Total Maximum Daily Loads of Polychlorinated Biphenyls (PCBs) for Tidal Portions of the Potomac and Anacostia Rivers in the District of Columbia, Maryland, and Virginia

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for
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Virginia Department of Environmental Quality

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This document is an inter-jurisdictional TMDL submitted by the Commonwealth of Virginia, the State of Maryland, and the District of Columbia, Washington D.C. It addresses PCB impairments in the tidal Potomac and Anacostia rivers. The document was prepared by the Interstate Commission on the Potomac River Basin in cooperation with a Steering Committee that included representatives from each affected jurisdiction, LimnoTech, Metropolitan Washington Council of Governments, and the U.S. Environmental Protection Agency. The following individuals participated as Steering Committee members for part or all of the Potomac PCB TMDL project:

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ICPRB was charged with drafting this report. The Steering Committee members and individuals at their agencies provided substantial editorial assistance and technical contributions, particularly Section VII (TMDL Implementation and Reasonable Assurance) and Appendix E (Semi-Permeable Membrane Devices (SPMDs)). The Potomac PCB model was developed by LimnoTech and their contribution was invaluable. The technical support of ICPRB staff members Kristin Bermann, Sunghee Kim, and Ross Mandel, and MDE staff member Jeff White is gratefully acknowledged.

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This document can be downloaded from www.potomacriver.org.

EXECUTIVE SUMMARY

[Note: This document originally was submitted to the EPA on September 28, 2007. After that date, certain inconsistencies between tables were identified, as were places where labeling on figures and modifications to text were needed to improve clarity. This version reflects all of those changes, none of which significantly changes TMDL allocations.]

This document, upon approval by the U.S. Environmental Protection Agency (US EPA), establishes Total Maximum Daily Loads (TMDLs) for polychlorinated biphenyls (PCBs) for 28 listed impaired water body segments in the tidal waters of the Potomac and Anacostia rivers in the District of Columbia, Maryland, and Virginia. Section 303(d) of the federal Clean Water Act (CWA) and EPA's implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLS), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is required to either establish a TMDL of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2007a).

The District of Columbia has listed, in five defined segments, all of the tidal Anacostia and Potomac rivers within District borders. These WQLSs are designated for Class D (protection of human health related to the consumption of fish and shellfish) beneficial use, which is not supported due to elevated levels of PCBs in fish tissue, and were initially listed on DC's 303(d) lists in 1996 and 1998 (DC DOH 2006). A PCB TMDL was established for the tidal Anacostia River by the District of Columbia in 2003. The TMDLs developed in this report will, when approved, replace the 2003 Anacostia TMDL.

The Commonwealth of Virginia has listed in the 2006 305(b)/303(d) Integrated Report 19 tidal embayments of the Potomac River as impaired due to PCBs. These WQLSs are designated for the beneficial uses of primary contact recreation, fish consumption, shellfish consumption (from Upper Machodoc Creek to the Potomac mouth), and the aquatic life use (VA DEQ 2006a). The fish consumption use is not supported due to elevated levels of PCBs in fish tissue (VA DEQ 2006b).

The State of Maryland has listed the Potomac River Lower Tidal (basin number 02140101), Potomac River Middle Tidal (basin number 02140102), Potomac River Upper Tidal (basin number 02140201), and tidal portion of the Anacostia River (basin number 02140205) as impaired due to elevated levels of PCBs in fish tissue and other causes (MDE 2006). These waters are designated Use II: Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting (COMAR 2007a, b). The Maryland Department of the Environment identified the waters of the Potomac River Lower Tidal watershed on the State's 303(d) List as impaired by nutrients (1996), sediments (1996), toxics (PCBs in fish tissue) (2002), bacteria (2004), and impacts to biological communities (2004 and 2006) (MDE 2006). A TMDL for Fecal Coliform to address the 2004 bacteria listing was approved by the EPA in 2005. The Department listed waters of the Potomac River Middle Tidal watershed as impaired by nutrients (1996), sediments (1996), toxics (PCBs in fish tissue) (2002), metals (Cadmium, Chromium, Copper, and Lead) (1996), and impacts to biological communities (2004 and 2006) (MDE 2006). A Water Quality Analysis (WQA) for Cadmium, Chromium, Copper, and Lead to address the 1996 metals listing was approved by the EPA in 2006. Waters of the Potomac River Upper Tidal watershed were placed on the State's 303(d) List as impaired by nutrients (1996), sediments (1996), toxics (PCBs in fish tissue) (2002), metals (Copper) (1996), and impacts to biological communities (2006 – non-tidal) (MDE 2006). A WQA for Copper to address the 1996 metals listing was approved by the EPA in 2006. The waters of the tidal Anacostia River watershed were placed on the State's 303(d) List as impaired by nutrients (1996), sediments (1996), toxics (PCBs in fish tissue) (2006), bacteria (2004), and trash/debris (2006). A TMDL for Fecal Coliform to address the 2004 bacteria listing was approved by the EPA in 2006, and a TMDL for sediments to address the 1996 listing was approved by EPA in 2007.

A data solicitation for PCBs was conducted by the PCB TMDL Steering Committee, and all readily available data have been considered. This document addresses the PCB impairment only. In all three jurisdictions, remaining impairment listings for causes other than PCBs will be addressed separately at a future date.

A consent decree was entered into by the EPA and the U.S. District Court (Kingman Park Civic Association, et al. v. U.S. Environmental Protection Agency, et al, No. 1:98CV00758 (D.D.C.)) that requires the District of Columbia to complete a PCB TMDL by September 30, 2007. Maryland and Virginia were not required to complete their PCB TMDLs by this date, but the three jurisdictions informally agreed in 2004 to coordinate their PCB TMDL development efforts and address all of their tidal Potomac PCB impairments by that date. This study is the result of that agreement. A joint TMDL was desirable because the impaired waterbodies in the three jurisdictions are in such close proximity to each other that flows and loads cross state lines in each direction. Furthermore, a single, joint TMDL would be more cost effective, and the jurisdictions would avoid confusing the public with three independent TMDLs completed on different dates using potentially different models and assumptions, and possibly reaching different conclusions, particularly with respect to PCB loads crossing state lines.

The provisions of this PCB TMDL are severable. If any provision of the PCB TMDL, or the application of any provision of this TMDL to any circumstances or participating jurisdiction, is held invalid by a court of competent jurisdiction, the application of such provision to other circumstances and any other participating jurisdiction, and the remainder of the TMDL document, shall not be affected.

The objective of the PCB TMDL established in this document is to ensure that the "fish consumption" use is protected in each of the impaired waterbodies. This was done by identifying maximum allowable PCB loads that would a) meet the applicable PCB water quality criteria and b) lead to fish tissue PCB concentrations that do not exceed jurisdictional fish tissue thresholds. The following measures were taken to achieve the objective of the PCB TMDL:

- PCB sources were identified and PCB loads in the baseline condition were estimated by an analysis of data collected from 2002 to 2007 and various models;
- A linked hydrodynamic and PCB transport and fate model (POTPCB) was built and calibrated to existing data;
- Analysis of ambient water column and fish tissue data showed that the current PCB water quality criteria are not protective of fish tissue concentrations in the tidal Potomac and Anacostia rivers, and new target water column concentrations were calculated, using EPA recommended methods, to be protective of fish tissue concentrations.

- The POTPCB model was run with a series of loading scenarios that identified the impact of individual sources, and then the model was run with an iterative series of adjustments to input loads until a set of loads (the TMDL scenario) that met the water column target in all model segments was achieved.
- Conservative assumptions were applied to the load estimation methods for each source category to provide an implicit Margin of Safety (MOS). In addition, an explicit MOS was set aside by deducting 5% from the TMDL scenario load allocation for all source categories except WWTPs. This was done to account for a somewhat greater level of uncertainty in load estimates for those sources.

The first table below shows the current water quality criteria and fish tissue threshold concentrations of each jurisdiction, as well as the new water column and sediment targets based on fish bioaccumulation factors (BAFs) calculated for this TMDL. The second table shows the annual load of total PCBs in the study's Baseline Scenario (Year 2005) for each PCB source category and the equivalent loads when the tidal Potomac and Anacostia TMDL is achieved.

EPA's regulations require TMDLs to take into account seasonality and critical conditions related to stream flow, loading, and water quality parameters (CFR 2007a). Seasonality and critical conditions are captured in this TMDL document through the use of 2005 as the hydrologic design year, and the use of daily surface flows and loads of total suspended solids and particulate carbon from 2005 as baseline conditions. The period from 2002 to the present has the most extensive and best documented water column and sediment PCB data. During this time period, Potomac River flows in calendar year 2005 most closely matched the river's long-term harmonic mean flow, which is the flow condition recommended by EPA as the critical condition for TMDLs for substances whose human health impact is derived from lifetime exposure (EPA 1991). Selection of the hydrologic design year is described in Appendix C. The use of daily surface flows and loads of total suspended solids and particulate carbon from 2005 further addresses the requirements of critical conditions and seasonality.

Jurisdiction Water Quality Criteria and Targets Derived from Bioaccumulation Factors (BAF)[1]

	Fish Tissue Impairment Threshold (ppb)[2]	Water Quality Criteria (ng/l)[3]	BAF-based, Target Water Concentration (ng/l)[4]	BAF-based Target Sediment Concentration (ng/g dry wt)[4]
DC	20	0.064	0.059	2.8
Maryland	88	0.64	0.26	12.0
Virginia	54[5]	1.70	0.064	7.6

[1] Water and sediment target concentrations are calculated by dividing fish tissue PCB impairment thresholds by a species specific BAF
[2] ppb = parts per billion PCBs, which is equivalent to nanograms per gram (ng/g)
[3] ng/l = nanograms PCBs per liter
[4] ng/g dry wt = nanograms PCBs per gram dry weight of sediment
[5] The Virginia Department of Health uses 50 ppb as the fish tissue threshold for establishing consumption advisories.

Total PCB loads to the tidal Potomac and Anacostia rivers, in g/year

Source category	Baseline (g/year)	TMDL (g/year)	Reduction
Potomac @ Chain Bridge[1]	16,433	312	98%
Lower Basin Tributaries[2]	2,857	387	86%
Direct drainage[3]	10,996	392	96%
WWTP[4]	762	68.2	91%
CSO[5]	3,020	58.1	98%
Atmospheric deposition[6]	3,070	206	93%
Contaminated sites[7]	15.1	10.3	32%
Margin of Safety (MOS)		71.8	
TOTAL[8]	37,156	1,510	96%

[1] The non-tidal Potomac River above Chain Bridge in the District of Columbia. Chain Bridge is the approximate head-of-tide of the tidal Potomac River, or estuary.
[2] The lower basin is that portion of the Potomac River watershed that contributes to the tidal waters, and excludes the watershed above Chain Bridge. The tributaries are the 17 streams in the lower basin defined in the Chesapeake Bay Watershed Model (WM5) as tributaries.
[3] That part of the lower basin watershed that is not in a WM5 defined tributary. Direct drainage areas are located adjacent to the Potomac and Anacostia rivers.
[4] Waste water treatment plant.
[5] Combined sewer overflow system.
[6] Atmospheric PCBs deposited directly on the tidal water surface.
[7] Those sites that have been identified as contaminated by PCBs, some of which have been remediated.
[8] This total does not include changes in the Downstream Boundary condition for reasons explained in Section V(5.2)

Although TMDLs were calculated for each impaired waterbody, or WQLS, it is important to recognize that these waterbodies are interconnected in a tidal system. Load and load reductions in one impaired segment can impact neighboring segments. This effect is most pronounced for the non-tidal Potomac River where Baseline loads affect water column PCB concentrations for at least half the length of the tidal river. Similarly, the downstream boundary of the tidal Potomac River with the Chesapeake Bay was found to influence water column PCB concentrations in the lower river enough that a 33% reduction in the downstream boundary concentration is necessary to meet the PCB water column target in the Coan River WQLS. The table on the next page lists the total Baseline and TMDL PCB loads for each impaired segment. Included in this table is a load allocation to those parts of the tidal Potomac that are not specifically listed as impaired. They are included because loads delivered to these non-listed waters have an impact on PCB levels in neighboring segments.

The Clean Water Act and current EPA regulations require reasonable assurance that TMDL LAs will be implemented. It is clear that progress toward achieving the Potomac PCB TMDL described in this report will require significant reductions from point, nonpoint, and atmospheric sources of PCBs to the estuary. The jurisdictions have agreed to proceed with an adaptive implementation approach using additional data collected concurrently with activities to reduce PCB loadings. New data and information will not necessarily re-open the TMDL, but the TMDL and allocation scenarios can be changed if warranted by new data and information. Data collection to better quantify loads from the non-tidal River above Chain Bridge, from atmospheric deposition and exchange, from lower basin tributaries and direct drainage, and at the Chesapeake Bay downstream boundary have high priority.

Annual Baseline and TMDL PCB loads to each impaired segment

Water Quality Limited Segment	Impairment ref. #[1]	Jurisdiction	Baseline (g/year)	TMDL (g/year)	Reduction
Upper Potomac	1	DC	16700	333.	98.0%
Middle Potomac	2	DC	3610	53.7	98.5%
Lower Potomac	3	DC	1880	80.9	95.7%
Upper Anacostia	4	DC	4990	3.74	99.9%
Lower Anacostia	5	DC	2700	4.95	99.8%
Accotink Creek	6	VA	618	49.5	92.0%
Aquia Creek	7	VA	54.3	44.5	18.0%
Belmont Bay	8	VA	41.5	4.84	88.3%
Chopawamsic Creek	9	VA	7.56	5.32	29.6%
Coan River	10	VA	15	6.98	53.5%
Dogue Creek	11	VA	89.2	30.6	65.7%
Fourmile Run	12	VA	193	12.6	93.4%
Gunston Cove	13	VA	43.7	5.62	87.1%
Hooff Run & Hunting Creek	14	VA	480	89.7	81.3%
Little Hunting Creek	15	VA	46.8	15.5	66.9%
Monroe Creek	16	VA	9.35	1.66	82.2%
Neabsco Creek	17	VA	17.4	8.76	49.7%
Occoquan River	18	VA	442	71.1	83.9%
Pohick Creek	19	VA	57.8	22.4	61.2%
Potomac Creek	20	VA	24.1	11.5	52.3%
Potomac River, Fairview Beach	21	VA	11.9	1.50	87.4%
Powells Creek	22	VA	6.57	0.70	89.3%
Quantico Creek	23	VA	22	15.3	30.5%
Upper Machodoc Creek	24	VA	13.9	9.12	34.4%
Tidal Anacostia	25	MD	1970	16.2	99.2%
Potomac River Lower	26	MD	1250	138	89.0%
Potomac River Middle	27	MD	454	56.2	87.6%
Potomac River Upper	28	MD	618	61.7	90.0%
Not Listed waterbodies		ALL	777	350.	55.0%
Total all tidal waters[2]		ALL	37143	1510.	95.9%

[1] Locations of Water Quality Limited Segments (Impaired Water Bodies) are shown on Figure 1, page 2, by reference number.
[2] Not included in this table are changes in the Downstream Boundary with the Chesapeake Bay. There is a net export of PCBs from the Potomac with the Baseline Scenario while there is a net import of PCBs, although at lower concentration with the TMDL scenario. See Section V(5.2).

PCB regulatory activities will include the issuance of NPDES permits that are consistent with the TMDL after it has been approved. In all the jurisdictions, several monitoring, restoration, and regulatory programs are already in place that will reduce PCB loads from both point and nonpoint sources. These programs involve storm water runoff controls, erosion control measures to reduce sediments and nutrients, identification of additional PCB sources and contaminated sites, non-numeric water quality based effluent limits, construction site inspections, and remediation of contaminated sites. Follow up monitoring of water, sediment, and fish tissue is an important feature of each jurisdiction's implementation strategy.

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ABBREVIATIONS

ANAC	Anacostia spatial zone
ANS	Academy of Natural Sciences, Philadelphia
BAF	Bioaccumulation factor
BAT	Battelle Laboratory
BIC	Biotic (algal) carbon
BMP	Best Management Practice
BOD	Biological oxygen demand
BSAF	Biota-sediment bioaccumulation factors
CBEMP	Chesapeake Bay Environmental Model Package
CBL	University of Maryland Chesapeake Biological Laboratory
CBP	Chesapeake Bay Program
CBWQM	Chesapeake Bay Water Quality Model
CFD	Cumulative frequency distribution
cfs	Cubic feet per second
CH3D	Chesapeake Bay Hydrodynamic Model
Chl a	Chlorophyll a concentration
CSO	Combined sewer overflow system
CWA	Clean Water Act
DC	District of Columbia
DC WASA	District of Columbia Water and Sewer Authority
DDOE	District of Columbia Department of the Environment
DD	Direct drainage
DOC	Dissolved organic carbon
DRBC	Delaware River Basin Commission
DYNHYD	Dynamic Hydrologic Model
EPA	U.S. Environmental Protection Agency
ERDC	Engineer Research and Development Center, Vicksburg, MS
ETM	Estuarine turbidity maximum
FIPS	Federal Information Processing Standard
g/yr	Grams per year
GERG	Geochemical and Environmental Research Group, Texas A&M
GMU	George Mason University
GPP	Gross primary production
H	Henry's Law Constant
ICPRB	Interstate Commission on the Potomac River Basin
IS	Inorganic solids
Kdoc	Partition coefficient to dissolved organic carbon
Koc	Partition coefficient to particulate organic carbon
LA	Load Allocation
LOWESS	Locally Weighted Least Squares
LPOTMH	Lower Potomac mesohaline spatial zone
LPOTTF	Lower Potomac tidal fresh spatial zone
LTCP	Long Term Control Plan (District of Columbia)
MD	State of Maryland
MDE	Maryland Department of the Environment
MGD	Million Gallons per Day
MODEF	Mineral-Oil DiElectric Fluids
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
MW	Molecular weight

MWCOG	Metropolitan Washington Council of Governments
ng/g	Nanograms per gram
ng/l	Nanograms per liter
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSWC	Indian Head Naval Surface Warfare Center at Indian Head
PC	Particulate (organic) carbon
PCB	Polychlorinated biphenyls
PCB3+	Polychlorinated biphenyl homologs 3 through 10
PDC	Particulate detrital carbon
PMP	Pollutant Minimization Plans (Virginia)
POC	Particulate organic carbon (sum of BIC and PDC)
POTMH	Potomac mesohaline salinity zone
POTOH	Potomac oligohaline salinity zone
POTPCB	Potomac PCB model
POTTF	Potomac tidal fresh spatial zone
ppb	Parts per billion
ppt	Parts per thousand (salinity)
RM	River mile
RUSLE2	Revised Universal Soil Loss Equation, Version 2
SOD	Sediment oxygen demand
SPMD	Semi-Permeable Membrane Device
SWMP	Stormwater Management Plan (District of Columbia)
TAC	Technical Advisory Committee
TMDL	Total maximum daily load
TOC	Total organic carbon (sum of POC and DOC)
TOX5	Toxic Chemical Model
TRIB	Minor Tributaries spatial zone
TS	Total solids
TSCA	Toxics Substance Control Act (Virginia)
TSP	Total suspended particulates
TSS	Total suspended solids
UOSA	Upper Occoquan Sanitation Authority Wastewater Treatment Plant
UPOTMH	Upper Potomac mesohaline spatial zone
UPOTTF	Upper Potomac tidal fresh spatial zone
USACE	U.S. Army Corps of Engineers
USDA	U. S. Department of Agriculture
USGS	U.S. Geological Survey
VA	Commonwealth of Virginia
VADCR	Virginia Department of Conservation and Recreation
VADEQ	Virginia Department of Environmental Quality
VEERF	Virginia Environmental Emergency Response Fund
WASP	Water Quality Analysis Simulation Program
WLA	Wasteload Allocation
WM5	Chesapeake Bay Watershed Model, Phase 5
WQA	Water Quality Analysis
WQBEL	Water Quality Based Effluent Limit
WQLS	Water Quality Limited Segment
WRAS	Watershed Restoration Action Strategy Program (Maryland)
wt	Weight
WWTP	Waste water treatment plant

I. INTRODUCTION

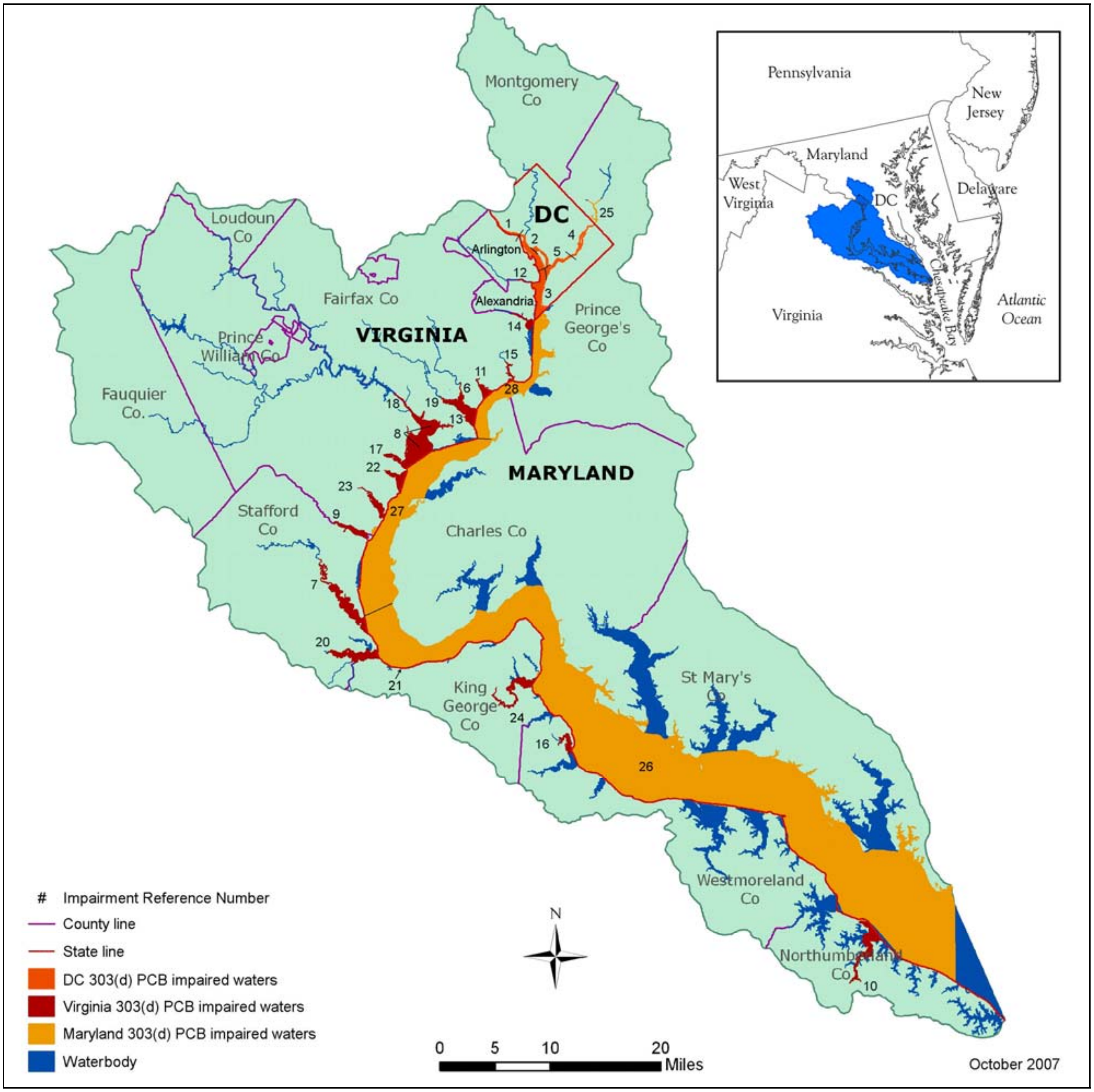
Section 303(d) of the federal Clean Water Act (CWA) and the US Environmental Protection Agency's (EPA) implementing regulations direct each state to identify and list waterbodies, or Water Quality Limited Segments (WQLS), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is required to either establish a Total Maximum Daily Load (TMDL) of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2007a). The TMDL needs to take into account seasonal variations, critical conditions, and a protective margin of safety (MOS) to account for uncertainty.

A TMDL reflects the loading of an impairing substance that a waterbody can receive and still meet water quality standards. TMDLs are established to determine the pollutant load reductions needed to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, as well as fish and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. Criteria may differ in waters with different designated uses.

Tidal waters of the Potomac River and several of its tributaries, including the Anacostia River (Figure 1), have been placed on 303(d) impaired waters lists of Maryland, Virginia, and the District of Columbia for elevated fish tissue levels of polychlorinated biphenyls (PCBs) (VA DEQ 2006a, MDE 2006, and DC DOH 2006). In 2000, a consent decree was entered into by the US EPA and the U.S. District Court (Kingman Park Civic Association, *et al. v.* U.S. Environmental Protection Agency, *et al.*, No. 1:98CV00758 (D.D.C.)) in which the EPA agreed to a schedule for completing TMDL studies for the impairments then on the District's 303(d) impaired waters list. That schedule required that the District of Columbia PCB TMDL be completed by September 30, 2007. Maryland and Virginia were not required to complete their PCB TMDLs by this date, but the three jurisdictions informally agreed in 2004 to coordinate their TMDL development efforts and address all their tidal Potomac PCB impairments by September 30, 2007. This study is the result of that agreement. A joint TMDL was considered desirable because the impaired waterbodies in the three jurisdictions are in such close proximity to each other. A single, joint TMDL would be more cost effective, and the jurisdictions would avoid having three independent TMDLs completed on different dates, using potentially different models and assumptions, and possibly reaching different conclusions with respect to PCB loads crossing state lines. See Figure 1 and Table 1 for locations and listings of the 303(d) listed waterbodies.

The agreement to coordinate the tidal Potomac PCB TMDL led to the creation of a PCB TMDL Steering Committee representing the District of Columbia Department of the Environment (DDOE), the Maryland Department of the Environment (MDE), the Virginia Department of Environmental Quality (VADEQ), the U.S. Environmental Protection Agency (US EPA), the Interstate Commission on the Potomac River Basin (ICPRB), LimnoTech, and the Metropolitan Washington Council of Governments (MWCOG). The Steering Committee is the body through which the jurisdictions resolved issues, reviewed data and model results, and guided the TMDL to completion. ICPRB was charged with coordinating the activities of the Steering Committee, managing monitoring contracts, collecting and analyzing data, and writing the TMDL document.

