Indeno[1,2,3-*cd*]pyrene	—	—	—	—	—	—	—	—	—	—	—
Dibenz[*a,h*]anthracene	—	—	—	—	—	—	—	—	—	—	—
Benzo[*g,h,i*]perylene	6.4	—	—	—	—	—	—	—	—	—	—

[a]K_{oc} values were estimated from K_{ow} values of Onuska *et al*. (1989) using the approximation $K_{oc} = 0.411K_{ow}$ (Karickhoff, 1981).
[b]Approximation based on values from sites 3 and 9.

APPENDIX J

Suspended and Dissolved Organic Carbon During High-Flow Conditions, 1998

Table J1. Organic carbon measured during high-flow conditions in the Columbia River Basin, 1998

[mg/L, milligrams per liter; — not applicable; shaded cells indicate duplicate sample pairs]

Site Name	Site Number	Data-Collection Date	Suspended Organic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)
		Phase 1 Deployment		
Willamette River	06	01/15/98	0.60	2.40
		02/10/98	0.30[a]	1.90[a]
Johnson Creek	08	01/15/98	1.40	2.20
		02/18/98	0.40	1.80
Equipment Blank	—	01/15/98	0.20	0.30
		Phase 2 Deployment		
Bradwood	01	05/19/98	0.50	2.40
		05/19/98	0.50	2.30
Beaver	02	06/08/98	0.40[a]	2.40[a]
Longview	03	05/21/98	0.20	2.40
Lake River	05	05/22/98	0.40	2.70
Warrendale	09	06/09/98	0.20[a]	2.40[a]
Yakima	11	06/04/98	0.80	1.90
		07/07/98	2.20	2.40
Crab Creek	12	06/03/98	2.50	3.40
		07/07/98	2.60	3.60
Snake River	13	06/22/98	0.50[a]	2.20[a]
		06/22/98	0.40[a]	2.10[a]
		07/06/98	0.50[a]	2.40[a]
Vernita	14	06/17/98	0.30[a]	1.90[a]
Wenatchee	15	06/03/98	0.60	1.30
		07/07/98	0.50	1.00
Northport	16	06/24/98	0.30[a]	1.40[a]
		06/24/98	0.20[a]	1.40[a]
Equipment Blank	—	05/22/98	0.50	1.00
Equipment Blank	—	06/23/98	0.20	0.30

[a]Data collected as part of the U.S. Geological Survey's National Stream Quality Accounting Network Program (unpublished data, 1998).