Figure 1. PCB impaired waterbodies in the lower Potomac River basin.



LimnoTech, under contract to the EPA, developed the Potomac PCB model and ran the model for TMDL scenarios.

The objective of the PCB TMDL established in this document is to ensure that the "fish consumption" use is protected in each of the impaired waterbodies. This is done by identifying maximum allowable loads of PCBs that would a) meet the applicable PCBs water quality criteria and b) lead to fish tissue PCBs concentrations that do not exceed jurisdictional thresholds.

The provisions of this TMDL are severable. If any provision of the TMDL, or the application of any provision of this TMDL to any circumstances or participating jurisdiction, is held invalid by a

Table 1. PCB impaired waterbodies in the tidal Potomac and Anacostia rivers.

Ref #	Impaired Waterbody	Juris	Description
1	Upper Potomac	DC	Potomac River, Chain Bridge to Key Bridge
2	Middle Potomac	DC	Potomac River, Key Bridge to Hains Point
3	Lower Potomac	DC	Potomac River, Hains Point to Wilson Bridge (DC/MD border)
4	Upper Anacostia	DC	Anacostia River, DC/MD border to Pennsylvania Ave. bridge
5	Lower Anacostia	DC	Anacostia River, Pennsyl. Ave. bridge to Potomac River
6	Accotink Bay	VA	In each Virginia embayment, the impairment generally includes all tidal waters within the embayment, from head-of-tide to the Potomac river mainstem. The Potomac River, Fairview Beach, impairment is an area on the mainstem off the beach. See the Virginia 2006 Integrated Assessment report for specific descriptions of the geographic extent of each impairment.
7	Aquia Creek	VA	
8	Belmont Bay / Occoquan Bay	VA	
9	Chopawamsic Creek	VA	
10	Coan River	VA	
11	Dogue Creek	VA	
12	Fourmile Run	VA	
13	Gunston Cove	VA	
14	Hooff Run & Hunting Creek	VA	
15	Little Hunting Creek	VA	
16	Monroe Creek	VA	
17	Neabsco Creek	VA	
18	Occoquan River	VA	
19	Pohick Creek / Pohick Bay	VA	
20	Potomac Creek	VA	
21	Potomac R. Fairview Beach	VA	
22	Powells Creek	VA	
23	Quantico Creek	VA	
24	Upper Machodoc Creek	VA	
25	*Tidal Anacostia	MD	Tidal Anacostia River, from head-of-tide on NE and NW Branches of the Anacostia to the DC/MD border
26	*Potomac River Lower	MD	Mouth of the Potomac to Smith Point, Charles County
27	*Potomac River Middle	MD	Smith Point to Pomonkey Point, Charles County
28	*Potomac River Upper	MD	Pomonkey Point, to DC/MD line at Wilson Bridge

*Maryland impaired waterbodies are listed by 8 digit watershed Hydrologic Unit Code (HUC). The HUC codes for these impairments are 02140101 (Potomac River Lower), 02140102 (Potomac River Middle), 02140201 (Potomac River Upper), and 02140205 (Anacostia River). For the Potomac River watersheds, only the tidal waters are listed as impaired by PCBs. For the Anacostia River watershed, tidal and non-tidal impairments are listed separately. This TMDL study does not address the non-tidal PCB impairment in the Anacostia watershed. By default the Maryland-side Potomac embayments that are within each listed 8-digit watershed are part of the impairment listing. Some of the larger Maryland embayments are parts of different 8-digit watersheds and are not listed as impaired by PCBs. These include: St. Mary's River, Breton Bay, St. Clements Bay, Wicomico River, Port Tobacco River, Nanjemoy Creek, Mattawoman Creek, and Piscataway Creek.

court of competent jurisdiction, the application of such provision to other circumstances and any other participating jurisdiction, and the remainder of the TMDL document, shall not be affected.

All three jurisdictions have numerical water quality criteria for total PCBs and, in addition, have established fish tissue concentration thresholds that, when exceeded, may result in fish consumption advisories and 303(d) listings. A waterbody is considered impaired when either the water quality criterion or the fish tissue concentration threshold is exceeded. The District of Columbia, Maryland, and Virginia tidal Potomac and tidal Anacostia PCB impairments were listed because fish tissue concentrations exceeded the respective jurisdiction's threshold.

Both the PCB fish tissue thresholds and the water quality criteria are calculated to be protective of human health with respect to fish consumption. They differ in the three Potomac jurisdictions (Table 2) depending on each state's choice of calculation method and assumptions about acceptable cancer risk levels, fish consumption, drinking water consumption, and biological concentration. EPA guidance allows some flexibility in this calculation. Prior to the initiation of this study, each jurisdiction followed its own risk assumptions and EPA guidance and arrived at a different PCB water quality criterion and fish tissue concentration threshold. All of the PCB impairments included in this TMDL were listed because fish tissue concentrations exceeded the respective jurisdiction's threshold.

PCBs are a class of man-made compounds that were manufactured and used for a variety of industrial applications, including coolants and lubricants in electrical equipment (US EPA 2000). First produced in 1929, new production was banned in 1979 due to concerns about possible human carcinogenicity. PCBs are known to cause cancer in laboratory animals and are classified as a probable human carcinogen. There are 209 PCB compounds, called congeners, which are distinguished by the number and placement of chlorine atoms (from 1 to 10) on a structure of two connected rings of six carbon atoms. The congeners are classified into groups called homologs based on the number of chlorine atoms attached to the carbon rings. Although new production was banned in 1979, their use in existing equipment was allowed to continue. Relatively stable and widely used, PCBs have become the second leading cause of fish consumption advisories in the United States. PCBs are released into the environment through leaks or fires in PCB containing equipment, accidental spills during transport, illegal or improper disposal, burning of PCB containing oils in incinerators, leaks from hazardous waste sites, and historical releases during manufacture, use, and disposal.

A data solicitation for PCBs was conducted by the PCB TMDL Steering Committee, and all readily available PCB data for water column, sediment, fish tissue, and waste water treatment plant effluent from the past five years have been considered. Additional data were collected specifically for this study, and several analytical approaches were used to estimate Baseline PCB loadings from multiple sources to the tidal Potomac and Anacostia rivers (Appendix A). A Potomac PCB model (POTPCB) was developed to simulate transport and fate of PCBs in the estuary (LimnoTech 2007). The model simulates PCB homologs 3 through 10 (PCB3+) to reduce uncertainty and overcome gaps in the historical data. Model output is converted back to total PCBs during post-processing (Appendix B). Model scenarios were run for a representative hydrologic design year (Appendix C). An analysis of the data led to new estimates of water column and sediment target concentrations necessary to be protective of PCB levels

Table 2. Jurisdiction water quality criteria and fish tissue thresholds. [1]The Virginia Department of Health uses 50 ppb as the fish tissue threshold for establishing consumption advisories.

	Fish Tissue PCB Impairment Threshold (ppb)	PCB Water Quality Criteria (ng/l)
Dist. of Col.	20	0.064
Maryland	88	0.64
Virginia	54[1]	1.70

in fish tissue (Appendix D). Finally, the fate and transport model was run with progressive reductions to input loads (see Section V(5)) to determine a TMDL that will result in the achievement of applicable water quality criteria and fish tissue concentration thresholds for PCBs, for each of the 28 impairments in the tidal Potomac and Anacostia Rivers.

II. SETTING AND WATER QUALITY DESCRIPTION

1. General Setting

The Potomac River estuary extends for 117 miles (188 km) from its mouth at Pt. Lookout on the Maryland side and Smith Point on the Virginia side, to its head-of-tide located approximately 0.4 miles (0.64 km) upstream of Chain Bridge in the District of Columbia. In this document, "Potomac River at Chain Bridge," or simply "Chain Bridge," is used to indicate the Potomac River estuary head-of-tide. The surface area of all tidal waters, including Potomac River embayments and the tidal Anacostia River, is about 434 mi^2 (1,125 km^2). The land area of the lower Potomac River basin, where small rivers, streams, and runoff drain into tidal waters, is 2,537 mi^2 (6,572 km^2), or approximately $^1/_6$ of the entire basin area (Lippson et al. 1979).

The lower Potomac River basin straddles the fall-line separating the Piedmont and Coastal Plain provinces of the North American East Coast. There are roughly two dozen soil groups represented in the lower basin, with each group comprised of two to three specific soil types. Generally, the nature of the soil is dependent on the underlying geologic material from which it is derived, the processes which have reworked the soil, and the soil's environment. The soils in the Piedmont Province are derived from crystalline rocks, and are on mostly hilly terrain with a dense dendritic stream network. The sediments of the Coastal Plain Province are formed from previous sea level stands, are on flat terrain, and have been reworked by the meandering streams from the west. The nature of the soils also varies roughly from east to west approaching the ocean as the depth to water generally decreases. (Braun et al. 2001, USDA 1994a,b).

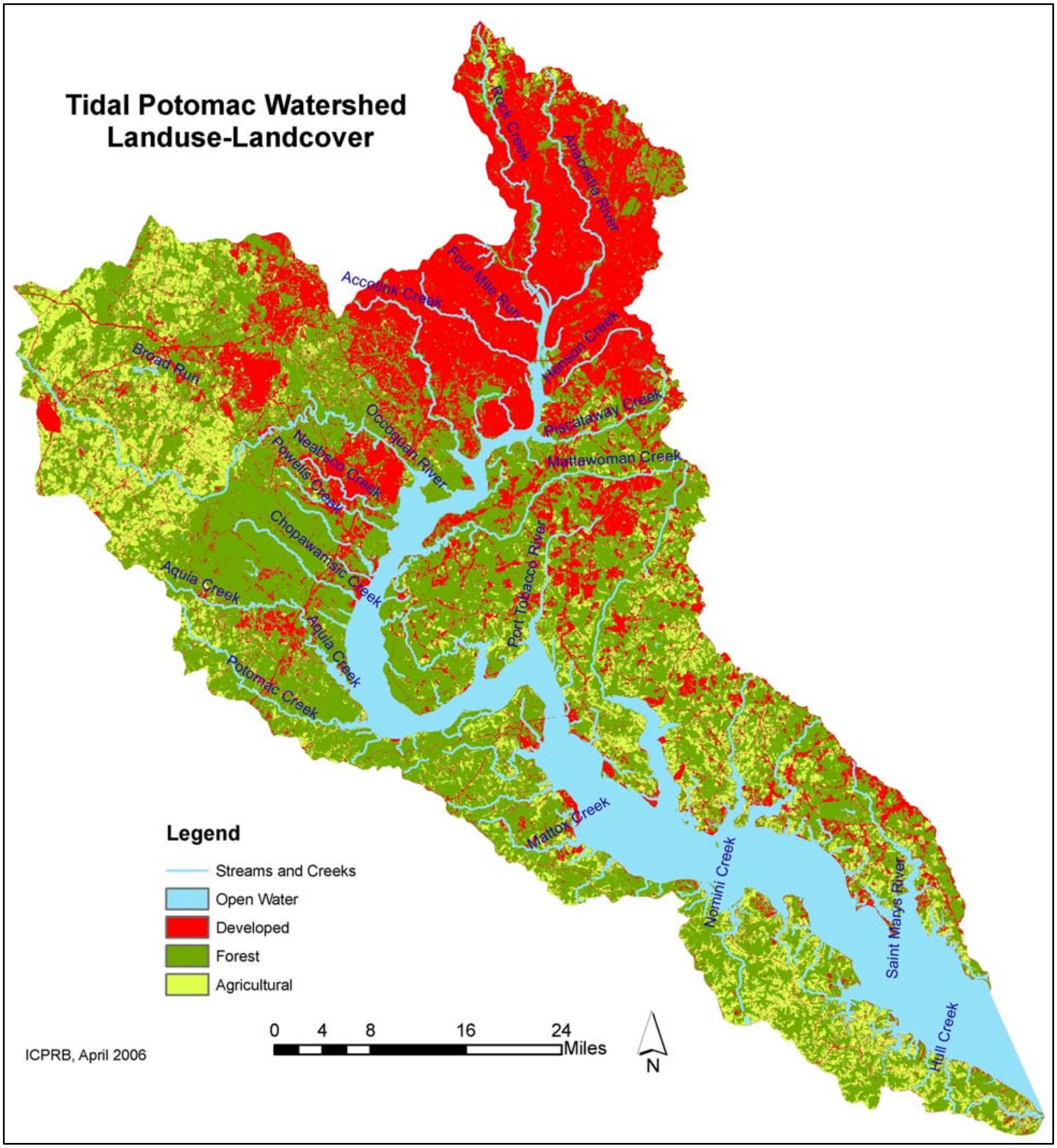
The population of the entire Potomac basin is 5.8 million (US EPA 2006), with approximately 4.4 million living in metropolitan Washington, D.C., an area that straddles the lower and upper portions of the basin. Land cover in the lower basin is 30% developed, 15% agricultural, and 55% forested (CBP 2002), however the distribution of these land covers is not even. Figure 2 shows that urban development and population are concentrated around the upper end of the estuary. Developed land in the individual watersheds of the lower basin ranges from greater than 95% to less than 10%.

2. District of Columbia Water Quality Impairments

The Anacostia and Potomac rivers in the District are designated for Class D (protection of human health related to consumption of fish and shellfish) beneficial use (DCMR 1998). Additional designated uses include primary and secondary contact recreation, and protection of aquatic life. The tidal waters currently do not support the Class D beneficial use due to elevated levels of PCBs in fish tissue, and thus were listed on DC's 1996 and 1998 303(d) lists (DC DOH 2006). A PCB TMDL was established for the tidal Anacostia River in 2003. The PCB TMDL developed for the Potomac and Anacostia tidal waters in this report, when approved, will replace the 2003 Anacostia PCB TMDL.

Figure 2. Land use and land cover for the lower Potomac basin.

Chesapeake Bay Program Phase 5.0 development version base10 data (2002).



3. Virginia Water Quality Impairment

The tidal waters of Virginia located in the study area of the PCB TMDL for the Potomac River estuary are all designated for the following beneficial uses: primary contact recreation, fish consumption, and the aquatic life use. Additional designated uses associated with the Chesapeake Bay and its tidal tributaries include migratory fish spawning and nursery, open water, deep water, and deep channel. These uses apply in the Potomac River estuary geographically and temporally as described in the Virginia 2006 Water Quality Assessment Guidance Manual (VA DEQ 2006b). Finally, the tidal waters of Virginia from Upper Machodoc Creek downstream to the mouth of the Potomac River at Smith Point are designated as shellfish waters.

The Virginia waterbodies identified in Table 1 are identified as impaired in the 2006 §303(d) report for not supporting the fish consumption use (VA DEQ 2006a). It is important to note that the scope of this study and the presentation of PCB impaired waterbodies in Table 1 focus exclusively on the fish consumption impairments. Other impairments for these waterbodies are not addressed in this study. A complete list of impairments for the waterbodies in the study area, and throughout the Commonwealth of Virginia, is available in the 2006 Water Quality Assessment 305(b)/303(d) Integrated Report, available on-line at:
http://www.deq.virginia.gov/wqa/ir2006.html.

4. Maryland Water Quality Impairments

MDE has identified the waters of the Potomac River Lower Tidal watershed (basin number 02140101) on the State's 303(d) list as impaired by nutrients (1996), sediments (1996), toxics (PCBs in fish tissue) (2002), bacteria (2004), and impacts to biological communities (2004 and 2006) (MDE 2006). A TMDL for Fecal Coliform to address the 2004 bacteria listing was approved by the EPA in 2005. The listings for nutrients, sediments, and impacts to biological communities will be addressed separately at a future date.

The waters of the Potomac River Middle Tidal (basin number 02140102) watershed were identified on the State's 303(d) list as impaired by nutrients (1996), sediments (1996), toxics (PCBs in fish tissue) (2002), metals (Cadmium, Chromium, Copper, and Lead) (1996), and impacts to biological communities (2004 and 2006) (MDE 2006). A Water Quality Analysis (WQA) for Cadmium, Chromium, Copper, and Lead to address the 1996 metals listing was approved by the EPA in 2006. The listings for nutrients, sediments, and impacts to biological communities will be addressed separately at a future date.

The waters of the Potomac River Upper Tidal watershed (basin number 02140201) were listed on the State's 303(d) list as impaired by nutrients (1996), sediments (1996), toxics (PCBs in fish tissue) (2002), metals (Copper) (1996), and impacts to biological communities (2006 – non-tidal) (MDE 2006). A WQA for Copper to address the 1996 metals listing was approved by the EPA in 2006. The listings for nutrients, sediments, and impacts to biological communities will be addressed separately at a future date.

The waters of the tidal Anacostia River watershed (basin number 02140205) were placed on the State's 303(d) list as impaired by nutrients (1996), sediments (1996), toxics (PCBs in fish tissue) (2006), bacteria (2004), and trash/debris (2006) (MDE 2006). A TMDL for Fecal Coliform to address the 2004 bacteria listing was approved by the EPA in 2006, and a TMDL for sediments to address the 1996 listing was submitted to the EPA in the spring of 2007. The listings for nutrients, trash/debris, and impacts to biological communities will be addressed separately at a future time.

5. Summary of Data Analysis

For this study, historical datasets were acquired and their suitability for characterizing ambient and external loading conditions was evaluated. Laboratory analytical methods for PCBs have evolved in the last decade, resulting in differences in the congener detection limits as well as in the number of PCB congeners recovered and reported. These changes limit the usefulness of much of the historical data, particularly data analyzed prior to about 2000. A master data set for the study was compiled from historical data sets collected after 1999 and new samples collected specifically for this study in 2006 and 2007. The master data set was used to characterize tributary input loads and ambient PCB levels in the estuary. It contains PCB homolog data from approximately 270 water samples, 250 sediment samples, and 350 fish tissue samples. The data are available on-line at http://www.potomacriver.org/water_quality/pcbtmdl.htm. Sources of data, results of analyses of various data sets, and interpretations of data are explored in detail in Appendix A. Summarized here are the principle findings with respect to PCB sources and ambient PCB levels.

Figures 3, 4, and 5 are graphical representations of the tidal Potomac showing the approximate locations and mean values of ambient water column, sediment, and fish tissue PCB samples. Figure 6 shows the change in PCB concentration in Semi-Permeable Membrane Devices (SPMDs) located in the Virginia tributaries bordering the tidal Potomac mainstem. These graphics reveal several important regional patterns. In water, sediment, and fish tissue, the highest total PCB concentrations are in the District of Columbia portion of the Anacostia River, followed by the upper mainstem Potomac and the Maryland portion of the Anacostia. Concentrations in the water column, sediments, and fish tissue, as well as the SPMDs, decrease downstream from the District. Mean water column concentrations exceed the District of Columbia PCB Water Quality Criterion in every DC segment with samples. The Maryland PCB Water Quality Criterion is exceeded in the Maryland portion of the Anacostia and in selected Potomac mainstem segments downstream from the DC-Maryland boundary. The Virginia PCB Water Quality Criterion is exceeded in only a few embayments. Analysis of the available fish tissue data, however, demonstrates that Virginia fish thresholds are exceeded throughout the length of the tidal Potomac system. The implications of these data for the PCB external loading framework are discussed in Appendix A, Section III.

III. TARGET WATER QUALITY GOAL

The Potomac PCB TMDL must result in an allocation that satisfies the following two benchmarks in all parts of the impaired waterbodies: a) water column concentrations less than or equal to jurisdiction-specific water quality criteria; and b) water column and sediment concentrations less than or equal to jurisdictional fish tissue thresholds, i.e. levels that do not exceed jurisdictional risk assessment limits for fish consumption.

The POTPCB model simulates water column and sediment concentrations but not fish tissue concentrations and, therefore, a method external to the POTPCB model is required to relate levels of PCBs in water column and sediment to fish tissue concentrations. The method used in

Figure 3. Mean water column PCB by model segment.

Approximately 270 samples collected from 2002 to 2006 are included. The polygons represent POTPCB model segments. The entire tidal system is shown in the larger figure. The two figures at the upper right show the Anacostia and the upper Potomac at an expanded scale for better resolution of model segments. Segment color and prism height indicate the mean value of samples collected 2002-2005 for water column PCB concentration, ng/l. Segments with no samples have no color. The upper limit of the first three color classes is defined by the jurisdiction water quality standard. Thus the mean of samples is below the DC PCB Water Quality Criterion (0.064 ng/l) only in green segments (there are none), and the mean of samples is below the MD PCB Water Quality Criterion (0.64 ng/l) only in green or bright yellow segments. Conversely, all segments colored black, red, or orange, exceed the VA PCB Water Quality Criterion (as well as the DC and MD PCB Water Quality Criteria).

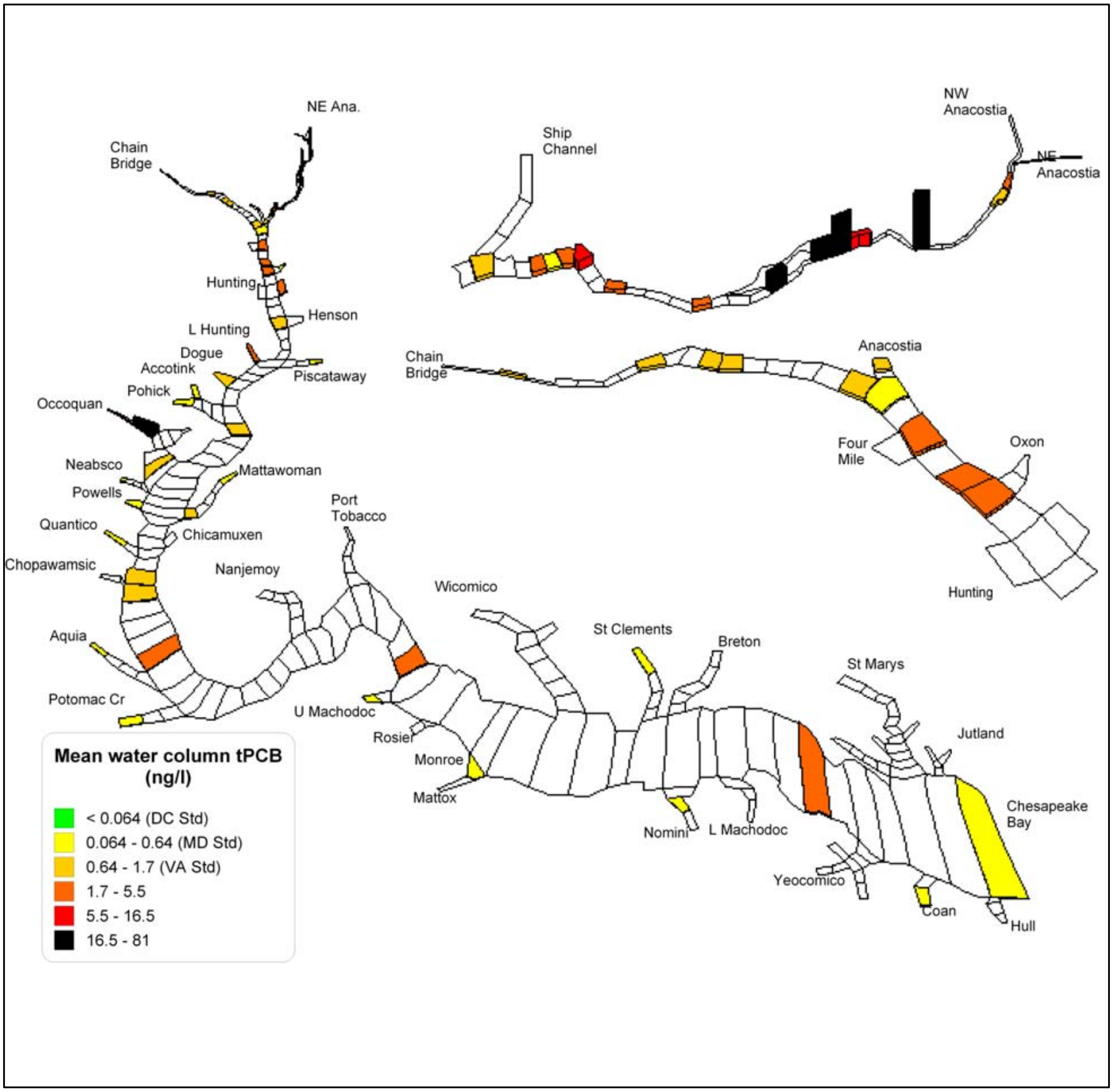


Figure 4. Mean sediment PCB concentration by model segment.

Approximately 250 sediment samples collected from 2000 to 2005 are included. The polygons represent POTPCB model segments. The entire tidal system is shown in the larger figure. The two figures at the upper right show the Anacostia and the upper Potomac at an expanded scale for better resolution of model segments. Segment color and prism height indicate the mean PCB value, ng/g dry wt, of sediment samples collected 2002-2005. Segments with no samples have no color. There are no jurisdiction criteria for sediment concentration. Color classes were selected to reveal the range of sediment concentrations.

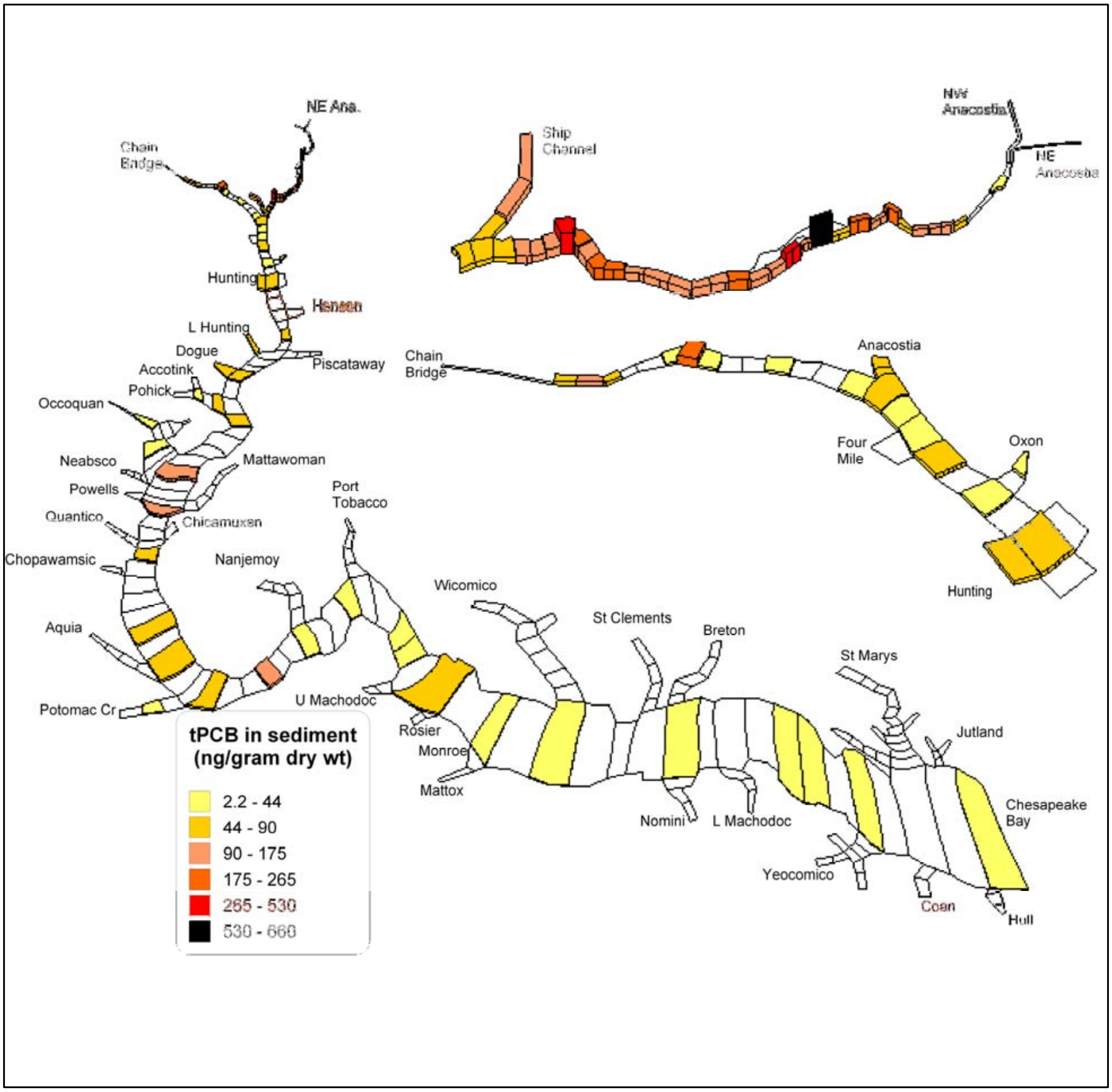


Figure 5. Mean fish PCB concentration by model segment.

Approximately 350 fish samples collected from 2002 to 2005 are included. The polygons represent POTPCB model segments. The entire tidal system is shown in the larger figure. The two figures at the upper right show the Anacostia and the upper Potomac at an expanded scale for better resolution of model segments. Segment color and prism height indicate the mean PCB value, ppb, of fish samples collected 2002-2005. Segments with no samples have no color. The upper limit of the first three color classes is defined by the jurisdiction fish tissue threshold concentration. Thus, the mean of samples is below the DC threshold (20 ppb) only in green segments, and the mean of samples is below the VA threshold (54 ppb) only in green or salmon colored segments. Conversely, all segments colored black or red exceed the fish threshold for all three jurisdictions.

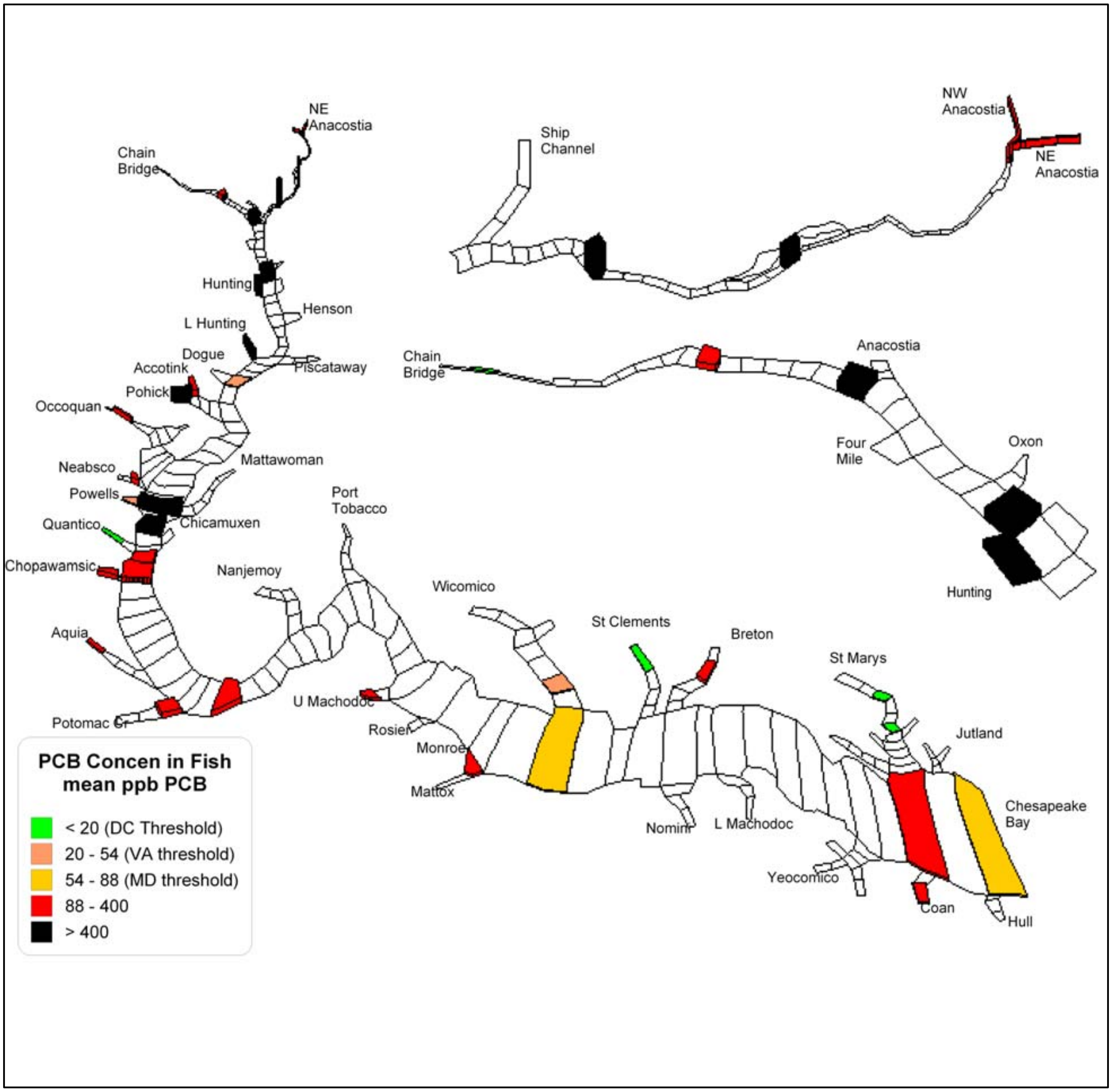
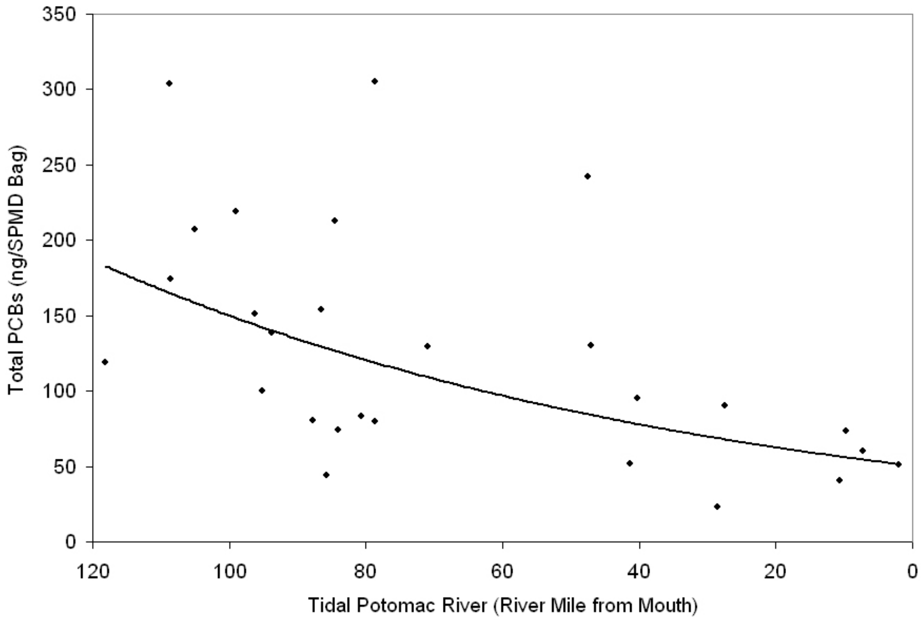


Figure 6. PCB concentration of Semi-Permeable Membrane Devices (SPMDs) in Virginia. (See Appendix E for details).



this study, described in Appendix D, is based on the calculation of bioaccumulation factors (BAFs) from historical data and the application of those BAFs to define PCB water and sediment concentration targets for the TMDL. BAFs were calculated for each fish species and then each jurisdiction selected a target species based on the highest BAFs and data availability. A higher BAF will result in a lower target PCB concentration, which should be protective of all fish species with lower BAFs. Gizzard shad have the highest water column BAF, followed by striped bass and then channel catfish. Historical PCB data sets in Maryland and the District of Columbia sets do not include gizzard shad, so those two jurisdictions selected the channel catfish BAF to calculate their water column targets.

Striped bass was not selected because, as a migratory fish, it may not be representative of PCB conditions in the Potomac River. Virginia selected gizzard shad to calculate its water column target because that species is specifically mentioned in the impairment listing for many of the Virginia water quality limited segments. To calculate target sediment PCB concentrations, all three jurisdictions selected channel catfish because there are historical PCB data for that species in all three jurisdictions and it has the highest sediment BAF.

Table 3 lists the existing water quality criteria and the BAF based water column and sediment targets. The BAF based water column targets are lower than the current water quality criteria in each jurisdiction. Figures 7a, b, and c are plots of fish tissue PCB concentration versus the median ambient water column PCB concentrations in the area where the fish samples were collected. They demonstrate that fish samples exceeding the fish tissue threshold frequently are found in areas where the water column data are below the jurisdictional PCB water quality criteria (quadrant D in Figures 7a, b, and c). In other words, a significant number of fish samples that violate the jurisdictional fish tissue threshold do not violate that jurisdiction's current criterion. This is especially true in Virginia (Figure 7b). Consequently, setting the TMDL water column targets at the lower, BAF based levels provides assurance that the TMDL will be protective of

Table 3. Water column and sediment target concentrations compared to water quality criteria.

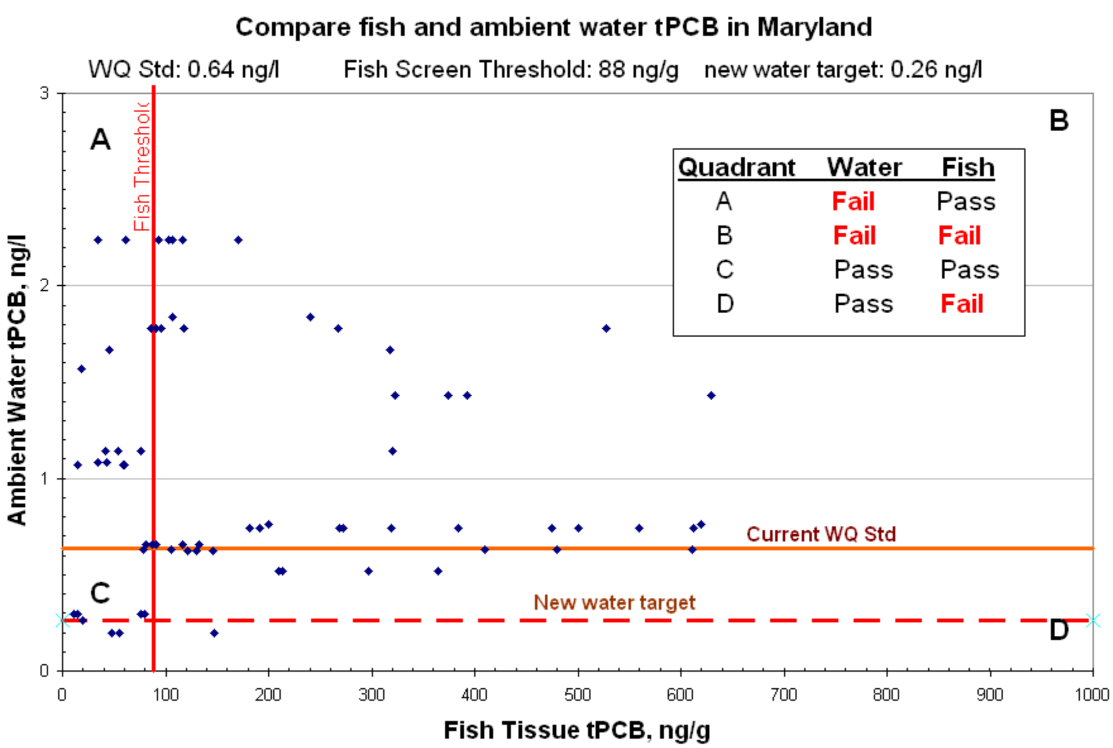
Water and column sediment target concentrations are calculated by dividing fish tissue PCB impairment thresholds by a species specific bioaccumulation factor (BAF).

	Fish Tissue PCB Impairment Threshold (ppb)	Water Quality PCB Criteria (ng/l)	BAF-based Target PCB Water Concentration (ng/l)	BAF-based Target PCB Sediment Concentration (ng/g dry wt)
DC	20	0.064	0.059	2.8
Maryland	88	0.64	0.26	12.0
Virginia	54	1.70	0.064	7.6

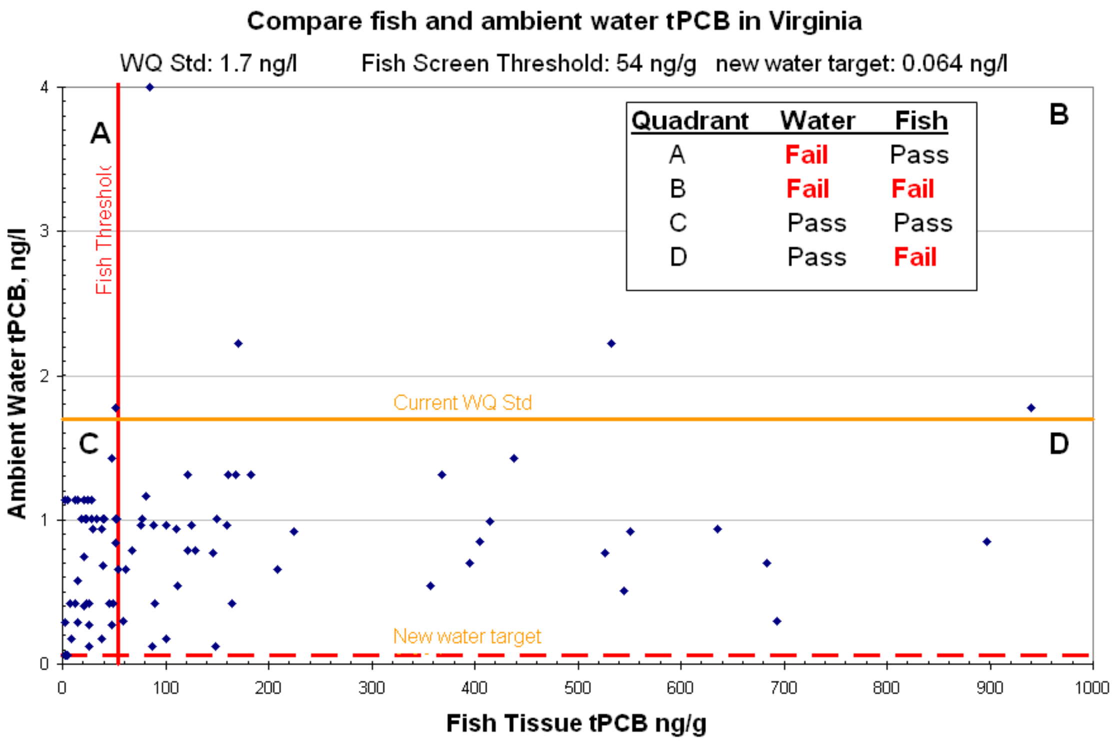
Figure 7. PCB concentrations in fish samples plotted against the median PCB water concentration in the fish's home range.

a) Maryland ambient water and fish concentrations compared with Maryland PCB Water Quality Criterion and fish thresholds; b) Virginia ambient water and fish concentrations compared with Virginia PCB Water Quality Criterion and fish thresholds; c) District of Columbia ambient water and fish concentrations compared with District of Columbia PCB Water Quality Criterion and fish thresholds. Points to the right of the Fish Threshold line, but below the Current WQ Criterion line (Quadrant D) have exceeded the fish threshold leading to fish consumption advisories but pass the PCB Water Quality Criterion. The new water column target value more reliably identifies places where fish tissue thresholds are exceeded.

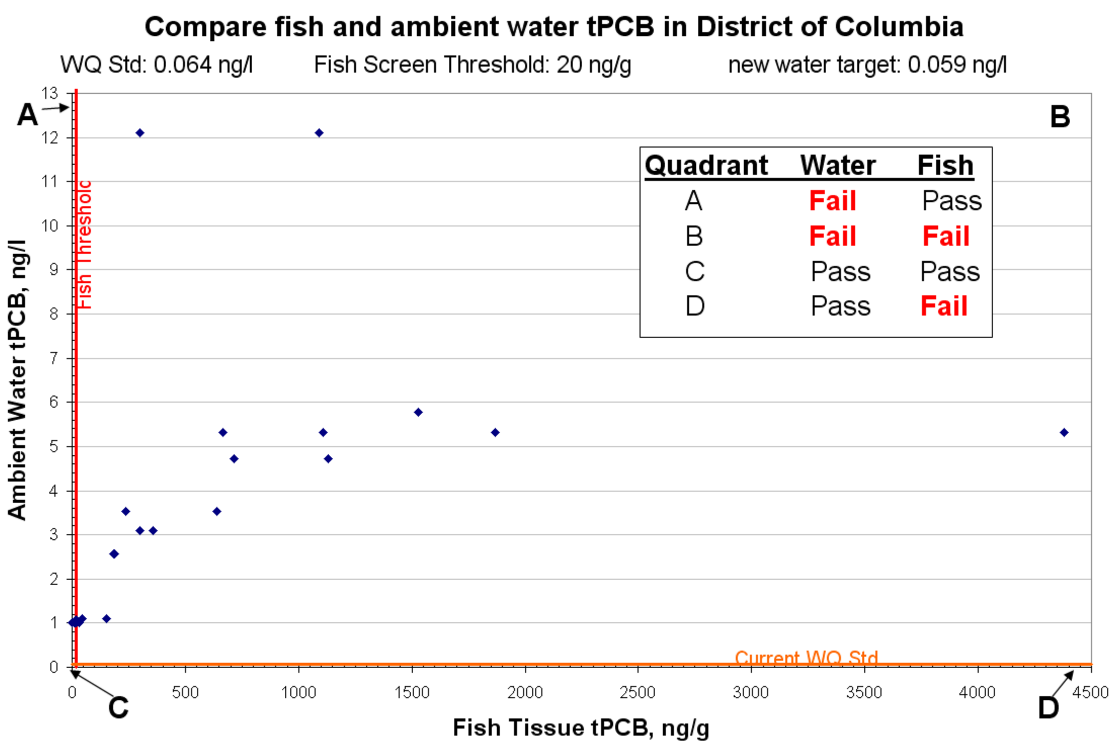
a) Maryland



b) Virginia



c) District of Columbia



human health, i.e. will not result in fish tissue PCB concentrations that exceed jurisdictional risk assessment limits for fish consumption.

IV. SOURCES OF PCBS TO THE TIDAL POTOMAC

A full description of the external load calculations for the Potomac PCB model and a summary of the annual flows and loads by source category can be found in Appendix A, while a summary is provided here. For modeling purposes, external loads of PCBs to the Potomac River estuary system are grouped into six categories: the non-tidal Potomac River at Chain Bridge, lower basin tributaries, direct drainage, wastewater treatment plants (WWTPs), combined sewer overflows (CSOs), atmospheric deposition to the water surface, and contaminated sites. The Potomac PCB model requires daily input values for flows and carbon and PCBs loads from each of these source categories (LTI 2007).

The WWTP loading category was determined by first identifying all known point sources within the study area that either have or have the potential to discharge PCB loads. This universe of point source discharges was further screened to eliminate the municipal WWTPs with a flow of 0.1 mgd or less, which were judged to contribute "de minimus" PCB loads. The resulting list of WWTPs that are the subject of this TMDL analysis is shown in Table 9 and represent the best available information regarding WWTP point source PCB loads.

Output from the Chesapeake Bay Watershed Model (WM5) was used to estimate daily flows and the associate loads from 17 lower basin tributaries and from direct drainage areas. Direct drainage areas are WM5 segments adjacent to the Potomac or Anacostia tidal rivers that are not within one of the 17 WM5 modeled tributaries. The advantages of using the WM5 are that the model is already built, has undergone extensive peer review, and has significant staff support from the Chesapeake Bay Program to assist in interpretation of model results. With these advantages, there are also certain constraints imposed by the WM5 model, including its partitioning of the watershed into tributaries and direct drainage areas. For this TMDL, the definition and interpretation of tributary and direct drainage flows and loads are as the WM5 defines them. The tributary loads are the sum of net atmospheric deposition to the land and water surface (PCBs are volatilizing to the air as well as depositing to the land and water surface), loads from unidentified contaminated sites, as well as point and non-point discharges including regulated and unregulated stormwater. While the overall load for each tributary is accounted for in this study, specific sources within watersheds are not characterized. Direct drainage loads are the sum of net atmospheric deposition to land and water surfaces, loads from small tributaries that are not specified in the WM5 model, regulated and unregulated stormwater runoff, loads from unidentified contaminated sites, and unspecified point source discharges (specified point sources are a separate load input). Additional detail on how watershed flows and loads were calculated can be found in Appendix A.

A Loadest Program regression model (Runkel et al, 2004) was used with US Geologic Survey (USGS) flows at Little Falls on the Potomac River to estimate daily carbon and PCB loads from the non-tidal Potomac River (referred to as “Chain Bridge”). Loadest model 9 (there are nine Loadest model options), rather than the WM5 model and other Loadest model options,, was used because it provided the best match to observed data. Loadest was not an option for other tributaries because the total suspended solids (TSS) and flow data required for Loadest are not available, and, furthermore, the flow volumes from the other tributaries are small enough relative to the volume of the tidal receiving waters that WM5 daily flow estimates are sufficient. Daily PCB and carbon loads from WWTPs were estimated from facility PCB and biochemical oxygen demand (BOD) concentrations and monthly average or daily flows. Daily CSO loads were based on modeled flows (LimnoTech 2006) and monitoring data collected in and around the CSO areas. Daily atmospheric loads were estimated from literature values, including an older Chesapeake Bay study (Baker et al. 1994). Contaminated site loads were estimated by the individual jurisdictions using the Revised Universal Soil Loss Equation (Version 2) (RUSLE2) methodology (Butt et al, 2007; Chowdhury, 2007; White and Soehl, 2007)The non-tidal Potomac River is the largest single source of PCBs delivered to the estuary. Atmospheric deposition, tributary, and direct drainage PCB loading rates are higher, by at least an order of magnitude, in urban areas than elsewhere. The combined impact of the Chain Bridge load, plus high loading rates for atmospheric deposition, other tributaries and direct drainage in the Washington, D.C. urban area, and CSOs and WWTPs, is such that 84% of the total load from all sources delivered to the entire Potomac estuary is delivered to the Anacostia and Potomac rivers upstream of the District-Maryland state line near the Wilson Bridge.

V. TOTAL MAXIMUM DAILY LOADS AND ALLOCATIONS

1. Overview

The POTPCB model developed for this TMDL by LimnoTech is a coupled, hydrodynamic, salinity, sorbent dynamics, and PCB mass balance model for the tidal portions of the Potomac and Anacostia rivers. Hydrodynamic simulation is based on a version of the Dynamic Hydrologic Model (DYNHYD), and sorbent dynamics and PCB mass balance are simulated with a version of the Water Quality Analysis Simulation Program 5 (WASP5)/Toxic Chemical (TOXI5) Model. This overview describes only a few key aspects of the output from the POTPCB model relevant to understanding how the TMDL allocations were made. For a complete description of the POTPCB model, the reader is referred to a separate report (LimnoTech 2007), which describes in detail the model, its development, and calibration.

The POTPCB model provides daily PCB water column and sediment concentrations in each of 257 segments. Diagnostic simulation model runs (LimnoTech 2007) demonstrated that sediment layer response to changes in input PCB loads lags behind the water column response, so a one-year hydrologic sequence is cycled repeatedly (50-100 years) until the water column and sediment layers achieve an approximate dynamic equilibrium. The median daily concentration in the final year, or the maximum 30-day average for DC (see below), represents the predicted water column and sediment concentrations for a loading scenario.

The hydrologic year used to represent the Baseline Scenario is calendar 2005. Year 2005 was selected because it was determined that, in the period of time for which sufficient data exist to allow for model calibration, the 2005 flow distribution at the Little Falls gage (the major flow input to the estuary) was closest to the long term harmonic mean flow. The EPA recommends using the harmonic mean flow as the critical flow condition for TMDLs for substances whose human health impact is derived from life time exposure (US EPA 1991). Appendix C provides a definition of harmonic mean flow and description of the analysis that led to the selection of year 2005. The Baseline Scenario in the POTPCB model is run with 2005 flows and 2005 loads from all sources. When the model is run to water / sediment quasi-equilibrium, the Baseline Scenario is a prediction of what PCB concentrations would be in the estuary with current external loading rates if water and sediment were in equilibrium.

The 2005 hydrologic year also is used for the TMDL Scenario, except for WWTPs and for the District of Columbia CSO system. WWTP facility design flows, obtained from the MDE, VADEQ, and DDOE, are used so that the TMDL Scenario represents facility loads at maximum flow capacity. The DC CSO system flows were based on an assumption that the DC Long Term Control Plan has been implemented. These flows were obtained from a DC CSO model simulation of 2005 hydrology with the Long Term Control Plan. Flows representing the Alexandria CSO system were the same for the TMDL and Baseline Scenarios because that city's Long Term Control Plan has already been implemented and no changes to the system are planned that would impact flows.

A deliberate process was followed to arrive at the TMDL allocations. That process began with a set of diagnostic model runs that provided a general sense of the overall level of load reductions required to achieve the targets in each impairment and a general sense of the contributions, both magnitude and geographic extent, of each source category to PCB levels. The next step was a series of model runs that adjusted loads from each source category (except WWTPs, see section V(5)) up or down in order to get as close as possible to the target concentrations in each model segment, without exceeding them. For each model run selected source loads are reduced, the POTPCB model is run to quasi-equilibrium, and PCB concentrations are compared to water column and sediment targets. The loads specified for each model run were an iterative adjustment informed by the results of previous model runs. This process continued until a set of loads is arrived at that provides quasi-equilibrium PCB concentrations at or below water column and sediment targets in all model segments.

Load adjustments included swapping load reductions (increasing one while decreasing the other) from different sources to see which source reduction provides the greatest water quality response. Percent load reductions for direct drain loads (regulated and unregulated stormwater) were specified by FIPS code jurisdiction and WM5 model segment rather than independently for each POTPCB model segment because the FIPS-WM5 segment is the smallest scale at which external loads estimates were made and because it didn't make sense from an implementation point of view to have non point source reductions that varied within a small watershed, inside a FIPS jurisdiction. For similar reasons, the DC CSO system and the Alexandria CSO system each were assigned one load reduction (the two systems received different load reductions). Atmospheric deposition rates across the entire watershed were assigned a single percent reduction on the premise that reductions to the sources of atmospheric PCBs would affect deposition in all areas fractionally the same. Load reductions assigned to sources frequently affected PCB concentrations in more than one POTPCB model segment. In other words, the load reduction assigned to a source to one model segment was frequently determined by the reduction level required for another model segment and, sometimes, even for another impairment. The best example of this is the reduction in atmospheric deposition. Iterative model runs determined that atmospheric deposition to the Anacostia River must be reduced by 93%, which set the level of atmospheric reductions for the entire watershed. That reduction in the atmospheric deposition source category was, by itself, sufficient to meet PCB targets in some of the impairments in the lower part of the watershed. Thus no reductions are required for tributary and direct drain loads to these impairments.

As noted above, the TMDL has to meet both water column and sediment targets. The ratio of the sediment target to water column target is 47.76 for Maryland and the District of Columbia, and 112.5 for Virginia. In the TMDL scenario, the ratio of the water column to sediment concentration is almost always less than these ratios. This means that when the water column concentration is at or below the water column target then the sediment concentration also is below its target. The few occurrences of the sediment to water column concentration ratio exceeding these values are in model segments where both water column and sediment concentrations are well below their respective target values.

2. TMDLs for Multiple Impairments

This study addresses 28 individually listed PCB impairments (Table 1) in the tidal Potomac and Anacostia rivers in the District of Columbia, Maryland, and Virginia. Load Allocations (LAs) and Wasteload Allocations (WLAs) are provided below for each of these impairments.

Although a TMDL allocation is provided for each impairment, it is important to recognize the inter-connectedness of the impaired waterbodies. Some of the impairments are nested within other impairments (e.g. Fairview Beach, Virginia and the Lower Potomac, Maryland) and many impairments are adjacent to each other across state lines. In a typical TMDL, when a load comes from another jurisdiction, that load is assigned to the non-point source Load Allocation portion of the TMDL equation. In this case, however, on the other side of the state line is an impairment with its own set of WLAs and LAs assigned to meets its water and sediment targets. These tidal waters move PCB loads between the impairments, and the TMDL allocation for one impairment has an impact on the TMDL allocation for the neighboring impairment. Loads entering the tidal Potomac system at the upstream (Chain Bridge) and downstream (Chesapeake Bay) boundaries have an impact on impaired waterbodies far beyond the impairment adjacent to the boundary. In addition, PCB loads from portions of the lower Potomac watershed that are not adjacent to impaired waterbodies (e.g. portions of Maryland and Virginia that drain to embayments that are not listed as impaired) may impact PCB concentrations in other, impaired, portions of the tidal Potomac through tidal action. For all of these reasons, the analytical approach used to arrive at these allocations addressed the entire tidal Potomac as a unit. The POTPCB model was “solved” to find a set of PCB loads from the entire watershed that meets water and sediment targets for all 28 impairments. Thus, it is most appropriate to view the TMDL allocations for all of the tidal Potomac and its 28 impairments as one package of allocations.

3. Margin of Safety

A Margin of Safety (MOS) is required as part of a TMDL allocation to account for uncertainties in load estimates and in the simulation of processes affecting PCB fate and transport. There are no strict EPA guidelines or methodologies for selecting a MOS, except to suggest that a MOS may be an explicit value, or a set of conservative assumptions built into the analysis, or a combination of the two (CFR 2007a). As a general rule, conservative assumptions were used for estimating loads and in developing the POTPCB model. To provide further assurance that water quality targets would be met when the TMDL load reductions are achieved, in addition to an implicit MOS derived from the conservative assumptions, an explicit MOS of 5% was applied to each source category with the exception of WWTPs. The explicit MOS was applied to account for the uncertainty inherent in load estimation methods for these sources.

4. Daily Load

Fish tissue concentrations are reflective of exposure to PCBs over extended time periods, ranging from season to annual in length, and human health impacts typically result from PCB exposure of many years duration. Consequently, the TMDL target condition in the POTPCB model for Maryland and Virginia waters was set at the annual median water column concentration at or below the jurisdictional water quality target. District of Columbia regulations require that the highest 30-day average water column concentration not exceed the water quality target. Thus, the 30-day average water column concentration became the TMDL target condition in model segments located in the District. To reflect the loading conditions that result in these annual median or high 30-day average concentrations, the TMDL allocations are expressed as annual loads. In order to comply with current EPA guidance the TMDL is also expressed as a daily load in two ways: a) the average daily loading condition, calculated as the annual load divided by 365; and b) peak one day loads in the TMDL evaluation year. The peak one day loads for tributaries (including the non-tidal Potomac River), direct drainage areas, CSOs, and the Blue Plains WWTP are the annual maximum daily loads in the daily load time series for the TMDL year. For atmospheric deposition and contaminated sites, which are input to the model in equal amounts each day, the peak one day loads were the annual load divided by 365. For WWTPs other than Blue Plains, the peak one day load was calculated as 1.31 times the average daily load. This multiplier was based on a statistical procedure that relates the maximum daily concentration to the long term average. In this case the 1.31 multiplier assumes 2 samples/month collected. The procedure is explained in the EPA document entitled *Technical Support Document (TSD) for Water Quality-based Toxics Control* (US EPA 1991).

5. The PCB TMDL

As noted in section V(2), loads to any part of the tidal Potomac can impact more than one impaired waterbody, therefore it is most appropriate to view all of these TMDLs together. In order to show a TMDL equation for each impairment, however, impairment specific TMDL equations were constructed based on the external loads directly entering each impaired waterbody.

The TMDL equation is:

TMDL = WLA + LA + MOS

The PCB TMDL for all of the tidal Potomac and its watershed, including the 28 impaired water quality segment PCB, which constitutes a 95.9% overall reduction of PCBs from the 2005 Baseline year load of 37,140 grams/year. TMDL load allocations are expressed in three ways in Tables 4-6. Table 4 shows annual load allocations for each impairment, plus the water bodies not listed as impaired. Table 4a provides additional detail on the "not listed" water bodies. Table 5 shows average daily load allocations, and Table 6 shows maximum daily load allocations. Table 7 is provided for Maryland and its mainstem Potomac impairments. The state of Maryland often lists its impairments on the Maryland 8-digit watershed scale. Part of Southern Maryland is in watersheds other than the Upper, Middle, and Lower Potomac watersheds that are listed for PCBs.

Because loads from these other watersheds contribute to the load going to the mainstem impairments, a watershed specific breakout of the load allocations to those watersheds is provided as a reference (Table 8).

5.1 Wasteload Allocation

The WLA portion of the TMDL comprises the permitted point sources. It includes WWTPs, regulated stormwater, and CSOs.

Wastewater Treatment Plants

WWTPs with the greatest annual flows were included in the WLA calculations. These 22 WWTPs account for approximately 95% of the total WWTP flow in the lower basin (Table 9). Included are all facilities with design flows greater than 0.1 MGD[1]. The jurisdictions have no information that suggests that any of the smaller municipal facilities, or any permitted industrial facilities, are discharging PCBs above de minimus amounts. For this TMDL, the jurisdictions agreed to apply a consistent approach to all WWTPs for determining load allocations. The allocations are determined by facility design flow multiplied by the applicable jurisdiction water column target. This approach was adopted to ensure that point source discharges should not exceed the water column target with no mixing zone. In some cases, because current flows are less than facility design flows, this approach results in a TMDL load allocation that is larger than the estimated Baseline load, which is indicated by negative reduction values in Table 9. It is important to note that, where it occurs, the increased load is entirely due to an increase in flow and that even though an increased load may be shown the effluent concentration is less than or equal to the Baseline concentration.

Regulated Stormwater

Pursuant to EPA Requirements, "Stormwater discharges that are regulated under Phase I or Phase II of the National Pollutant Discharge Elimination System (NPDES) stormwater program are point sources that must be included in the WLA portion of a TMDL" (US EPA 2002). Phase I and II permits can include the following types of discharges:

- small, medium, and large Municipal Separate Storm Sewer Systems (MS4s) – these can be owned by local jurisdictions, municipalities, and state and federal entities (i.e., departments of transportation, hospitals, military bases, etc.),
- general industrial stormwater permitted facilities, and
- small and large construction sites.

The EPA recognizes that available data and information are usually not detailed enough to determine WLAs for NPDES regulated stormwater discharges on an outfall-specific basis (US EPA 2002). Therefore, in the tidal Potomac watershed, loads from the regulated NPDES stormwater outfalls will be expressed as a single stormwater WLA for each impaired water body. The stormwater WLAs are calculated for the direct drainage areas located in the District of Columbia as well as Maryland and Virginia Counties covered by a NPDES stormwater permit. For

[1] One exception is Purkins Corner WWTP, NPDES Permit # VA0070106, which has a highest permit tier of 0.5 MGD. It is currently operating at a 0.06 MGD permit tier and therefore, lacking any facility specific information on PCB concentrations, based on current flows its potential PCB load is considered to have no material impact.

these areas, the stormwater WLA is derived by multiplying the direct drainage PCB load for the TMDL scenario in each WM5 "riverseg-landseg" area (the smallest watershed area defined in WM5) by its percent of developed land. Upon approval of the TMDL "NPDES-regulated municipal stormwater and small construction storm water discharges effluent limits should be expressed as Best Management Practices (BMPs) or other similar requirements, rather than as numeric effluent limits" (US EPA 2002).

Lists of Municipal- and County-level MS4 permits in the District of Columbia, Maryland and Virginia are provided in Table 10. The jurisdictions to which these permits apply may be located within both direct drainage and tributary watershed segments; however the NPDES regulated stormwater WLAs, shown in Tables 5-7 and 12, apply only to the direct drainage portions of the MS4 permitted jurisdictions. While tributary stormwater WLAs have not been characterized as part of this TMDL effort, additional stormwater WLAs might be assigned through future TMDL development addressing either (1) PCB fish consumption impairments within the specific tributary or (2) tributary watershed contribution to the PCB fish consumption impairments in the receiving tidal water bodies. Stormwater WLAs for specific watersheds and FIPs code jurisdictions are shown in Table 12. For some of the FIPs jurisdictions and watersheds, the WLA is a 5% reduction from the baseline, which is entirely due to the Margin of Safety (MOS). In other words, in these watersheds, absent the MOS, no additional reduction in PCB load is necessary. While the exact relationship between atmospheric deposition to the land surface and non point source runoff of PCBs is unclear at this time, it is expected that the proposed 93% reduction in atmospheric deposition of PCBs will yield the 5% reduction in stormwater loads represented by the MOS.

<u>Combined Sewer Overflow</u>

Combined Sewer Overflow systems serve portions of the District of Columbia and Alexandria, VA (Appendix A, Figure A-13). During high precipitation events, when storm water exceeds WWTP capacity, the excess flow is diverted to the Anacostia and Potomac rivers, Rock Creek, and Four Mile Run. There are 53 CSO outfalls in the District of Columbia discharging into all five DC impaired waterbodies and there are four outfalls in Alexandria which discharge into Hooff Run / Hunting Creek and to the Lower Potomac DC waterbody. The Baseline CSO loads are based on daily flows and PCB3+ loads for each CSO outfall obtained from two CSO models developed by LimnoTech for the District of Columbia and Alexandria (LimnoTech 2006). As noted above, the TMDL assumes that the DC Long Term Control Plan has been implemented, which significantly reduces CSO flows. This TMDL requires a 98.9% reduction in loads from the DC CSO system and a 5% reduction in loads (the MOS) from the Alexandria CSO system. Appendix F provides additional explanation on how the WLAs for the DC and Alexandria CSO systems were derived.

5.2 Load Allocation

The LA portion of the TMDL is divided into tributary, nonpoint source runoff, atmospheric deposition to tidal water surface, and identified contaminated sites. PCB exchanges with the Chesapeake Bay, which is the lower boundary of the tidal Potomac River, are considered in the TMDL analysis (see Downstream Boundary subsection below) but are not tracked in the TMDL summary tables. Load Allocations for tributaries and for nonpoint source runoff are shown in Tables 11 and 12. For some tributaries, and all or parts of some FIPs jurisdictions, the LA is a 5% reduction from the baseline, which is entirely due to the Margin of Safety (MOS). In other words, in these areas, absent the MOS, no additional reduction in PCB load is necessary.

Table 4. Annual TMDL load allocations for each PCB impairment.

The TMDL total = Total WLA + Total LA + MOS, and all values are expressed to 3 significant digits only. Units are total PCBs in g/year. Does not include PCB flux at Downstream Boundary (see Section V(5.2)).

			WLA				LA						
Ref #	**Impaired Waterbody**	**Juris.**	**WWTP**	**Reg. Stormwtr**	**CSO**	**Total WLA**	**Trib.**	**nonpoint source**	**Atmos. Dep.**	**Contam. Sites**	**Total LA**	**MOS**	**TMDL**
1	Upper Potomac	DC	0	1.46	0.604	2.07	312	0.141	1.33	0	314	16.6	333
2	Middle Potomac	DC	0	7.42	3.58	11.0	34.5	0.843	4.61	0.000632	40.0	2.68	53.7
3	Lower Potomac	DC	30.3	5.41	33.2	68.9	0	0.923	8.59	0	9.51	2.53	80.9
4	Upper Anacostia	DC	0	1.76	0.0562	1.81	0	0.262	1.47	0.00140	1.74	0.187	3.74
5	Lower Anacostia	DC	0	0.612	2.18	2.79	0	0.173	1.74	0	1.91	0.247	4.95
6	Accotink Creek	VA	0	0.0992	0	0.0992	46.1	0.084	0.711	0	46.9	2.47	49.5
7	Aquia Creek	VA	1.06	5.28	0	6.34	21.0	14.2	0.757	0	36.0	2.17	44.5
8	Belmont Bay	VA	0	0.409	0	0.409	0	1.56	2.63	0	4.19	0.242	4.84
9	Chopawamsic Creek	VA	0	1.35	0	1.35	0	3.54	0.160	0	3.70	0.266	5.32
10	Coan River	VA	0	0	0	0	0	6.06	0.573	0	6.63	0.349	6.98
11	Dogue Creek	VA	0	20.2	0	20.2	0	7.28	1.56	0	8.84	1.53	30.6
12	Fourmile Run	VA	3.54	7.50	0	11.0	0	0.218	0.905	0	1.12	0.454	12.6
13	Gunston Cove	VA	0	0.517	0	0.517	0	0.437	2.73	1.65	4.82	0.281	5.62
14	Hooff Run & Hunting Creek	VA	4.77	13.6	18.5	36.8	45.8	0.452	1.56	0.722	48.6	4.25	89.7
15	Little Hunting Creek	VA	0	10.1	0	10.1	0	3.65	0.925	0	4.58	0.774	15.5
16	Monroe Creek	VA	0.177	0	0	0.177	0	1.06	0.352	0	1.41	0.0742	1.66
17	Neabsco Creek	VA	2.94	3.69	0	6.63	0	1.13	0.716	0	1.84	0.291	8.76
18	Occoquan River	VA	0	2.86	0	2.86	51.3	4.20	8.08	1.18	64.7	3.56	71.1
19	Pohick Creek	VA	5.96	7.58	0	13.5	0	6.35	1.74	0	8.08	0.824	22.4
20	Potomac Creek	VA	0	0.556	0	0.556	0	9.47	0.898	0	10.4	0.577	11.5
21	Potomac R. Fairview Beach	VA	0	0.0183	0	0.0183	0	0.668	0.745	0	1.41	0.0752	1.50
22	Powells Creek	VA	0	0.0675	0	0.0675	0	0.177	0.420	0	0.597	0.035	0.700
23	Quantico Creek	VA	0	0.742	0	0.742	11.4	1.94	0.481	0	13.8	0.765	15.3
24	Upper Machodoc Creek	VA	0.0883	0	0	0.0883	0	8.24	0.340	0	8.58	0.452	9.12
25	Tidal Anacostia	MD	0	1.13	0	1.13	13.8	0.0404	0.410	0.00124	14.3	0.812	16.2
26	Potomac River Lower	MD	0.0640	1.99	0	2.06	0	44.1	79.5	5.12	129	6.89	138
27	Potomac River Middle	MD	7.55	3.04	0	10.6	0	13.4	28.8	1.05	43.2	2.43	56.2
28	Potomac River Upper	MD	0	16.4	0	16.4	0	10.6	31.2	0.467	42.2	3.09	61.7
	Not Listed water bodies	ALL	11.8	18.2	0	30.0	162	119	22.2	0.0979	303	16.9	350
	Total all tidal waters	ALL	68.2	132	58.1	258	699	260	206	10.3	1180	71.8	1510

Table 4a. Annual TMDL load allocation for Not Listed waterbodies.

The TMDL total = Total WLA + Total LA + MOS, and all values are expressed to 3 significant digits only. Units are total PCBs in g/year. Does not include PCB flux at Downstream Boundary (see Section V(5.2)).

		WLA				LA						
Waterbody	**Juris.**	**WWTP**	**Reg. Stormwtr**	**CSO**	**Total WLA**	**Trib.**	**nonpoint source**	**Atmos. Dep.**	**Contam. Sites**	**Total LA**	**MOS**	**TMDL**
St Marys River	MD	0	0	0	0	9.01	12.7	3.60	0	25.3	1.33	26.6
Yeocomico River	VA	0	0	0	0	0	7.78	1.60	0	9.37	0.493	9.90
Lower Machodoc	VA	0	0	0	0	0	1.85	0.704	0	2.55	0.134	2.70
Breton Bay	MD	0.245	0	0	0.245	8.87	7.31	1.30	0	17.5	0.921	18.7
Nomini Bay	VA	0	0	0	0	0	7.52	0.884	0	8.40	0.442	8.80
St. Clements Bay	MD	0	0	0	0	7.05	7.49	1.05	0	15.6	0.821	16.4
Wicomico River	MD	0	0.996	0	0.996	66.7	24.3	3.92	0	94.9	5.05	101.0
Mattox Creek	VA	0	0	0	0	0	3.93	0.233	0	4.16	0.219	4.40
Port Tobacco River	MD	0.538	4.09	0	4.63	0	11.1	0.711	0	11.9	0.842	17.4
Nanjemoy Creek	MD	0	1.38	0	1.38	6.08	14.3	1.10	0	21.4	1.20	24.0
Mattawoman Creek	MD	0.179	2.87	0	3.05	36.7	8.55	2.48	0.0979	47.8	2.67	53.5
Piscataway Creek	MD	10.8	7.70	0	18.5	27.9	6.81	2.39	0	37.1	2.36	58.0
Oxon Run	MD / DC	0	1.09	0	1.09	0	0.232	0.803	0	1.04	0.112	2.20
Hull Creek	VA	0	0	0	0	0	3.03	0.405	0	3.43	0.181	3.60
Rosier Creek	VA	0	0	0	0	0	1.87	0.240	0	2.11	0.111	2.20
Wash. Ship Channel	DC	0	0.0824	0	0.0824	0	0.0934	0.779	0	0.873	0.0503	1.00
Total Not Listed water bodies		11.8	18.2	0	30.0	162	119	22.2	0.0979	303	16.9	350

Table 5. Average daily TMDL load allocations for each PCB impairment.

All values are expressed to 3 significant digits only. Units are mg/day total PCBs. Does not include PCB flux at Downstream Boundary (see Section V(5.2)).

			WLA				LA						
Ref #	Impaired Waterbody	Juris.	WWTP	Reg. Stormwtr	CSO	Total WLA	Trib.	nonpoint source	Atmos. Dep.	Contam. Sites	Total LA	MOS	TMDL
1	Upper Potomac	DC	0	4.00	1.65	5.67	855	0.386	3.64	0	860	45.5	912
2	Middle Potomac	DC	0	20.3	9.81	30.1	94.5	2.31	12.6	0.00173	110	7.34	147
3	Lower Potomac	DC	83.0	14.8	91.0	189	0	2.53	23.5	0	26.1	6.93	222
4	Upper Anacostia	DC	0	4.82	0.154	4.96	0	0.718	4.03	0.00384	4.77	0.512	10.2
5	Lower Anacostia	DC	0	1.68	5.97	7.64	0	0.474	4.77	0	5.23	0.677	13.6
6	Accotink Creek	VA	0	0.272	0	0.272	126	0.230	1.95	0	128	6.77	136
7	Aquia Creek	VA	2.90	14.5	0	17.4	57.5	38.9	2.07	0	98.6	5.95	122
8	Belmont Bay	VA	0	1.12	0	1.12	0	4.27	7.21	0	11.5	0.663	13.3
9	Chopawamsic Creek	VA	0	3.70	0	3.70	0	9.70	0.438	0	10.1	0.729	14.6
10	Coan River	VA	0	0	0	0	0	16.6	1.57	0	18.2	0.956	19.1
11	Dogue Creek	VA	0	55.3	0	55.3	0	19.9	4.27	0	24.2	4.19	83.8
12	Fourmile Run	VA	9.70	20.5	0	30.1	0	0.597	2.48	0	3.07	1.24	34.5
13	Gunston Cove	VA	0	1.42	0	1.42	0	1.20	7.48	4.52	13.2	0.770	15.4
14	Hooff Run & Hunting Creek	VA	13.1	37.3	50.7	101	125	1.24	4.27	1.98	133	11.6	246
15	Little Hunting Creek	VA	0	27.7	0	27.7	0	10.0	2.53	0	12.5	2.12	42.5
16	Monroe Creek	VA	0.485	0	0	0.485	0	2.90	0.964	0	3.86	0.203	4.55
17	Neabsco Creek	VA	8.05	10.1	0	18.2	0	3.10	1.96	0	5.04	0.797	24.0
18	Occoquan River	VA	0	7.84	0	7.84	141	11.5	22.1	3.23	177	9.75	195
19	Pohick Creek	VA	16.3	20.8	0	37.0	0	17.4	4.77	0	22.1	2.26	61.4
20	Potomac Creek	VA	0	1.52	0	1.52	0	25.9	2.46	0	28.5	1.58	31.5
21	Potomac R. Fairview Beach	VA	0	0.0501	0	0.0501	0	1.83	2.04	0	3.86	0.206	4.11
22	Powells Creek	VA	0	0.185	0	0.185	0	0.485	1.15	0	1.64	0.0959	1.92
23	Quantico Creek	VA	0	2.03	0	2.03	31.2	5.32	1.32	0	37.8	2.10	41.9
24	Upper Machodoc Creek	VA	0.242	0	0	0.242	0	22.6	0.932	0	23.5	1.24	25.0
25	Tidal Anacostia	MD	0	3.10	0	3.10	37.8	0.111	1.12	0.0034	39.2	2.22	44.4
26	Potomac River Lower	MD	0.175	5.45	0	5.64	0	121	218	14.0	353	18.9	378
27	Potomac River Middle	MD	20.7	8.33	0	29.0	0	36.7	78.9	2.88	118	6.66	154
28	Potomac River Upper	MD	0	44.9	0	44.9	0	29.0	85.5	1.28	116	8.47	169
	Not Listed water bodies	ALL	32.3	49.9	0	82.2	444	326	60.8	0.268	830	46.3	959
	Total all tidal waters	ALL	187	362	159	707	1920	712	564	28.2	3230	197	4140

Table 6. Maximum Daily TMDL load allocations for each PCB impairment.

All values are expressed to 3 significant digits only. Units are mg/day total PCBs. Does not include PCB flux at Downstream Boundary (see Section V(5.2)).

			WLA				LA						
Ref #	**Impaired Waterbody**	**Juris.**	**WWTP**	**Reg. Stormwtr**	**CSO**	**Total WLA**	**Trib.**	**nonpoint source**	**Atmos. Dep.**	**Contam. Sites**	**Total LA**	**MOS**	**TMDL**
1	Upper Potomac	DC	0	197	2.37	199	34200	19.2	3.63	0	34300	1820	36300
2	Middle Potomac	DC	0	1130	1190	2310	4210	126	12.6	0.00173	4350	351	7010
3	Lower Potomac	DC	3090	924	7250	11300	0	153	23.5	0	176	439	11900
4	Upper Anacostia	DC	0	300	26.1	326	0	51.1	4.04	0.00384	55.2	20	401
5	Lower Anacostia	DC	0	125	795	920	0	35.4	4.77	0	40.1	50.5	1010
6	Accotink Creek	VA	0	12.9	0	12.9	5780	11	1.95	0	5790	305	6110
7	Aquia Creek	VA	3.82	642	0	645	3010	1730	2.07	0	4750	284	5680
8	Belmont Bay	VA	0	58.4	0	58.4	0	223	7.22	0	230	15.2	304
9	Chopawamsic Creek	VA	0	143	0	143	0	376	0.439	0	376	27.3	546
10	Coan River	VA	0	0	0	0	0	1050	1.57	0	1050	55.3	1110
11	Dogue Creek	VA	0	2590	0	2590	0	934	4.28	0	938	186	3710
12	Fourmile Run	VA	12.7	1130	0	1140	0	32.8	2.48	0	35.3	61.3	1240
13	Gunston Cove	VA	0	67.3	0	67.3	0	57	7.47	4.53	69	7.18	143
14	Hooff Run & Hunting Creek	VA	17.1	2980	1110	4110	6590	99.4	4.26	1.98	6690	567	11400
15	Little Hunting Creek	VA	0	1300	0	1300	0	469	2.53	0	471	93.2	1860
16	Monroe Creek	VA	0.636	0	0	0.636	0	156	0.964	0	157	8.26	166
17	Neabsco Creek	VA	10.6	510	0	520	0	155	1.96	0	157	35.1	712
18	Occoquan River	VA	0	393	0	393	3180	574	22.1	3.23	3780	220	4390
19	Pohick Creek	VA	21.4	988	0	1010	0	828	4.75	0	832	95.8	1940
20	Potomac Creek	VA	0	93.5	0	93.5	0	1590	2.46	0	1600	89.1	1780
21	Potomac R. Fairview Beach	VA	0	2.76	0	2.76	0	100	2.04	0	102	5.51	110
22	Powells Creek	VA	0	10.3	0	10.3	0	27	1.15	0	28.1	2.02	40.4
23	Quantico Creek	VA	0	113	0	113	1460	297	1.32	0	1750	98.1	1960
24	Upper Machodoc Creek	VA	0.317	0	0	0.317	0	1150	0.931	0	1150	60.5	1210
25	Tidal Anacostia	MD	0	161	0	161	1580	5.78	1.12	0.00338	1590	92.2	1840
26	Potomac River Lower	MD	0.23	254	0	255	0	6420	218	14	6650	363	7270
27	Potomac River Middle	MD	27.1	401	0	428	0	1730	78.9	2.86	1810	116	2350
28	Potomac River Upper	MD	0	2140	0	2140	0	1350	85.4	1.28	1430	188	3760
	Not Listed water bodies	ALL	42.2	2310	0	2360	16500	16800	60.8	0.268	33400	1880	37600
	Total all tidal waters	ALL	3220	19000	10400	32600	76600	36600	564	28.2	114000	7540	154000

Table 7. Maryland and Potomac mainstem impairments.

Maryland lists its impairments by state 8 digit HUC code watershed. Tidal waters of the Potomac River Upper, Potomac River Middle, and Potomac River Lower watersheds are listed for PCBs. The additional watersheds shown in this table contribute loads to the impaired waterbodies, and load allocations are shown for reference purposes. *Impaired waterbody refers to the specific tidal impairment that this tributary is contributing to. Sources of loads within tributaries were not addressed in this study. Units are total PCBs in g/year. Does not include PCB flux at Downstream Boundary (see Section V(5.2)).

Impaired Waterbody* (Ref #)	MD 8-digit Watershed	MD 8-digit Code	WLA				LA					MOS	TMDL
			WWTP	Reg. Stormwtr	CSO	Total WLA	Trib.	nonpoint source	Atmos. Dep.	Contam. Sites	Total LA		
Potomac River Lower (26)	St Marys River	02140103	0	0	0	0	9.01	12.7	3.60	0	25.3	1.33	26.6
	Breton Bay	02140104	0.245	0	0	0.245	8.87	7.31	1.30	0	17.5	0.92	18.6
	St Clements Creek	02140105	0	0	0	0	7.05	7.49	1.05	0	15.6	0.821	16.4
	Wicomico - Gilbert - Zekiah	02140106 -07 -08	0	0.996	0	0.996	66.7	24.3	3.92	0	94.9	5.05	101
	Port Tobacco River	02140109	0.538	4.09	0	4.63	0	11.1	0.711	0	11.9	0.839	17.3
	Nanjemoy Creek	02140110	0	1.38	0	1.38	6.08	14.3	1.10	0	21.4	1.20	24.0
	Potomac River Lower	02140101	0.064	1.99	0	2.06	0	44.1	79.5	5.12	129	6.87	138
	Total	-	**0.847**	**8.46**	**0**	**10.7**	**97.7**	**121**	**91.2**	**5.12**	**316**	**17.0**	**342**
Potomac River Middle (27)	Mattawoman Creek	02140111	0.179	2.87	0	3.05	36.7	8.55	2.48	0.0979	47.8	2.67	53.5
	Potomac River Middle	02140102	7.55	3.04	0	10.6	0	13.4	28.8	1.05	43.2	2.43	56.2
	Total	-	**7.73**	**5.91**	**0**	**13.7**	**36.7**	**22.0**	**31.3**	**1.15**	**91.0**	**5.10**	**110**
Potomac River Upper (28)	Piscataway Creek	02140203	10.8	7.70	0	18.5	27.9	6.81	2.39	0	37.1	2.36	58.0
	Potomac River Upper	02140201	0	16.4	0	16.4	0	10.6	31.2	0.467	42.2	3.09	61.7
	Total	-	**10.8**	**24.1**	**0**	**34.9**	**27.9**	**17.4**	**33.6**	**0.467**	**79.3**	**5.45**	**120**

Table 8. TMDL reductions for Maryland watersheds listed in Table 7.

*Impaired waterbody refers to the specific tidal impairment that this tributary is contributing to. Sources of loads within tributaries were not addressed in this study. Units are grams of total PCBs per year. Does not include PCB flux at Downstream Boundary (see Section V(5.2).

Impaired Waterbody* (Ref #)	MD 8-digit Watershed	MD 8-digit Code	Baseline	TMDL	Reduction
Potomac River Lower (26)	St Marys River	02140103	81	26.6	67.2%
	Breton Bay	02140104	38.8	18.7	51.8%
	St Clements Creek	02140105	32.7	16.4	49.8%
	Wicomico - Gilbert - Zekiah	02140106 -07 -08	164.0	101	38.4%
	Port Tobacco River	02140109	28.4	17.4	38.7%
	Nanjemoy Creek	02140110	41.4	24	42.0%
	Potomac River Lower	02140101	1320	138	89.5%
	Total	-	**1710**	**342**	**80.0%**
Potomac River Middle (27)	Mattawoman Creek	02140111	93	53.5	42.5%
	Potomac River Middle	02140102	478	56.2	88.2%
	Total	**-**	**571**	**110**	**80.7%**
Potomac River Upper (28)	Piscataway Creek	02140203	86.6	58	33.0%
	Potomac River Upper	02140201	651	61.7	90.5%
	Total	**-**	**738**	**120**	**83.7%**

Table 9. WLA for wastewater treatment plants.

For this TMDL, the jurisdictions agreed to apply a consistent approach to all wastewater treatment plants (WWTPs) for determining load allocations. The allocations are determined by facility design flow times the applicable jurisdiction water column target. This approach was adopted to recognize a) the limited number of samples available for estimating current loads, and b) the jurisdictions' decision that point source discharges should not exceed the water column target (with no mixing zone). In some cases, this policy results in a wasteload allocation (WLA) that is larger than the estimated Baseline load. NOTE: Calculation of the Baseline PCB concentrations was done using the PCB3+ fraction of samples collected at facilities. To be consistent with usage elsewhere in this document, the Baseline PCB concentrations were converted to total PCBs by dividing PCB3+ by 0.92. Negative reductions indicate that the TMDL load is higher than the Baseline load. [a] The tidal receiving waterbody is currently listed as impaired, and the Waterbody name and Reference number in brackets in this table correspond to those in Table 1.

			Baseline			TMDL			
Facility	NPDES	Tidal Receiving Waterbody (Ref #)	Flow (MGD)	[tPCB] (ng/l)	tPCB Load (g/year)	Design Flow (MGD)	[tPCB] (ng/l)	tPCB Load (g/year)	Reduction
Blue Plains	DC0021199	[a] DC Lower Potomac (3)	321.20	1.58	701	370.00	0.059	30.2	95.7%
Indian Head	MD0020052	MD Mattawoman Creek	0.30	0.163	0.068	0.5	0.26	0.18	-164.7%
La Plata	MD0020524	MD Port Tobacco Creek	1.17	0.163	0.264	1.5	0.26	0.539	-104.2%
NSWC-Indian Head	MD0020885	[a] MD Potomac Middle (27)	0.45	3.98	2.47	0.5	0.26	0.18	92.7%
Piscataway	MD0021539	MD Piscataway Creek	21.39	0.0554	1.64	30	0.26	10.8	-558.5%
Mattawoman	MD0021865	[a] MD Potomac Middle (27)	9.49	0.0533	0.699	20	0.26	7.18	-927.2%
Leonardtown	MD0024767	MD Breton Bay	0.43	0.376	0.224	0.68	0.26	0.244	-8.9%
NSWC-Dahlgren	VA0021067	[a] MD Potomac Lower (26)	0.28	0.0565	0.0221	0.72	0.064	0.064	-189.6%
Dale City #8	VA0024678	[a] VA Neabsco Creek (17)	2.96	0.0217	0.0887	4.6	0.064	0.407	-358.9%
Dale City #1	VA0024724	[a] VA Neabsco Creek (17)	3.05	0.0446	0.1879	4.6	0.064	0.407	-116.6%
H.L. Mooney	VA0025101	[a] VA Neabsco Creek (17)	12.25	0.107	1.8108	24	0.064	2.12	-17.1%
Arlington	VA0025143	[a] VA Four Mile Run (12)	26.38	0.462	16.8	40	0.064	3.54	78.9%
Alexandria	VA0025160	[a] VA Hooff/Hunting Creek (14)	37.37	0.323	16.7	54	0.064	4.77	71.4%
Noman M. Cole Jr.	VA0025364	[a] VA Gunston Cove (13)	42.11	0.291	16.9	67	0.064	5.92	65.0%
Colonial Beach	VA0026409	VA Mattox Creek	0.83	2.57	2.95	2	0.064	0.177	94.0%
Dahlgren Sanitary Dist.	VA0026514	[a] VA Up Machodoc Creek (24)	0.24	0.359	0.118	1	0.064	0.088	25.4%
Quantico-Mainside	VA0028363	[a] MD Potomac Middle (27)	1.20	0.0674	0.112	2.2	0.064	0.195	-74.1%
Aquia	VA0060968	[a] VA Aquia Creek (7)	4.86	0.0312	0.21	12	0.064	1.06	-404.8%
TOTAL all WWTPs					762.3			68.2	91.1%
These WWTPS are located within tributaries and are not part of the WLA for the TMDL. These calculations are provided for reference only.									
Beltsville USDA East	MD0020842	[a] MD Tidal Anacostia (25)	0.2	0.163	0.045	0.62	0.26	0.223	-395.6%
Beltsville USDA West	MD0020851	[a] MD Tidal Anacostia (25)	0.09	0.163	0.02	0.2	0.26	0.072	-260.0%
UOSA	VA0024988	[a] VA Occoquan River (18)	28.94	0.00217	0.0868	64	0.064	5.66	-6420.7%
The following WWTP was not included in this TMDL study because its current design flow is below the 0.1 MGD minimum that MDE used to determine which facilities to include in the loading model. There are plans, however, to expand this WWTP 0.6 MGD in the future. When that expansion is complete, then the facility will get a WLA of 0.216 g/year, based on the default PCB concentration for MD WWTPs of 0.26 ng/l and design flow of 0.6 MGD.									
Swan Point	MD0057525	[a] MD Potomac Lower (26)	0.067			0.6	0.26	0.216	

Table 10. Municipal- and County-level MS4 permits.

The Municipal- and County-level MS4 permits issued in the District of Columbia, Maryland, and Virginia are listed separately. Some of the permits may cover areas located in direct drainage as well as tributary watershed segments, but the stormwater WLAs apply only to the direct drainage areas and, also, apply to other NPDES regulated stormwater entities located within the direct drainage watershed segments as well as these Municipal- and County-level MS4 permits.

District of Columbia MS4 Permit		
Primary Location	**Facility Name**	**NPDES**
District of Columbia	Government of the District of Columbia - MS4	DC0000221

Virginia MS4 Permits		
Primary Location*	**Facility Name**	**Permit No**
Arlington County	Arlington County	VA0088579
	US Army - Fort Myer MS4	VAR040068
	US Department of Defense – Pentagon	VAR040103
City of Alexandria	City of Alexandria	VAR040057
City of Manassas	City of Manassas	VAR040063
City of Manassas Park	City of Manassas Park	VAR040070
Fairfax County	City of Fairfax	VAR040064
	City of Falls Church	VAR040065
	Fairfax County	VA0088587
	Fairfax County Public Schools	VAR040104
	George Mason University**	TBD
	George Washington Memorial Parkway**	TBD
	Northern Virginia Community College	VAR040095
	Town of Vienna	VAR040066
	US Army - Fort Belvoir	VAR040093
	US Central Intelligence Agency - George Bush Cntr	VAR040101
Fairfax, Arlington, Prince William Counties	VDOT - Northern Virginia District	VAR040062
Prince William County	FBI Academy	VAR040105
	Prince William County	VA0088595
	Prince William County Public Schools	VAR040100
	US Marine Corps - Quantico - MS4	VAR040069
Stafford County	Stafford County	VAR040056
	Stafford County - Public Schools	VAR040071
	VDOT - Fredericksburg District	VAR040061

*Primary location denotes the primary geographic area where the permit applies. Selected permits may cross multiple jurisdictional boundaries.
**MS4 permits for these entities have not yet been issued. They are included as they are subject to permitting under the MS4 program and will be required to address applicable TMDL provisions.

Maryland Phase I&II MS4 County		
County	**MS4 Permit**	**NPDES**
Charles	Phase I (Medium)	MD0068365
Prince George's	Phase I (Large)	MD0068284
State Highway Administration	Phase I	MD0068276

Maryland Phase II MS4 Municipality				
Municipality	**MS4 Permit**	**County**	**8 Digit Basin**	**8 Digit Code**
Indian Head	Phase II	Charles	Mattawoman Creek / Middle Tidal Potomac	02140111 / 02140102
Bladensburg	Phase II	Prince Georges	Anacostia River	02140205
Cheverly	Phase II	Prince Georges	Anacostia River	02140205
Glenarden	Phase II	Prince Georges	Anacostia River	02140205
Brentwood	Phase II	Prince Georges	Anacostia River	02140205
Hyattsville	Phase II	Prince Georges	Anacostia River	02140205
Cottage City	Phase II	Prince Georges	Anacostia River	02140205
Colmar Manor	Phase II	Prince Georges	Anacostia River	02140205
Capitol Heights	Phase II	Prince Georges	Anacostia River	02140205
Fairmont Heights	Phase II	Prince Georges	Anacostia River	02140205
Seat Pleasant	Phase II	Prince Georges	Anacostia River	02140205
Forest Heights	Phase II	Prince Georges	Oxon Creek	02140204
Morningside	Phase II	Prince Georges	Upper Tidal Potomac	02140201
Landover Hills	Phase II	Prince Georges	Anacostia River	02140205
La Plata	Phase II	Charles	Port Tobacco River	02140109
Mount Rainier	Phase II	Prince Georges	Anacostia River	02140205
New Carrollton	Phase II	Prince Georges	Anacostia River	02140205

Table 11. TMDL load allocations by tributary.

Sources of loads within tributaries were not addressed in this study. Units are total PCBs, in g/year. Reference #'s refer to impaired water bodies shown in Figure 1 and Table 1.

Ref #	Tributary	Baseline	TMDL	Reduction
1	Potomac R at Chain Br.	16,433	312	98.1%
1	Rock Cr	727	34.2	95.3%
25	NW Br Anacostia R	298	5.66	98.1%
25	NE Br Anacostia R	429	8.14	98.1%
14	Upper Hunting Cr	322	45.8	85.8%
28	Upper Piscataway Cr	29	27.6	4.8%
6	Accotink Cr	607	46.1	92.4%
18	Occoquan R	270	51.3	81.0%
27	Mattawoman Cr	39	37.1	4.9%
23	Quantico Cr	12	11.4	5.0%
7	Aquia Cr	22	20.9	5.0%
26	Nanjemoy Cr	6	5.70	5.0%
26	Wicomico / Zekiah	70	66.5	5.0%
26	St Clements Cr	7	6.65	5.0%
24	Upper McIntosh Run	9	8.55	5.0%
26	St Marys R	9	8.55	5.0%
	TOTAL	19,289	696	96.4%

While the exact relationship between atmospheric deposition to the land surface and non point source runoff of PCBs is unclear at this time, it is expected that the proposed 93% reduction in atmospheric deposition of PCBs should yield the 5% reduction in loads represented by the MOS.

Tributary

Tributary LAs are obtained from POTPCB model output for each of the 17 lower basin tributaries specified in the POTPCB model and for the Potomac River at Chain Bridge. Each tributary load is the sum of all PCB loads to the watershed, including atmospheric deposition to the land and water surface, unidentified contaminated sites, non-point sources, and point source discharges. TMDL load allocations by tributary are shown in Table 11.

Nonpoint source

In this document the non-point sources account for loads from unregulated storm water runoff. The non-point source Baseline loads and LAs are calculated from the Baseline direct drainage loads derived with the WM5 model and the TMDL condition direct drainage loads obtained from POTPCB model output. In the absence of NPDES stormwater permits, the non-point source load is equal to the direct drainage load. However, when a model segment covers an NPDES regulated stormwater area, the non-point source load is calculated by subtracting the associated NPDES load from the direct drainage load. TMDL baseline loads and load allocations for non-point sources are presented by FIPS code in Table 12. Table 12 is further broken out into watershed segments where a segment straddles FIPS boundaries. Figure 8 provides a graphic reference for watershed segment and FIPS boundaries.

Atmospheric deposition to tidal water surface

Atmospheric deposition to tidal water surface was based on results of the Chesapeake Bay Program Atmospheric Deposition Study (CBP 1999). That study found, as did the Delaware River TMDL (Fikslin et al 2006), that there is a gradient in PCB net deposition rates from high levels in urban centers to lower levels distant from urban centers. For the tidal Potomac PCB TMDL, a gradient of net atmospheric deposition rates ranging from 16.3 ug PCB/m^2/year in the Washington, D. C. metropolitan area to 1.6 ug PCB/m^2/year in areas farthest from the metropolitan area was applied to tidal water surfaces for the baseline scenario. This range of deposition rates is the same as was reported in the Chesapeake Bay Program Atmospheric Deposition Study. Atmospheric deposition loads were input at a constant daily rate (the annual rate divided by 365). For the TMDL scenario, a uniform % reduction from these baseline rates was applied to all areas.

Identified contaminated sites

Contaminated sites are areas with known PCB releases or contaminated soils. The three jurisdictions reviewed their contaminated site records for the Potomac River lower basin and provided total PCB annual loads for 21 identified sites using the RUSLE2 methodology (Butt et al 2007; Chowdhury 2007; White & Soehl 2007). Eight sites are located in WM5-specified tributaries, and their loads were not direct inputs to the POTPCB model because they were implicit in the loads estimated for the tributaries. Thirteen sites are located in the WM5 direct drainage watershed segments, and their loads were inputs to the POTPCB model as constant daily loads (annual load/365).

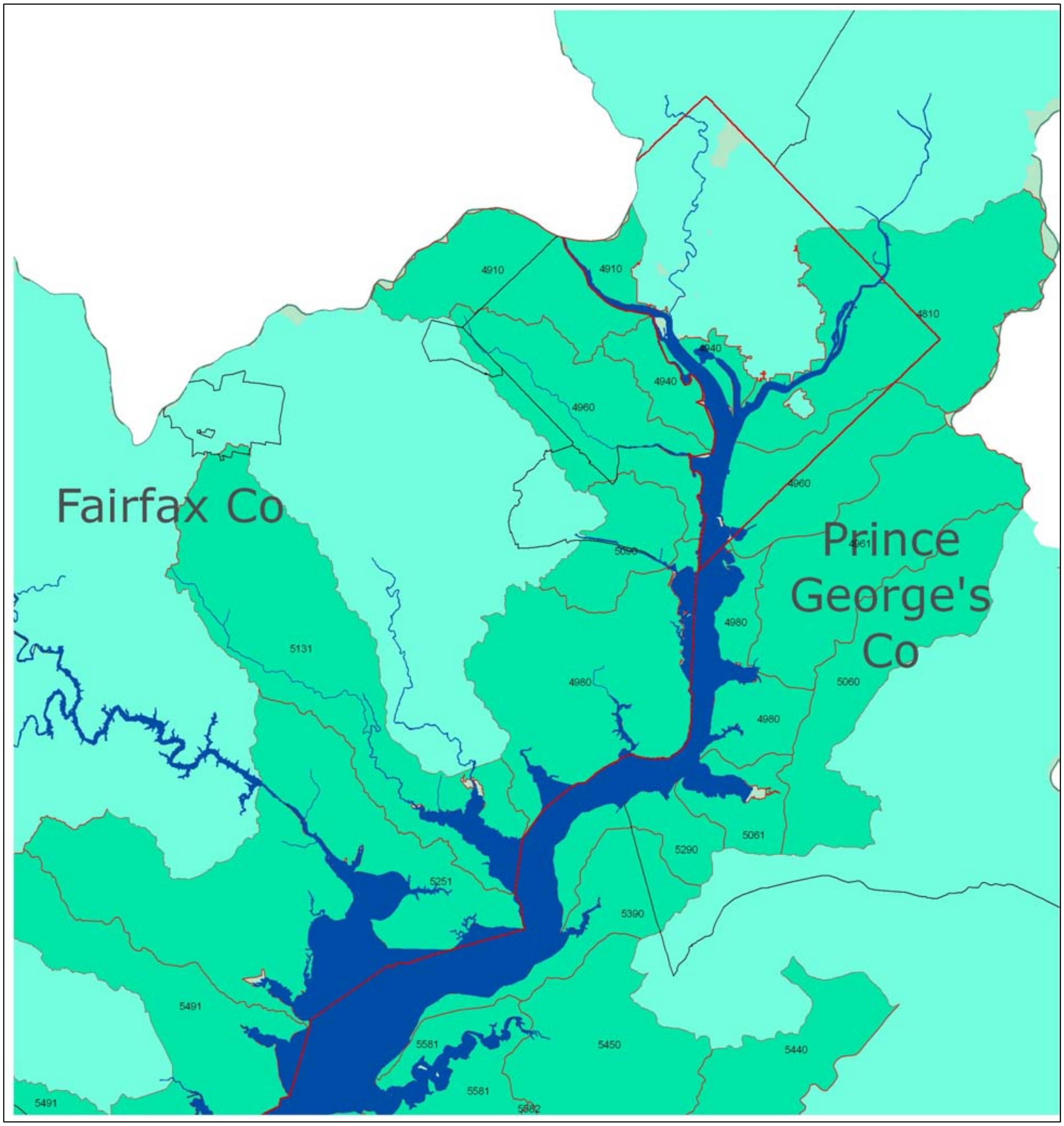
Table 12. Direct drainage loads by watershed and FIPS code.

Direct drain loads were allocated to watershed segments and to FIPS code jurisdictions within segments, and apply only to the portion of jurisdictions that are in direct drain watersheds. Figure 8 provides a visual reference for the watershed codes. For those watersheds where the percent reduction is 5%, all of that reduction is due to the Margin of Safety (MOS). It is expected that the proposed 93% reduction in atmospheric deposition of PCBs will accomplish the 5% reduction in loads represented by the MOS. Units are total PCBs, in g/year.

			Baseline		TMDL		
Jurisdiction	**Impairment Ref #'s**	**Water-shed code**	**tPCB reg storm**	**tPCB NPS LA**	**tPCB reg storm WLA**	**tPCB NPS LA**	**percent reduction**
District of Columbia	3, 4, 5	4810	3420	970	2.65	0.751	99.9%
	1	4910	27.6	11.5	0.139	0.0583	99.5%
	2	4940	279	316	0.582	0.660	99.8%
	3	4960	51.9	30.5	0.898	0.527	98.3%
	3	4980	0	0.241	0	0.0114	95.3%
		Total	3780	1330	4.27	2.01	99.9%
Prince Georges Co., MD	3, 4, 5, 25	4810	2980	54.3	1.94	0.0353	99.9%
	3	4960	92.6	11.2	0.88	0.107	99.0%
	28	4961	96	24.7	0.912	0.235	99.0%
	3, 28	4980	28.4	13.5	8.72	4.15	69.3%
	28	5060	6.95	5.24	6.6	4.97	5.0%
	28	5061	1.16	1.94	1.1	1.84	5.0%
	28	5290	0.451	2.49	0.348	1.92	22.9%
	27	5390	0.0678	0.615	0.0644	0.584	5.0%
		Total	3210	114	20.6	13.8	99.0%
Charles County, MD	26, 27, 28	Total	13.2	68.3	12.6	64.9	5.0%
St. Marys Co., MD	26	Total	0	53.5	0	50.9	5.0%
Arlington Co., VA	1	4910	67	7.82	0.36	0.042	99.5%
	2, 3	4940	1540	61.3	7.33	0.291	99.5%
	3, 12	4960	132	4.37	6.27	0.207	95.3%
		Total	1740	73.5	14	0.54	99.2%
City of Falls Church, VA	3, 12	Total	6.16	0.216	0.293	0.0102	95.2%
City of Alexandria, VA	3, 12	4960	62.7	2.21	2.98	0.105	95.2%
	3, 14	4980	4.92	0.674	0.503	0.0688	89.8%
	14	5090	47.6	0.00141	6.79	0.000201	85.7%
		Total	115	2.88	10.3	0.174	91.1%
Fairfax Co., VA	1	4910	78.6	3.44	0.973	0.0425	98.8%
	3, 12	4960	19.9	0.0031	0.943	0.000147	95.3%
	11, 14, 15, 28	4980	85.9	31	37.4	13.5	56.5%
	14	5090	39.7	0.941	5.65	0.134	85.8%
	6, 13, 19	5131	8.54	7.23	8.11	6.87	5.0%
	8, 17, 18, 27, 28	5251	9.81	37.4	1.64	6.24	83.3%
		Total	242	80	54.7	26.8	74.7%
Fairfax City, VA	6, 13, 19	Total	0.0888	0.0000621	0.0843	0.000059	5.0%
Prince William Co., VA	8, 18, 27	5251	39.4	12.0	5.61	1.71	85.8%
	9, 22, 23, 27	5491	3.26	8.53	3.09	8.11	5.0%
		Total	42.6	20.5	8.7	9.82	70.6%
Stafford Co. VA	9, 7, 20, 26, 27	Total	6.29	26.9	5.98	25.5	5.0%
King George Co., VA	20, 21, 24, 26	Total	0	21.6	0	20.5	5.0%
Westmoreland Co., VA	16, 26	Total	0	28.8	0	27.4	5.0%
Northumberland Co., VA	10, 26	Total	0	19.6	0	18.6	5.0%
Grand Total			9155	1840	132	261	96.4%

Figure 8. Upper basin direct drain watershed segments.

This graphic provides a reference for direct drain watershed segments (green areas) in the upper Potomac region that are listed in Table 12. The TMDL load allocation is the same as the Baseline loads for all of the direct drain watershed segments below the area shown in this graphic.



Downstream Boundary

In the Baseline Scenario the net flux of PCBs is from the Potomac to the Chesapeake Bay. When external loadings are reduced to approximate TMDL conditions the net flux of PCBs is from the Bay into the Potomac so that the downstream boundary concentration becomes a factor for meeting water column targets in lower Potomac impairments, including impairments that are not adjacent to the Chesapeake Bay boundary. It was determined that, in addition to the WLAs and LAs described above, meeting the jurisdiction water column and sediment targets in the tidal Coan River required that the PCB concentration at the boundary with the Chesapeake Bay be reduced by 33% from the Baseline 0.108 ng/l to 0.072 ng/l PCB. The net flux of PCBs in the Baseline Scenario is 12,400 g/year PCBs from the Potomac to the Chesapeake Bay. In the TMDL scenario the net flux of PCBs is 1,710 g/year from the Chesapeake Bay to the Potomac. The TMDL allocations presented in Tables 4-8, 13, and 14 do not include this flux.

6. The TMDL Allocation

Figures 9-12 compare the model simulated PCB water column concentrations for the Baseline and the TMDL conditions. Results are displayed in four charts which break the entire estuary into the Potomac Mainstem, the Anacostia River, Maryland side embayments, and Virginia side embayments. While the POTPCB model simulates PCB3+, results have been converted to total PCBs (tPCB = PCB3+ / 0.92) on these charts. The charts clearly show the large gap between the Baseline condition and the water column targets. The gap is especially large in the District of Columbia where the PCB loads are the highest and the water concentration target is the lowest. In the Anacostia River, Baseline concentrations are more than 100 times higher than the DC water column target. The gap narrows with distance downstream, but Baseline concentrations exceed the water column target in Virginia embayments all the way to the mouth of the Potomac. The TMDL scenario indicates that water column targets will be met in every model segment when loads are reduced to the TMDL loading levels. Table 13, which shows Baseline and TMDL scenario loads by the major source categories, indicates high levels, greater than 80%, of PCB reduction levels for all sources except known contaminated sites. Table 14, which shows Baseline and TMDL scenario total loads by impaired water body, indicates that most of the impairments require reductions exceeding 80% and that the overall reduction is 96%. Together, these two tables imply that high levels of reductions are required everywhere and for all sources. There are, however, pronounced differences in required reductions by geographic area. One can see in Tables 10 and 12 that no reduction in PCBs is required in some tributaries and some direct drainage areas. The geographic distribution of tributaries and direct drain areas with high PCB load reductions versus low, or no, reductions is shown graphically in Figure 13. In the District of Columbia and surrounding counties, PCB reductions in excess of 90% are necessary with reduction levels decreasing to zero further away. The Washington area reductions in tributary, direct drain, CSO, and WWTP loads, plus the 93% reduction in atmospheric deposition everywhere, achieve the necessary water quality improvement for the lower part of the tidal Potomac (with the exception of Coan River, which requires the reduction in the downstream boundary noted above). This geographic pattern of reductions is consistent with the pattern of input loads under current conditions for which this study estimates 84% of loads to the tidal Potomac enter above the DC-MD state line near Wilson Bridge.

Figure 9. Potomac mainstem model simulated PCB water concentration and PCB loads for the Baseline and the TMDL Scenario.

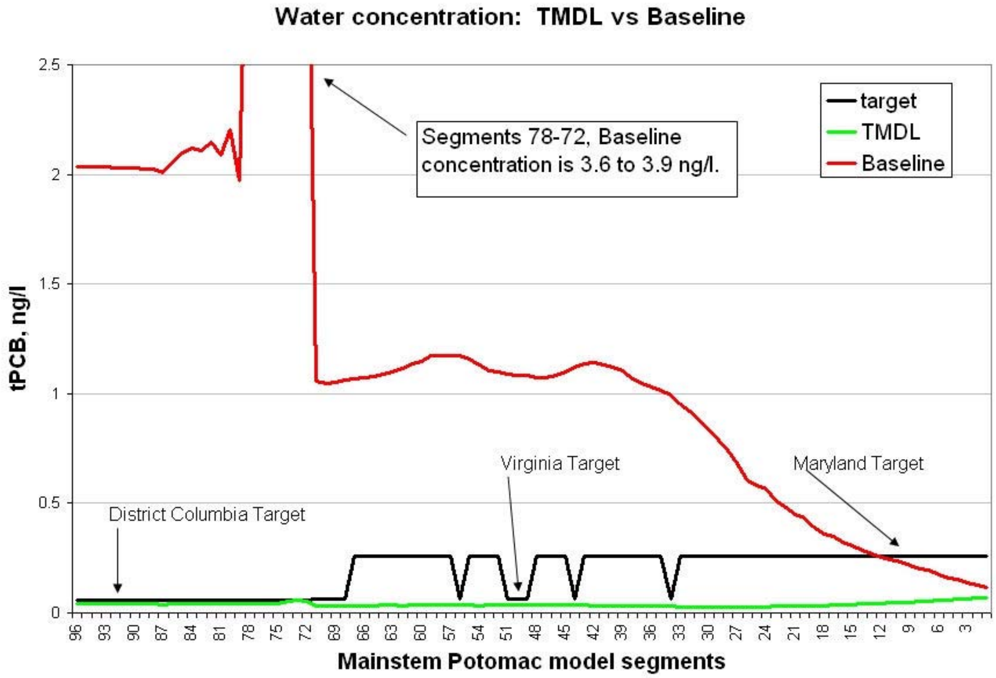


Figure 10. Anacostia River model simulated PCB water concentration and PCB loads for the Baseline and the TMDL Scenario.

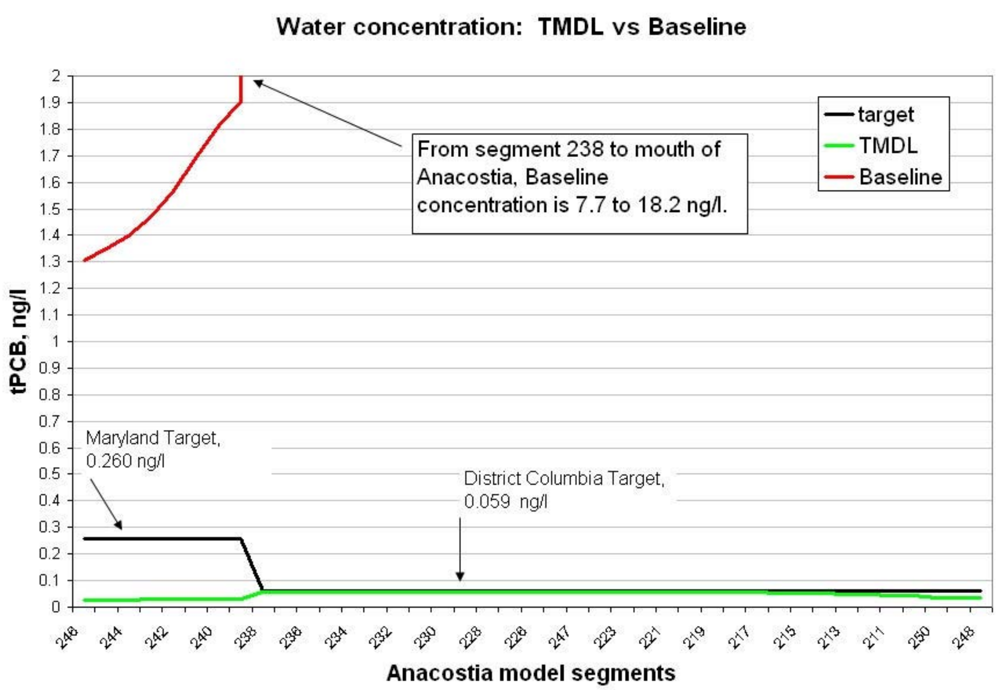


Figure 11. Virginia embayments model simulated PCB water concentration and PCB loads for the Baseline and the TMDL Scenario.

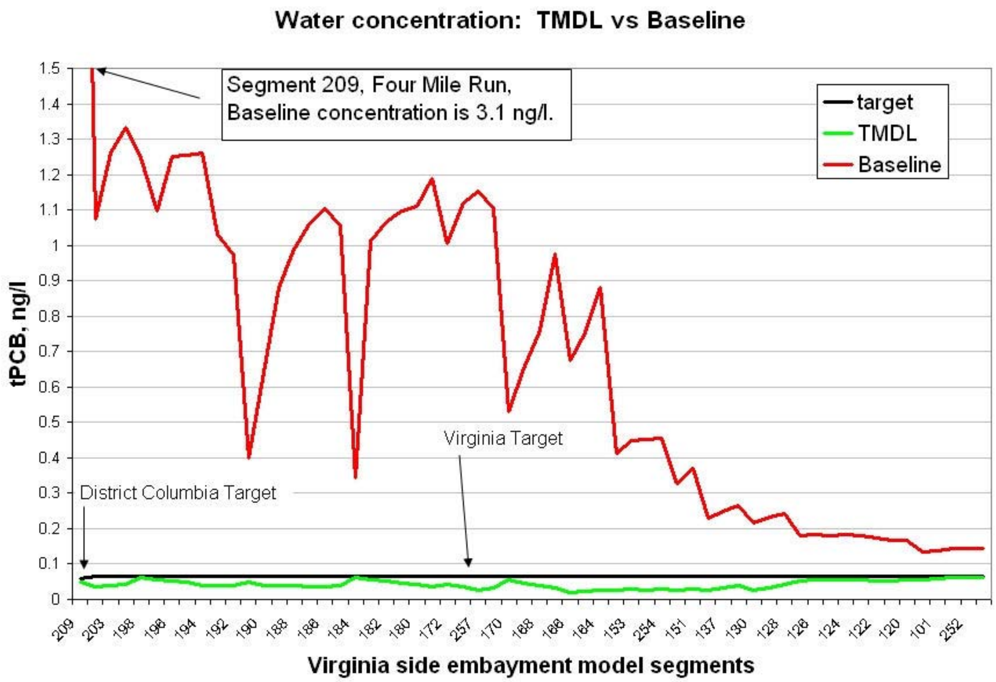


Figure 12. Maryland embayments model simulated PCB water concentration and PCB loads for the Baseline and the TMDL Scenario.

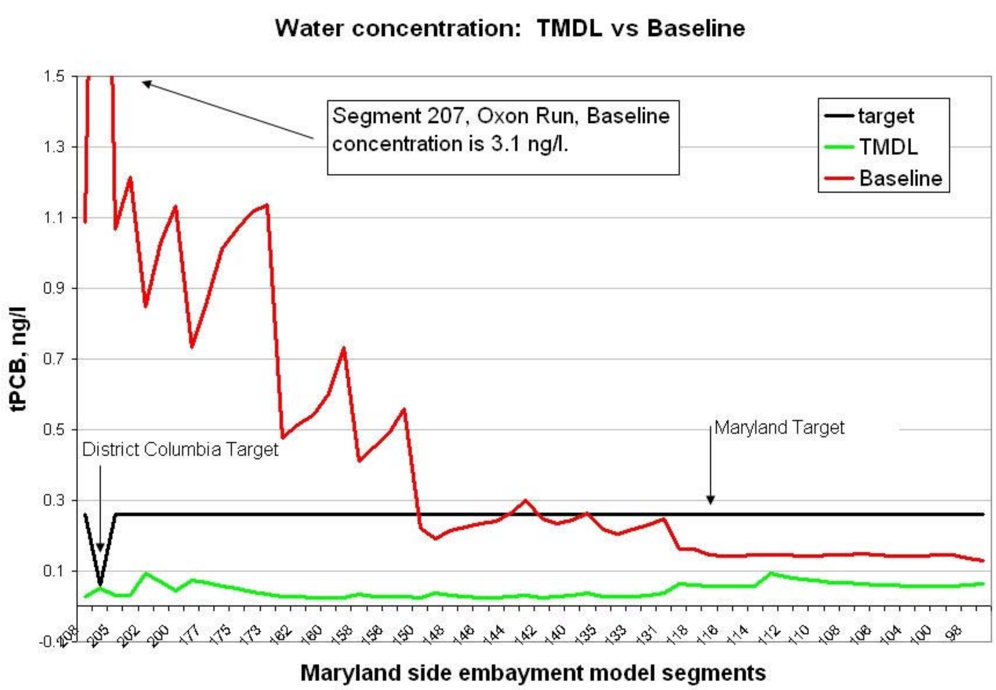


Figure 13. Reductions in tributary (LA), direct drain (WLA & LA), DC CSO, and WWTPs.

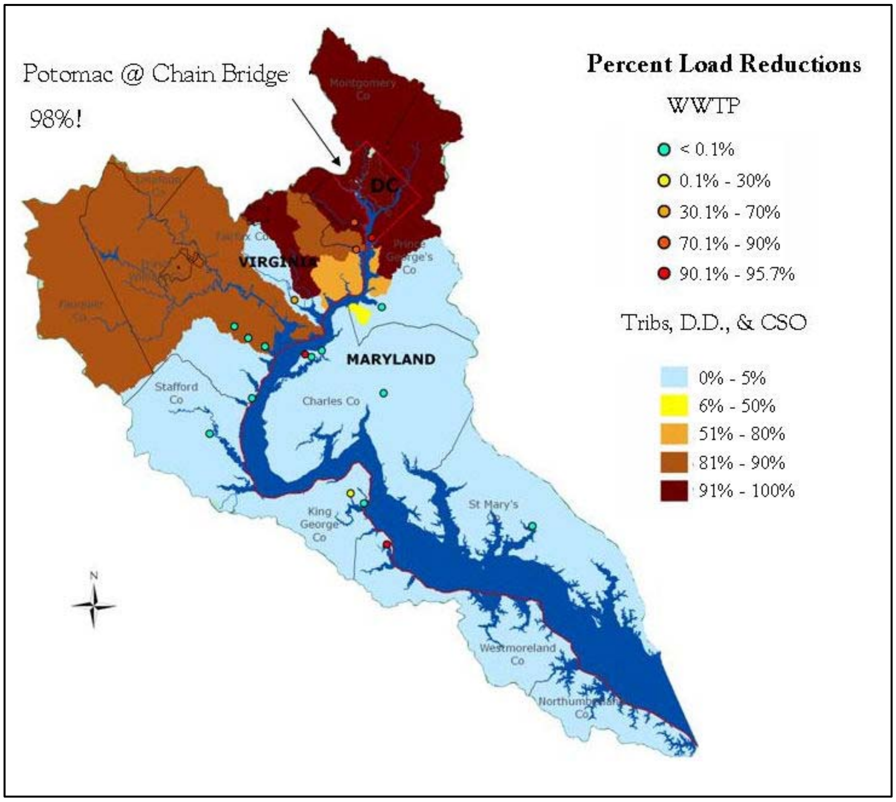


Table 13. PCB loads by major source category to the tidal Potomac and Anacostia rivers, in g/year.

Source category	Baseline	TMDL	Reduction
Potomac @ Chain Bridge[1]	16,433	312	98%
Lower Basin Tributaries[2]	2,857	387	86%
Direct drainage[3]	10,996	392	96%
WWTP[4]	762	68.2	91%
CSO[5]	3,020	58.1	98%
Atmospheric deposition[6]	3,070	206	93%
Contaminated sites[7]	15.1	10.3	32%
Margin of Safety		71.8	
TOTAL[8]	37,156	1510	96%

[1] The non-tidal Potomac River above Chain Bridge in the District of Columbia. Chain Bridge is the approximate head-of-tide of the tidal Potomac River, or estuary.
[2] The lower basin is that portion of the Potomac River watershed that contributes to the tidal waters, and excludes the watershed above Chain Bridge. The tributaries are the 17 streams in the lower basin defined in the Chesapeake Bay Watershed Model (WM5) as tributaries.
[3] That part of the lower basin watershed that is not in a WM5 defined tributary. Direct drainage areas are located adjacent to the Potomac and Anacostia rivers.
[4] Waste water treatment plant.
[5] Combined sewer overflow system.
[6] Atmospheric PCBs deposited directly on the tidal water surface.
[7] Those sites that have been identified as contaminated by PCBs, some of which have been remediated.
[8] This total does not include changes in the Downstream Boundary condition for reasons explained in Section V(5.2)

Table 14. Annual Baseline and TMDL PCB loads to each impaired segment, in grams/year total PCBs.

Does not include PCB flux at Downstream Boundary (see Section V(5.2)).

Ref #	Impaired Waterbody	Jurisdiction	Baseline	TMDL	Reduction
1	Upper Potomac	DC	16700	333	98.0%
2	Middle Potomac	DC	3610	53.7	98.5%
3	Lower Potomac	DC	1880	81	95.7%
4	Upper Anacostia	DC	4990	3.74	99.9%
5	Lower Anacostia	DC	2700	4.95	99.8%
6	Accotink Creek	VA	618	49.5	92.0%
7	Aquia Creek	VA	54.3	44.5	18.0%
8	Belmont Bay	VA	41.5	4.84	88.3%
9	Chopawamsic Creek	VA	7.56	5.32	29.6%
10	Coan River	VA	15	6.98	53.5%
11	Dogue Creek	VA	89.2	30.6	65.7%
12	Fourmile Run	VA	193	12.7	93.4%
13	Gunston Cove	VA	43.7	5.62	87.1%
14	Hooff Run & Hunting Creek	VA	480	89.7	81.3%
15	Little Hunting Creek	VA	46.8	15.5	66.9%
16	Monroe Creek	VA	9.35	1.66	82.2%
17	Neabsco Creek	VA	17.4	8.76	49.7%
18	Occoquan River	VA	442	71.1	83.9%
19	Pohick Creek	VA	57.8	22.4	61.2%
20	Potomac Creek	VA	24.1	11.5	52.3%
21	Potomac River, Fairview Beach	VA	11.9	1.5	87.4%
22	Powells Creek	VA	6.57	0.7	89.3%
23	Quantico Creek	VA	22	15.3	30.5%
24	Upper Machodoc Creek	VA	13.9	9.12	34.4%
25	Tidal Anacostia	MD	1970	16.2	99.2%
26	Potomac River Lower	MD	1250	138	89.0%
27	Potomac River Middle	MD	454	56.2	87.6%
28	Potomac River Upper	MD	618	61.7	90.0%
	Not Listed waterbodies	ALL	777	350	55.0%
	Total all tidal waters	ALL	37143	1510	95.9%

7. Uncertainty in the Estimates

This TMDL is based, to the greatest extent possible, on observed data for estimating external loads, calculating BAFs to set water column and sediment targets, and to calibrate the POTPCB model. As described in Appendices A and D, and in the companion model calibration report (LimnoTech 2007), estimates based on these data are subject to some uncertainty. A formal analysis to calculate confidence limits around estimates of loads and predicted PCB concentrations was beyond the available time or resources for this project. Some qualitative observations about uncertainty in the estimates of load allocations can still be made:

- While estimates of loads from all source categories can be improved with more monitoring data, the geographic pattern of calculated Baseline loading rates is consistent with the available ambient water column and sediment data.

- TMDL allocations are based on the water quality targets, so possible errors in the estimates of Baseline loads have no bearing on the TMDL allocations (only the percent reduction would change). Additional data and analysis may improve the calculation of BAFs, but the available local water column and fish tissue data clearly show that lower water column concentrations in Maryland, Virginia and the District of Columbia tidal waters are necessary to protect public health.

- The very large gap between Baseline water column concentrations and the water quality targets, especially in the metropolitan Washington region, and the levels of reductions specified by the TMDL model to reach those water column targets indicates that large reductions in PCB loads are necessary.

VI. PUBLIC PARTICIPATION

Stakeholders in this TMDL were kept informed as the study developed through the establishment of a Technical Advisory Committee (TAC) and periodic briefings of that group. Participation in TAC meetings was solicited, initially, by an announcement of the TMDL study that was broadcast via e-mail distribution lists provided by MDE, VADEQ, and DDOE of persons and organizations potentially interested in, or affected by, TMDLs in the lower Potomac watershed. From the response to this initial announcement, an e-mail distribution list was developed specifically for this TMDL and announcements of all TAC meetings and of the availability of draft documents were distributed via this list. The distribution list was revised periodically as new people indicated their interest. Six TAC meetings were held. The first meeting, on September 29, 2005, informed the TAC why a PCB TMDL was necessary, explained the intent of the jurisdictions to accomplish this TMDL as a cooperative, interstate effort, and outlined the technical approach that was planned. The last meeting, on July 17, 2007, presented the draft TMDL. Between those two meetings were four additional meetings at which the TAC was given progress reports and their feedback was solicited.

In addition to the six TAC meetings, additional briefings were provided to the Virginia Association of Municipal Wastewater Agencies and to the MWCOG Water Resources Technical Committee. The public was informed about this TMDL through two sets of public meetings. Three public meetings, one each in the District of Columbia, Maryland, and Virginia, were held in June, 2006, to explain why the TMDL was needed and the technical approach to be used to calculate the TMDL. Three additional public meetings, one in each jurisdiction, were held in July, 2007 to present the draft TDML. For both sets of public meetings, advance announcements were placed in the Virginia electronic Town Hall and District of Columbia public register, in local newspapers in Maryland, and distributed via e-mail to "TMDL interest groups" by each of the three jurisdictions and documents were placed in local libraries in Maryland and the District of Columbia.

Briefing materials for all TAC and public meetings, and drafts of documents, were posted on a public website maintained by ICPRB, http://www.potomacriver.org/water_quality/pcbtmdl.htm. Notices and links to the ICPRB webpage were posted on VA DEQ and MDE websites. The draft TMDL was distributed also on CD-ROM.

The draft TMDL was made available for public comment on July 17, 2007, with an Addendum released on August 8, and a comment period that extended to August 23, 2007. Approximately 100 comments were received from 17 organizations. These comments and the responses to those comments are published in a companion to this document, *Response-to-Comment Document for the Tidal Potomac PCB TMDL*, (Tidal Potomac PCB TMDL Steering Committee, 2007).

VII. TMDL IMPLEMENTATION AND REASONABLE ASSURANCE

It is clear that progress toward achieving the PCB loading capacity allocations described in this report will require significant reductions from atmospheric, nonpoint, and point sources of PCBs to the estuary, with an emphasis on those sources with the greatest relative impact on use impairments. While neither the Clean Water Act nor current EPA regulations direct states to develop a detailed implementation plan as part of the TMDL development and approval process, a reasonable assurance of implementation for the load allocation is required as part of the TMDL process. This section addresses the general implementation approach that the jurisdictions have agreed to and provides recommendations for future data collection in order to refine the understanding and characterization of PCB loadings to the estuary. Additionally, reasonable assurance provisions unique to each jurisdiction are also provided.

1. Adaptive Implementation Strategy

As described in Wong (2006), adaptive implementation is an iterative implementation process that makes progress toward achieving water quality goals while using new data and information to reduce uncertainty and adjust implementation activities. The focus of this approach is oriented towards increasingly efficient management and restoration and is not generally anticipated to lead to a re-opening of the TMDL, but the TMDL and allocation scenarios can be changed if warranted by new data and information.

The jurisdictions involved in the tidal Potomac PCB TMDL effort have agreed that following the adaptive implementation guidelines is appropriate due to the uncertainty associated with the TMDL loading capacity and specific allocation scheme. Therefore, the project partners intend to pursue implementation strategies that focus on additional data collection concurrently with activities to reduce PCB loadings. New data and information will be used to steer control strategies aimed to mitigate PCB loadings into the estuary and to better understand and characterize PCB loadings from key sources, such as the Chain Bridge boundary, significant tributary contributions, and atmospheric deposition.

2. Implementation of Waste Load Allocations

Following the approval of the TMDL for the tidal Anacostia and Potomac River estuary, the water quality-based effluent limitations (WQBELs) in NPDES permits that are issued, reissued or modified after the TMDL approval date must be consistent with the WLAs (CFR 2007b). EPA's NPDES regulations at 40 CFR 122.44(k) allow permits to use non-numeric, BMP-based WQBELs under certain conditions. The regulation, in subsections 3 and 4, states that BMP-based WQBELs can be used where "Numeric effluent limitations are infeasible; or [t]he practices are reasonably necessary to achieve effluent limitations and standards or to carry out the purposes and intent of the CWA."

The jurisdictions intend to use non-numeric WQBELs to comply with the WLA provisions of the TMDL because BMPs are appropriate and reasonably necessary to achieve water quality standards and to carry out the goals of the CWA for the tidal Potomac PCB TMDL. This approach will first entail additional data collection from selected NPDES permitted facilities to better characterize PCB discharges. Where warranted, non-numeric, BMPs will be implemented. These BMPs are intended to focus on PCB source tracking and elimination at the source, rather than end-of-pipe controls.

<u>Permit re-issuance after approval of the Tidal Potomac River PCB TMDL</u>
As previously referenced, non-numeric rather than numeric WQBELs can be used in NPDES permits to ensure that the permits are consistent with the WLA provisions of the TMDL. To ensure this consistency, non-storm water permits that are issued, reissued, or modified after the TMDL approval date should incorporate specific provisions for additional data collection. Permits for non-storm water discharges identified as possible significant PCB sources should include the following provisions when reissued or renewed:

- If not already available, congener specific data should be collected using the most current version of EPA Method 1668 (currently, Method 1668, Revision A), or other equivalent methods capable of providing low-detection level, congener specific results, or other methods appropriate under the circumstances which are approved in advance by the permitting authority.
- The frequency of testing, quality control requirements, and specific test conditions such as flow conditions shall be prescribed in the permit.
- Conditions or criteria warranting implementation of BMPs to locate sources of PCBs should be included in the permit.

The presentation of daily loads in Section V(4) satisfies the federal requirements to present loadings on this time scale. However, as this TMDL addresses PCB accumulation in fish and human consumption thereof over long periods of time, annual loads are more appropriate for expressing PCB loading goals. Depending on the number of samples collected and the frequency of sampling, data from non-stormwater discharges should be evaluated using appropriate scientific and regulatory procedures.

NPDES regulated stormwater permits and permits for CSO systems also may incorporate BMP based controls as described above and additional provisions described in sections specific to each jurisdiction provided below.

3. Implementation of Load Allocations

LAs are assigned to nonpoint sources, including atmospheric deposition, stormwater not regulated under the NPDES stormwater program, and tributary loadings. Tributary loadings represent boundary conditions to the tidal Potomac PCB TMDL study area (Appendix A, Figure A-2, tributary watersheds). As such, they are contained generally in the LA component of the TMDL.

Permitted facilities nested in the tributary drainage areas that require reductions will most likely require similar implementation measures as NPDES permitted sources included under the TMDL WLA. This includes implementation measures for NPDES regulated stormwater entities and wastewater treatment facilities. Three wastewater treatment facilities, the Upper Occoquan Sewage Authority (UOSA), Beltsville United States Department of Agriculture (USDA) East, and Beltsville West are located in this upstream tributary area. It is expected that in the future the permitting recommendations and guidelines outlined above will be incorporated into the NPDES permits issued for these facilities. Although explicit WLAs are not stated for these facilities, it is recognized that they have WLAs on at least the same basis as the other regulated point sources. Specific TMDL WLAs will be assigned to these facilities through future TMDL development addressing PCB fish consumption impairments either in specific tributaries or for the impaired water segments listed in this TMDL.

<u>Priorities for data collection</u> In addition to the recommendations noted for implementing the waste load allocations in Section VI(2), the Steering Committee recommends that the jurisdictions, along with the ICPRB and the EPA Region III, work together to achieve the following objectives in order to effectively pursue the adaptive implementation approach for the Potomac estuary:

- develop and implement a monitoring strategy to fill key data gaps;
- craft and implement PCB load reduction strategies; and
- develop and implement programs to monitor and report progress toward achieving both PCB load reduction and water quality goals.

Priorities for data collection to better refine PCB loading estimates to the estuary from PCB sources not governed under the NPDES permitting program, and those sources that are outside of the study area (i.e., LA) are identified below. The uncertainty associated with the Baseline PCB loadings from these sources warrants additional data collection to enhance the current understanding of PCB loadings and to help characterize the potential source(s) of the PCBs. The recommendations below are listed in order of priority, and should be implemented cooperatively by the EPA and the jurisdictions as resources allow.

- Chain Bridge. The volume of water delivered from the upstream, non-tidal Potomac watershed is substantial, rendering this the dominant source of PCBs into the estuary. Thus, it is suggested that a long term monitoring program be established at the fall line that will add to currently available data and to better characterize PCB loading trends over time. Additionally, monitoring programs should be put in place that will help to characterize the PCB contribution from upstream tributaries.

- Atmospheric Deposition and Exchange. Atmospheric loadings for the tidal Potomac River PCB TMDL were generated from the Chesapeake Bay Program Atmospheric Deposition Study published in 1999 (CBP 1999). Due to the substantial contributions estimated from atmospheric deposition and the lack of region specific data, additional sampling and analysis is recommended to better characterize deposition, volatilization, transport and fate of PCBs. It also is recommended that, since the burning of waste oils and Mineral-Oil DiElectric Fluids (MODEF) may be contributors to atmospheric PCBs, facilities which burn waste oils and/or MODEF and other potential incineration facilities be monitored to determine if they are potential sources.
- Other Tributaries and Direct Drainage: Regulated stormwater loadings from both of these source categories are governed under the NPDES program. In areas where tributary loadings and direct drainage contributions of PCBs to the estuary are significant and limited data were available, further source characterization will be necessary.
- Chesapeake Bay Downstream Boundary Conditions. The downstream boundary conditions are expected to be addressed through TMDL development for other tributaries of the Chesapeake Bay that have been listed on the 303(d) list as impaired by PCBs. Implementation of these TMDLs is expected to result in the reduction of the downstream boundary's influence on the tidal Potomac PCBs concentrations. Monitoring programs should be established to allow for a better characterization of the PCB loading trends over time.

4. Implementation and Reasonable Assurance Provision for the District of Columbia

The District of Columbia has several programs in place to control the effects of storm water runoff and promote nonpoint source pollution prevention and control. For the Anacostia watershed, the District is addressing toxics and legacy contaminant issues through the Anacostia Watershed Restoration Committee, whose goal is to coordinate efforts to improve water quality in the Anacostia Watershed. Significant resources have been spent over the last several years in identifying and characterizing toxic pollutants, including PCBs in the Anacostia and Potomac rivers. A number of steps have been taken to deal with the problem, including sediment capping pilot projects in the Anacostia River.

The DC Water and Sewer Authority (DC WASA) has established a Long Term Control Plan (LTCP) for the reduction of CSOs and the pollutant loads associated with them. The LTCP when implemented is expected to reduce the PCB loads significantly through a reduction in CSO flows. Under its MS4 NPDES permit, the District is implementing a stormwater management plan (SWMP) to control the discharge of pollutants from separate storm sewer outfalls. DC is also implementing a nonpoint source management plan through its Nonpoint Source Management and Chesapeake Bay Implementation programs.

The District has several well-established programs to draw upon, including the Erosion and Sedimentation Control Amendment Act of 1994 and DC Law 5-188 (Storm Water Management Regulations – 1988) of The District of Columbia Water Pollution Control Act of 1984, and the Federal Nonpoint Source Management Program (Section 319 of the Clean Water Act).

The District, under authority of various laws, implements a number of action plans that involve reviewing and approving construction plans for stormwater runoff control measures, erosion and sediment control measures, and landscaping; conducting routine and programmed inspections at construction sites; providing technical assistance to developers and DC residents; and conducting investigations of citizen complaints related to drainage and erosion and sediment control. In conjunction with regulatory activities, voluntary programs are implemented through the Nonpoint Source Management and Chesapeake Bay Implementation programs. It is expected that through implementation of sediment and nutrient control measures sediment-laden pollutants, including PCBs, will also be removed.

DC intends for the required reduction to be implemented in an iterative process that first addresses those sources with the largest impact to water quality, with consideration given to ease and cost of implementation. This adaptive implementation has several benefits: tracking of water quality improvements following BMP implementation through follow-up stream monitoring; providing a mechanism for developing public support through periodic updates on BMP implementation; and helping to ensure that the most cost-effective practices are implemented first.

As shown in the TMDL analysis, atmospheric deposition is a significant source of PCBs in the Potomac watershed. However, the TMDL analysis does not specifically identify the contribution of atmospheric deposition on land. The releases from unidentified land sources are accounted for in the model by the CSOs, WWTPs, stormwater, and tributary loads. Implementation of this TMDL may require further identification of potential PCB sources, including identification of air deposition fluxes and background PCBs such as PCBs in water supply that may affect PCBs reduction goals for treatment plans, CSOs, and other sources. Atmospheric deposition is expected to decrease over time since the production and use of PCBs was banned in the 1970's.

<u>Follow-up monitoring</u>
The DDOE regularly monitors the tidal Anacostia and Potomac rivers for various contaminants. Under its biological monitoring program, DDOE periodically collects and analyzes fish tissue to evaluate contaminant levels and trends. A comprehensive monitoring program has also been established under the District's MS4 permit to monitor a range of organic contaminants, including PCBs, from storm sewers. The District will continue to monitor sources of PCBs and water quality conditions to evaluate effectiveness of various implementation measures.

5. Reasonable Assurance Provision for Maryland

To attain the water quality goals presented in this document, MDE plans to use existing state and local programs. In general, MDE intends for the reductions to be implemented in an iterative process. These efforts will focus on the most critical sources as identified in section VII(3) because of the substantial differences in magnitude of the different categories of sources. In particular, as shown in the TMDL analysis, atmospheric deposition is a significant source of PCBs in the Potomac watershed. Although the TMDL analysis does not specifically quantify the contribution of atmospheric deposition on land, TMDL implementation will evaluate this significant source and its impact on point sources including regulated stormwater.

Ongoing restoration efforts

The WLA component of the TMDL will be addressed through the permitting process, which will initially focus on monitoring efforts to better estimate the point source contribution and confirm which facility loadings exceed the assigned WLA. Where necessary, monitoring requirements will be followed with pollution minimization and reduction measures that will feature best management practices for reducing runoff from urban areas, detection and termination of ongoing sources, along with other measures.

If not already available, congener specific data should be collected using the most current version of EPA Method 1668 (currently, Method 1668, Revision A), other equivalent methods capable of providing low-detection level, congener specific results, or other methods appropriate under the circumstances which are approved in advance by the permitting authority.

In establishing the necessity and extent of data collection, MDE will take into account data already available, and intake (or pass through) or other original sources of PCBs consistent with NPDES program "reasonable potential" determinations and the applicable provisions of the Environment Article and COMAR for permitted facilities including regulated stormwater.

Nonpoint sources will initially be addressed through the implementation of the existing TMDLs for sediments and nutrients throughout the Potomac watershed. Since PCBs concentrations in the water column are linked to TSS concentrations, a reduction in the sediment loads entering the tidal Anacostia and Potomac watersheds are expected to result in lower PCBs concentrations. Also, implementation of BMPs intended to reduce nutrient runoff will contribute to PCBs runoff reductions. Table 15 summarizes existing programs which are intended to help reduce the amount of runoff entering Maryland waterways.

With respect to the upstream tributary sources, MDE is in the process of drafting a monitoring plan that will help to characterize the PCB contribution from the upstream Potomac and Anacostia watersheds. The results of this monitoring effort will help to inform future implementation measures about specific ongoing sources or hotspots. Additionally, MDE has developed sediment TMDLs, which in the long term will reduce the amount of sediment runoff to the tidal Potomac and Anacostia watersheds.

Follow-up monitoring

As part of Maryland's Watershed Cycling Strategy, follow-up monitoring and assessment will be conducted to evaluate the impairment status of the tidal Potomac and Anacostia watersheds. Additionally, MDE has the responsibility to monitor and evaluate concentrations of contaminants in recreationally caught fish, shellfish, and crabs throughout Maryland, in order to determine if contaminant levels are within limits established as safe for human consumption. The fish consumption advisories currently issued by MDE are one result of the execution of this responsibility. As additional data and information are collected for the tidal Anacostia and Potomac watersheds, MDE will continue to evaluate the effectiveness of the regulatory and non-regulatory programs in achieving the water quality targets under this TMDL.

Also, MDE is in the process of gathering information to develop TMDLs for other tributaries of the Chesapeake Bay that have been identified as impaired by PCBs on the 303(d) list. Implementation of these TMDLs is expected to result in the reduction of the downstream

Table 15. Maryland Department of the Environment and Prince George's County's Watershed Restoration Activities.

Maryland Department of the Environment	1. Stormwater Management: In the 2000 Maryland Stormwater Design Manual, MDE requires 80% sediment reduction for new development. For existing development, MDE's NPDES stormwater permits require watershed assessments and restoration based on impervious surface area. Currently, Prince George's County is required to restore 10% of its impervious areas. 2. Sediment and Erosion Control Program: Some local governments have shown the ability to enforce the provisions of their ordinances relating to soil erosion and sediment control. In other cases, the State has retained enforcement responsibilities. MDE conducts periodic reviews of local programs to ensure that implementation is acceptable and it has the authority to suspend delegation and take over any program that does not meet State standards. 3. In 2000, the Maryland DNR initiated the Watershed Restoration Action Strategy (WRAS) Program as one of several new approaches to implementing water quality and habitat restoration and protection. The WRAS Program encouraged local governments to focus on priority watersheds for restoration and protection. Since the program's inception, local governments have received grants and technical assistance from DNR for 25 WRAS projects in which local people identify watershed priorities for restoration, protection, and implementation. MDE has directed the WRAS Program since January 2005. The WRAS project area in Prince George's County, Maryland totals about 86 square miles. In the WRAS, the County has identified and prioritized local restoration and protection needs associated with water quality and habitat (MDE 2005).
Prince George's County	1. Conducts regular stream assessment monitoring and MS4 monitoring for constituents including TSS. 2. Implements programs of street-sweeping, storm drain-inlet cleaning, and storm pipe cleaning in urban areas. 3. Conducting the Anacostia LID demonstration project, in partnership with the Anacostia Watershed Toxics Alliance, with $1 million in funding from a Congressional appropriation

boundary's influence on the tidal Potomac PCBs concentrations. Future monitoring programs will be focused on tracking PCBs loading trends over time.

6. Implementation and Reasonable Assurance Provisions for Virginia

The TMDL program does not impart new implementation authorities. Therefore, the Commonwealth intends to use existing programs in order to attain its water quality goals. Available programmatic options include a combination of regulatory authorities, such as the NPDES and Toxics Substances Control Act (TSCA), as well as state programs including the *Toxics Contamination Source Assessment Policy*, and the Virginia Environmental Emergency Response Fund (VEERF). The *PCB Strategy for the Commonwealth of Virginia*, published in October 2004, establishes the general strategy and outlines the regulatory framework and state initiatives that Virginia will use to address PCB impaired waterbodies. This document is available at: www.deq.virginia.gov/fishtissue/pcbstrategy.html.

These efforts will focus on the most critical sources as identified in section VII(3) above because of the substantial differences in magnitude of the different categories of sources. In particular, as shown in the TMDL analysis, atmospheric deposition is a significant source of PCBs in the Potomac watershed. Although the TMDL analysis does not specifically quantify the contribution of atmospheric deposition on land, TMDL implementation will evaluate this significant source and its impact on point sources including regulated stormwater.

In general, implementation measures for point sources and regulated stormwater are established through the NPDES permit program. Measures for nonpoint source reductions, which can include source identification and remediation are implemented in an iterative process that is described in the TMDL implementation plan.

<u>Implementation Plan development</u>
The WLA component of the TMDL is implemented through the NPDES permit program. Provisions noted in Section VII (2) should be applied to non-stormwater discharges. NPDES regulated stormwater permits and permits for CSO systems should include the following provisions when issued or renewed:

- Permittees should review the history of activities on properties under their control for historical presence or known spills of PCBs.
- Requirements for testing of selected outfalls and/or receiving streams. Testing should be performed to better characterize stormwater/CSO loadings as well as for source tracking.
- Selection of test locations should be based on a review of current and historical land use. Testing for purposes of source tracking should be based on the location of historical activities such as outside storage areas and maintenance yards that may be PCB hotspots.
- If not already available, congener specific data should be collected using the most current version of EPA Method 1668 (currently, Method 1668, Revision A), other equivalent methods capable of providing low-detection level, congener specific results, or other methods appropriate under the circumstances which are approved in advance by the permitting authority.
- The frequency of testing, quality control requirements, specific test conditions, and testing program termination shall be prescribed in the permit.
- Spill response programs should have policies and procedures to address spills when PCBs are expected to have been released.
- Permittees should develop and implement procedures based on historical activity and land use that identifies potential high-risk properties during the plan review phase for development and redevelopment projects. Potential high-risk sites should be reported to the appropriate regulatory agency for follow-up.

For the implementation of the TMDL's LA component, a TMDL implementation plan will be developed that addresses at a minimum the requirements specified in the Code of Virginia, Section 62.1-44.19.7. Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters". The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards (US EPA 1999).

In order to qualify for other funding sources, such as EPA's Section 319 grants, additional plan requirements may need to be met. The detailed process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the VADEQ and Virginia Department of Conservation and Recreation (VADCR) TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf

Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDL implementation plan. Regional and local offices of VA DEQ, VA DCR, the Virginia Department of Game and Inland Fisheries and other cooperating agencies are technical resources to assist in this endeavor. With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

On-going efforts to characterize and reduce PCB loadings

The Commonwealth of Virginia is currently developing guidance for PCB monitoring and/or data collection and analysis to characterize point source loadings in waters listed as impaired due to elevated levels of PCBs. This guidance will specify procedures for monitoring in support of TMDL development, as well as procedures for impaired waters with completed TMDLs. This guidance is scheduled to be completed in the summer of 2007. Virginia considers this guidance to be a companion document to this TMDL study.

As discussed in Section VII(2), Virginia will use non-numeric WQBELs (BMPs) to comply with the WLA provisions of the tidal Potomac River TMDL. While NPDES permits will be developed to be consistent with applicable regulations, this approach will not require specific WLA numbers in the permits. Additional PCB data will be collected from selected NPDES permitted facilities to better characterize dischargers. In establishing the necessity and extent of data collection, this approach will take into account data already available, and intake (or pass through) or other original sources of PCBs consistent with NPDES program "reasonable potential" determinations and the provisions of 9 VAC 25-31-230.G, for VPDES permitted facilities including regulated stormwater. Where warranted, development of pollutant minimization and reduction plans is recommended as the primary pollutant reduction strategy. These plans, referred to as Pollutant Minimization Plans (PMP) and "updated MS4 Program Plans" in Virginia stormwater MS4 permits, may involve identifying known and potential PCB sources, provide strategies for identifying unknown sources, note previous minimization efforts, establish pollutant minimization measures (i.e. reducing runoff from urban areas, contaminated site remediation, reducing inputs to wastewater sewer systems, etc.), establish source prioritization, and determine schedule and reporting criteria.

In 2006, the General Assembly passed legislation requiring the Secretary of Natural Resources to develop a plan for the cleanup of the Chesapeake Bay and Virginia's waters (HB 1150). This plan was completed in 2007 (Commonwealth of Virginia 2007). The plan addresses both point and non-point sources of pollution and includes measurable and attainable objectives for water cleanup, attainable strategies, a specified timeline, funding sources, and mitigation strategies. Additionally, challenges to meeting the clean up plan goals (i.e. lack of program funding, staffing needs, monitoring needs) are identified. Information regarding Virginia's Water Clean-Up Plan can be found at http://www.naturalresources.virginia.gov/Initiatives/WaterCleanupPlan/

The Chesapeake Bay Nutrient and Sediment Tributary Strategy, published in January 2005, outlines goals for reducing nutrients and sediment inputs to the Chesapeake Bay (Commonwealth of Virginia 2005). As PCBs cling to the organic carbon on sediments, efforts to meet tributary strategy sediment goals will also be beneficial to reducing PCBs, and vise-versa. Up-to-date information on this effort and others throughout Virginia can be found at the tributary strategy web site under http://www.naturalresources.virginia.gov/Initiatives/WaterQuality/.

Reductions in sediment from construction sites and development areas will also be of benefit for reducing PCBs. The Virginia Erosion and Sediment Control and Virginia Stormwater Management Programs – administered by the Department of Conservation and Recreation and delegated to local jurisdictions – provides the framework for implementing sediment reduction BMPs throughout localities. More information regarding these programs can be found at http://www.dcr.virginia.gov/soil_&_water/e&s.shtml.

Atmospheric deposition sources of PCBs can be numerous and difficult to quantify. PCBs enter the air through a variety of pathways, and the deposition of PCBs from the atmosphere to the land surface and the volatilization of PCBs from the land to the atmosphere are not well understood. Atmospheric deposition studies (recommended above) will help identify these pathways, and efforts to remediate contaminated sites will help reduce possible atmospheric contributions.

<u>Follow-up monitoring</u>

Following the development of the TMDL, VADEQ will make every effort to continue to monitor the PCB impaired waterbodies in accordance with its fish tissue, sediment, and special study monitoring programs. The objective of the Statewide Fish Tissue and Sediment Monitoring Program is to systematically assess and evaluate, using a multi-tier screening, waterbodies in Virginia in order to identify toxic contaminant(s) accumulation with the potential to adversely affect human users of the resource.

The purpose, location, parameters, frequency, and duration of the monitoring will be determined by the VADEQ staff, in cooperation with stakeholders. Whenever possible, the location of the follow-up monitoring station(s) will be in similar locations as the listing stations. At a minimum, the monitoring stations should be representative of the original impaired segments. The details of the follow-up monitoring will be outlined in the annual Fish Tissue and Sediment Monitoring Plan prepared by the VADEQ Water Quality Standards and Biological Monitoring Programs, Office of Water Quality Programs as well as the annual water monitoring plans prepared by the regional offices. Other agency personnel, watershed stakeholders, etc. may provide input on the annual water monitoring plan.

The long term monitoring of fish tissue, sediment and, as resources allow, ambient water concentrations for PCBs will be used to evaluate trends in PCB concentrations in different environmental media, better characterize PCB loadings into the estuary and identify potential PCB hotspots for remedial activity. Semi-permeable membrane devices (SPMDs) are a potential monitoring tool (see Appendix E). New information will be considered in light of the TMDL reduction goals. Recommendations may then be made, when necessary, to target implementation efforts in specific areas and continue or discontinue monitoring at follow-up stations.

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APPENDIX A

CALCULATION OF POLYCHLORINATED BIPHENYL (PCB) EXTERNAL LOADS FOR THE POTOMAC PCB MODEL

This appendix describes the methods used to estimate input loads of polychlorinated biphenyl (PCB) pollutants, flow, and particulate carbon to the Potomac PCB model, and summarizes the input load results.

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Appendix A

Calculation of Polychlorinated Biphenyl (PCB) External Loads for the Potomac PCB Model

I. INTRODUCTION

This appendix describes the data sources and methods used to compute the daily time series of external flows, and carbon and PCB loads that are inputs to the POTPCB model. Daily time series are required by the POTPCB model to perform its routines and calculate TMDL loads. The POTPCB modeling package is described elsewhere.

II. DATA SOURCES

Three principal data sources were used to develop most of the PCB load estimates: historical PCB data, new PCB samples, and regression-derived PCB data. These sources were supplemented by additional information from the literature.

1. Historical Data

Early in the TMDL process, an extensive effort was made to locate and acquire fish tissue, water column, and sediment PCB data. Sample data sets for studies performed from 1989 to 2003 were obtained from multiple government agencies and universities (Tables A-1 and A-2). As described in Section III, PCB concentrations tended to decline over time. The Steering Committee decided that for the purpose of estimating POTPCB model inputs, data would be limited to those samples collected from 1/1/2000 to the present. Data collected in studies after 2003 were subsequently acquired. Copies of the historical data may be obtained from ICPRB, and will eventually be available on the ICPRB web page, www.potomacriver.org.

2. PCB Data Collection in 2005-2007

New PCB samples were collected specifically for this TMDL in 2005-2007. Samples for input load calculations were collected from the effluent of 15 wastewater treatment plants, 26 tributary sites, and Chain Bridge near the Potomac River fall-line. The tributary samples were collected at locations close to the head of tide and were intended to represent the discharge from the entire tributary watershed. Samples were analyzed at one of three laboratories: the University of Maryland Chesapeake Biological Laboratory (CBL), Battelle Laboratory, or the Geochemical and the Environmental Research Group of Texas A&M University (GERG). All used Method 1668A or an equivalent methodology, achieving congener specific detection limits of 10 pg/liter or less (sample specific, as reported by labs).

Semi Permeable Membrane Devices (SPMD) were successfully deployed at 28 tributary and Potomac mainstem sites for 30-day periods. These devices absorb PCBs from the water column to provide a long term integrated measure of PCB concentration. They are intended to be used as a screening tool to identify waters with higher (or lower) concentrations, are used in the

Table A-1. Data sets used to examine pre 2000 and 2000-2003 PCB concentrations in Potomac estuary sediments.

STUDY	BEGIN DATE	END DATE	SOURCE	PROJECT NAME
ANS_2000	1-Sep-00	1-Sep-00	ANS-PCER; David Velinsky	Sediment Transport: Additional Chemical Analysis Study, Phase II
EMAP_1992	27-Jul-92	28-Aug-92	EMAP-Estuaries Program Level Database; downloaded from CBP toxics database	Virginia Province 1992 Sediment Chemistry Data
EMAP_1993	1-Aug-93	11-Aug-93	EMAP-Estuaries Program Level Database; downloaded from CBP toxics database	Virginian Province Sediment Chemistry Data
GMU_2000	1-Aug-00	1-Aug-00	GMU; Phil McEachern	Hydrophobic Organic Compounds in Sediments of the Potomac River Watershed
GMU_2001	13-May-01	13-May-01	George Mason University; Greg Foster provided data from a Masters project	Sediment Chemistry in DC Waters: Master's Project
ICPRB_1989	11-Oct-89	11-Oct-89	ICPRB & LimnoTech, downloaded from CBP toxics database	Sediment Survey of Priority Pollutants in the District of Columbia Waters
NCA_ROUTINE	1-Jan-01	3-Mar-04	VADEQ Mark Richards	National Coastal Assessment Program
NOAA_1999	26-Aug-99	6-Sep-99	NOAA; downloaded from CBP toxics database	1999 NOAA Sediment Chemistry
QUAN_2002	25-Sep-02	1-Oct-02	Quantico Marine Corps Combat Development Command (MCCDC); Kristen Stein	Final Quantico Watershed Post IRA Study
USEPA_1999	25-Oct-99	25-Oct-99	USEPA; downloaded from CBP toxics database	Methods for the determination of chemical substances in marine and estuarine environmental samples
USEPA_USGS_1997	15-Sep-97	15-Sep-97	USEPA/USGS; downloaded from CBP toxics database	Mid-Atlantic Integrated Assessment 1997 Chesapeake Bay Sediment Data
VADEQ_ROUTINE	4-Jun-96	26-Sep-01	VADEQ Mark Richards	Routine tributary sediment samples

Table A-2. Data sets used to examine pre 2000 and 2000-2003 PCB concentrations in Potomac estuary bottom feeding fish (carp, catfish, eel).

STUDY	BEGIN DATE	END DATE	SOURCE	PROJECT NAME
EPA_1998	24-Jul-98	27-Jul-98	CBP Toxics Database and also at EPA: http://www.epa.gov/emap/maia/html/data/estuary/9798/	MAIA Estuaries 1998 Fish Tissue Data
FWS_2000	2-Nov-00	3-Nov-00	FWS Fred Pinkney Publication No. CBFO-C01-01	Analysis of Contaminant Concentrations in Fish Tissue Collected from the Water of the District of Columbia
ICPRB_1992	1-Jan-89	1-Jan-93	ICPRB David Velinsky Report # 94-1	Distribution of Chemical Contaminants in Wild Fish Species in Washington D.C. 1989-1992
ICPRB_1995	1-Jan-93	1-Jan-95	ICPRB David Velinsky Report # 96-1	Distribution of Chemical Contaminants in 1993-95 Wild Fish Species in the District of Columbia
MDE_ROUTINE	8-Feb-99	29-Oct-03	CBL Joel Baker	Maryland Department of the Environment Fish Tissue Monitoring Program: 1999 - 2004
NOAA_ROUTINE	30-Jun-89	9-Jan-97	CBP Toxics Database	NOAA National Status and Trends Program Mussel Watch Project Data, 1994-1997
VADEQ_ROUTINE	4-Jun-96	26-Sep-01	VADEQ Mark Richards	VA DEQ Routine Tributary Sampling: 1996, 2000, 2001

Virginia 305(b) process, and can be the basis for 303(d) impairment listings of Water Quality Limited Segments (WQLSs). The SPMD data were not directly used for PCB load estimates because the technique still requires refinement. A comparison between SPMD data, fish tissue concentrations, and the CBP watershed model (WM5) load estimates is presented in Appendix E.

Figures A-1A through A-1D show the locations where the 2005-2006 samples were collected. Sample results are available from ICPRB, currently by request and eventually directly from the ICPRB website, www.potomacriver.org.

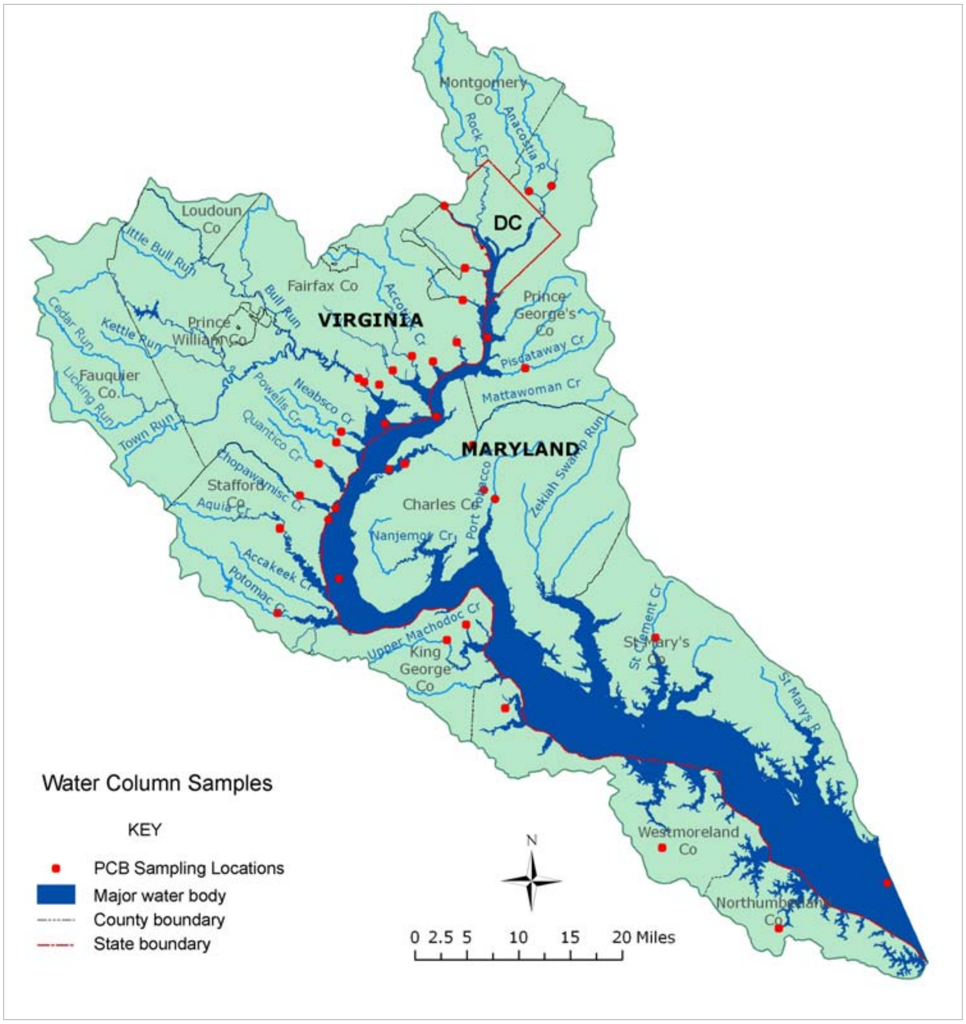
3. Regression-Derived PCB Data

The POTPCB model built by LimnoTech (LTI) requires daily input values for flow, PCBs, and carbon from the non-tidal Potomac River at the head of the estuary and all the direct drainage areas and tributaries in the lower Potomac watershed. The U. S. Geological Survey (USGS) maintains stream gages at Little Falls, which is essentially the end of the non-tidal river, and at a few of the other tributaries entering the estuary. There are only scattered observations of PCBs and carbon in tributaries from which daily loads are needed. For the purpose of developing a tidal Potomac PCB TMDL, the Chesapeake Bay Watershed Model version 5 (WM5) was used to provide daily flows and generate daily estimates of carbon and PCBs loads from all tributaries and direct drainage areas in the lower Potomac watershed. For the non-tidal river, USGS Little Falls data provided daily flows and the Loadest program regression model 9 was used to generate daily PCB and carbon loads. Loads were generated by applying PCB and carbon regressions with total suspended solids (TSS) to daily times series of TSS concentration predicted by the WM5 and Loadest models.

The Chesapeake Bay Watershed Model (WM5)

The advantages of using the WM5 are that the model is already built, has undergone extensive peer review, and has significant staff support from the Chesapeake Bay Program (CBP) to assist in interpretation of model results (US EPA, 2005; US EPA 2006a; US EPA 2006b). There are also certain constraints imposed by the WM5. These include the quality of the model calibrations and the characterization of the watershed. WM5 provides estimates of daily flow and constituent loads from tributaries and direct drainage watershed segments. All point and nonpoint source flows and loads in a tributary watershed are delivered to a stream reach with a direct link to a single Chesapeake Hydrodynamic Model (CH3D) cell. There are 17 tributaries defined by WM5 in the lower Potomac watershed, plus the Potomac River at Chain Bridge, which is the input point for all of the Potomac basin above Washington, DC. The 17 tributary watersheds comprise 1,036 sq. mi. (about 44%) of lower Potomac watershed area, while the watershed above Chain Bridge is 11,560 sq. mi, or almost five times the size of the lower Potomac watershed. Flow and loads from direct drainage segments are considered to come from nonpoint sources, even though the segments include smaller tributaries. Direct drainage flows and loads are proportionally allocated to adjacent CH3D model cells by drainage area. Point sources in the direct drainage segments are not included in the WM5 and their contribution to the tidal model is a separate input. The WM5 has 49 direct drainage segments that are further subdivided by county jurisdiction, which allows nonpoint source loads to be allocated by political subdivision. These segments account for 1,308 sq. miles (55%) of the lower Potomac watershed. An additional WM5 segment is defined for that portion of the District of Columbia served by

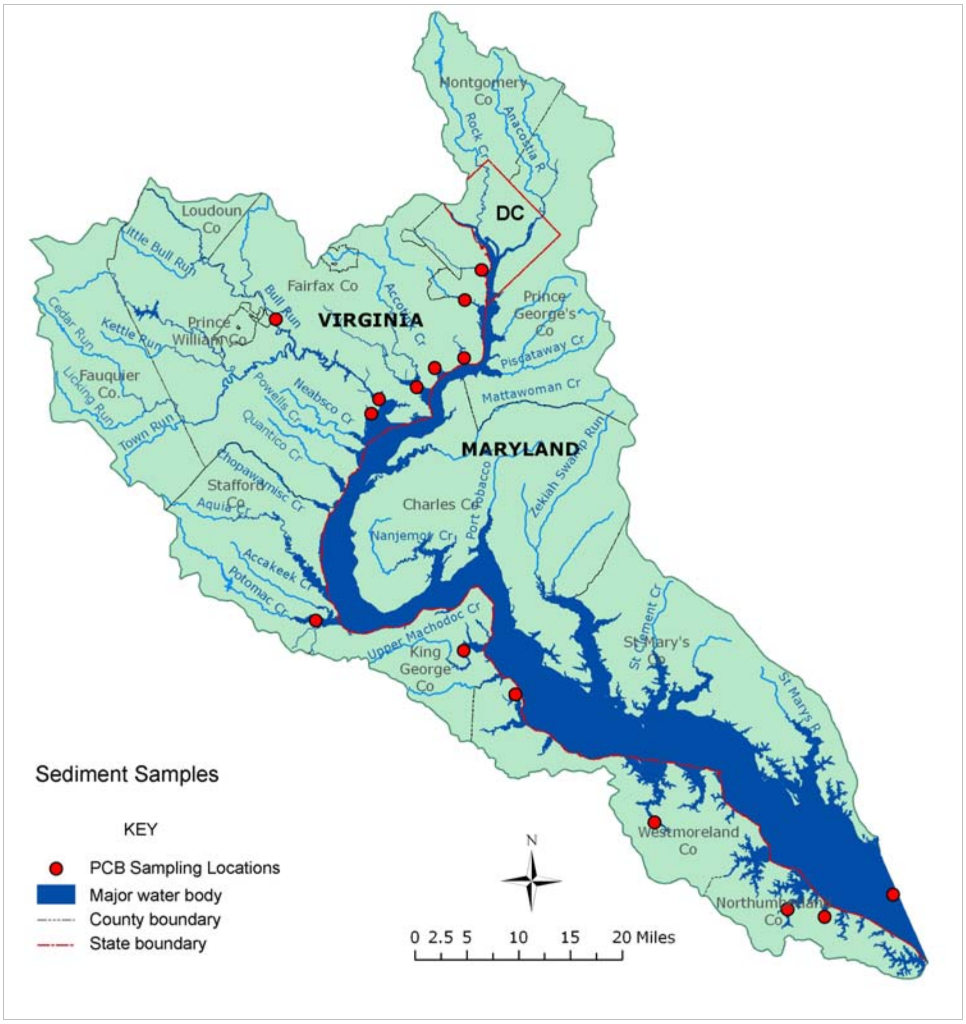
Figure A-1A. PCB Sampling locations for water column samples collected in 2005-2006. Specific locations and sample analysis results are available from ICPRB.



combined sewers. In the WM5 framework, all runoff from this segment is assumed to reach the Potomac and Anacostia rivers via the combined sewer overflow (CSO) system, and is therefore counted as a CSO input (see below). Table A-3 lists the tributaries and Figure A-2 provides a spatial reference.

Using the WM5 model for organizing point and nonpoint loads for the Potomac PCB TMDL defines what areas are considered nonpoint source direct drainage to tidal waters versus upland tributaries. The effluent from all point sources located in direct drainage segments is considered to be delivered directly to the tidal model with no dilution or instream processes prior to delivery. Similarly, nonpoint source flow in direct drainage segments is delivered to the tidal model with no instream processes. The flow and constituent loads delivered to the tidal model from upland tributaries represents the combined contribution of point and nonpoint sources as well as instream processes in tributary stream reaches.

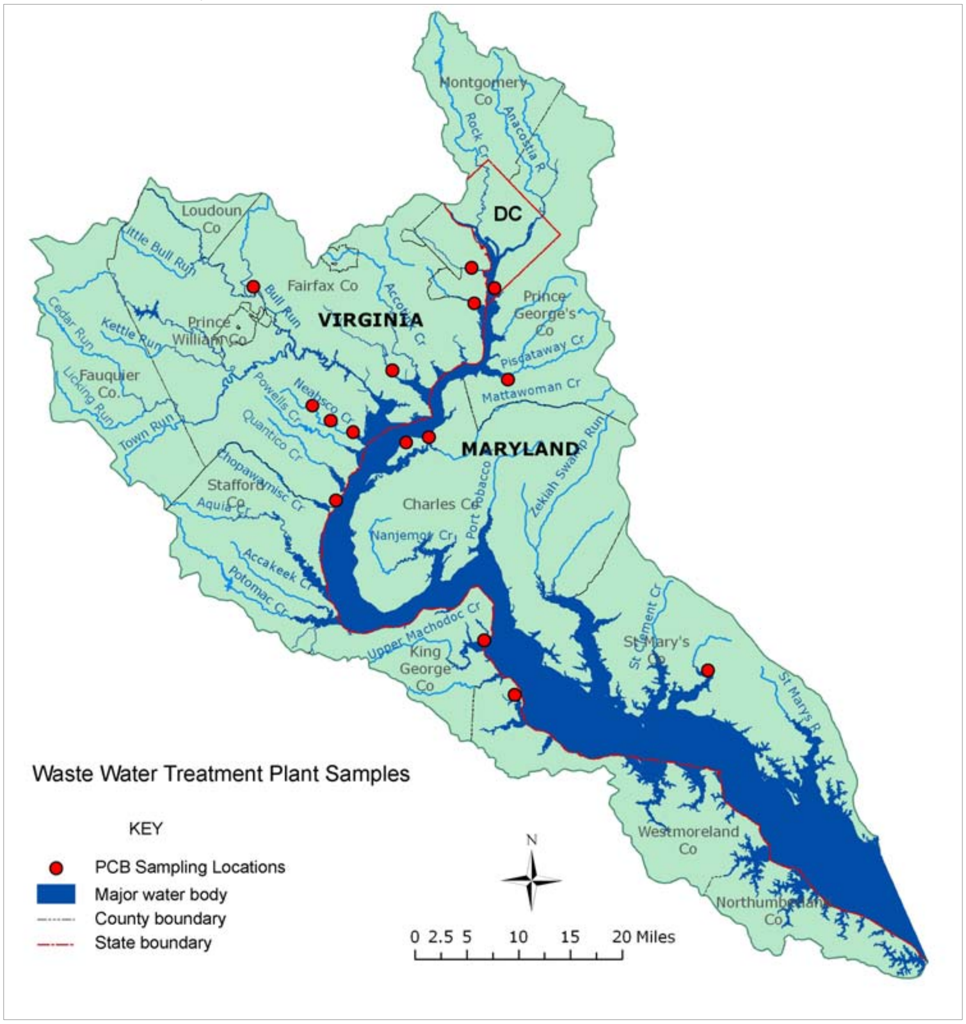
Figure A-1B. PCB sampling locations for bed sediment samples collected in 2005-2006. Specific locations and sample analysis results are available from ICPRB.



<u>Loadest Model</u>

Daily freshwater flows observed at the USGS Little Falls gaging station (01646500) and predicted by the WM5 for the Potomac River at nearby Chain Bridge are mismatched, even though seasonal or annual sums can match up fairly well. The explanation for this is that the WM5 is designed and calibrated to simulate the distribution of daily flows from tributaries but predicted and observed flows may not match on a day to day basis. For annual load estimation purposes, getting the distribution of daily flows "right" is important but the individual daily flows do not matter as much. For the purpose of calibrating the POTPCB model to observed data in the upper tidal Potomac, however, getting a good simulation of flow and PCB load at Chain Bridge on a daily basis is important. The mismatch at Chain Bridge is a timing problem that makes it difficult to calibrate the PCB model to observed data in the DC portion of the Potomac River. Several alternative approaches for generating daily flow and TSS load time series to the most upstream cell of the POTPCB model (96) were examined by ICPRB. The Loadest Model 9 (Runkel et al, 2004) regression model, predicting TSS based on flow, provided the best fit to observed data.

Figure A-1C. PCB Sampling locations for waste water treatment facilities collected in 2006. Some of these samples were collected by cooperating facilities and the results made available to the states for this project. Specific locations and sample analysis results are available from ICPRB.

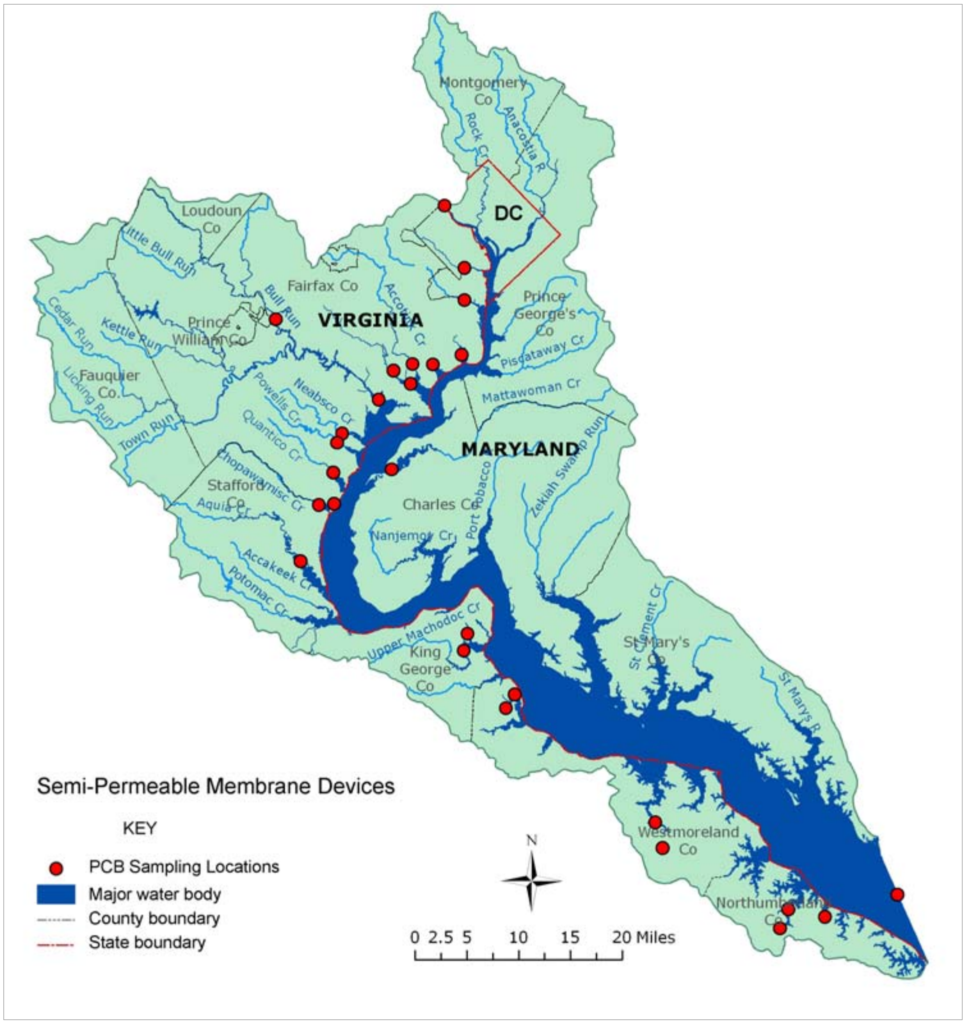


The Loadest regression model was not an option for other tributaries because the TSS and flow data required for Loadest are not available and, furthermore, the flow volumes from the other tributaries are small enough relative to the volume of water in the tidal receiving waters that potential mismatches between WM5 simulated flow and actual flow should not have a significant impact on predicted PCB concentration.

III. ANALYSIS OF PCB DATA

An examination of PCB data sets collected by multiple agencies between 1989 and 2003 (Tables A-1 and A-2) revealed a lack of consistency in the congeners analyzed, and some areas were more extensively sampled than others. To provide fair comparisons between data sets, a set of common congeners (i.e., reported in most or all studies) was identified and initial analysis of the historical data was restricted to those congeners. The Anacostia River and tidal fresh Potomac

Figure A-1D. PCB Sampling Locations for Semi Permeable Membrane Devices (SPMDs) collected in 2006. Specific locations and sample analysis results are available from ICPRB.



River near Washington, D.C., were sampled more heavily than downstream regions, so the data were grouped by zones based on geographic region and salinity to avoid biasing the results.

1. Pre and Post 1999 PCB Samples and Geographic Zones

As a quick test of trends over time (i.e., "are older data sets comparable to more recent data?"), the historical data were split into two pools, 1989-1999 and 2000-2003, and mean concentrations in the two pools compared. Congeners common to all data sets (i.e., analyzed by all laboratories) were identified and the analysis was done on those data. The analysis focused on PCB concentrations in sediments and filets of bottom oriented fish (carp, catfish, eel) because concentrations in these fish species exceeded the guidelines for unrestricted human consumption in each jurisdiction, causing the affected jurisdictional WQLSs to be listed as impaired. Concentrations in bottom sediments declined 64% and 20% in the Anacostia River and tidal fresh Potomac River, respectively (Figure A-3A). However, they were 949% higher in the

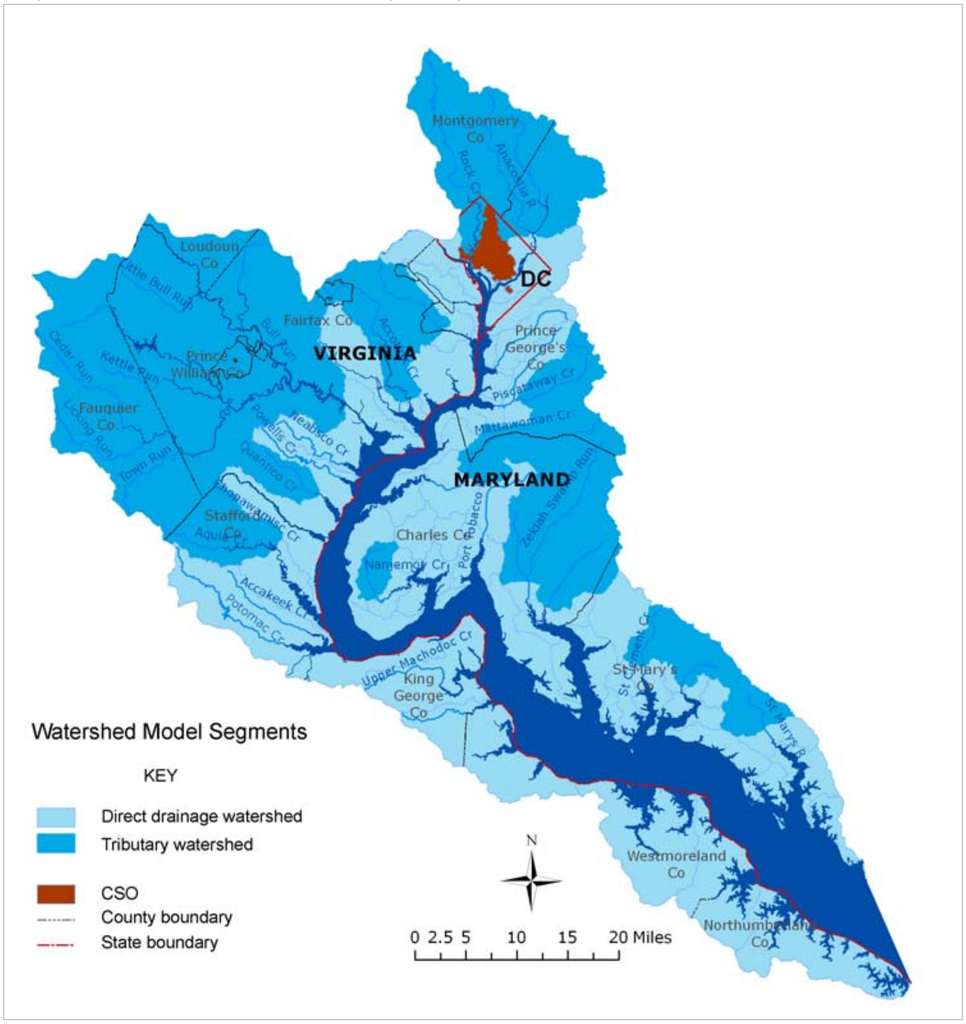
Table A-3. Tributary segments in the Chesapeake Watershed Model. WM5 river segment ID: "PL" designates the lower Potomac River watersheds; the middle four digits are a unique watershed identifier; the last four digits indicate whether the watershed drains directly into the Potomac River estuary (0000) or drains to a tributary of the Potomac (0001).

Tributary Name	WM5 riverseg ID	Area (sq. mi.)
NW Br Anacostia	PL0_4510_0001	51.9
NE Br Anacostia	PL1_4540_0001	74.7
Rock Cr	PL1_4780_0001	70.3
Upper Hunting Creek	PL0_5000_0001	34.6
Upper Piscataway	PL0_5070_0001	38.6
Accotink Cr	PL1_5130_0001	50.3
Mattawoman Creek	PL1_5230_0001	54.9
Occoquan River	PL0_5250_0001	354.1
Quantico Cr	PL0_5490_0001	27.0
Trib to Upper Wicomico Bay	PL0_5510_0001	42.1
Middle Zekiah Swamp Run	PL2_5630_0001	86.5
Aquia Cr Bay	PL1_5690_0001	50.7
Trib. To Zekiah Swamp Run	PL0_5710_0001	14.7
Nanjemoy Creek	PL0_5720_0001	15.0
St Clements Cr	PL0_5750_0001	18.0
Upper McIntosh Run	PL0_5830_0001	28.7
St Marys River	PL1_5910_0001	24.1
Total area of tributaries excl. Potomac River		1,036.2
Potomac R. at Chain Br.	PM7_4820_0001	11,560.0

oligohaline zone and 95% higher in the mesohaline zone of the Potomac (Figure A-3B). Fish tissue PCB concentrations declined 53%-66% in the 2000-2003 period in all geographic zones monitored. Based on this analysis, and considering the differences in the methods used to analyze the historical samples, the Steering Committee decided in March 2006 that the most recent, least variable, and most accurate estimates of PCB concentrations from source areas presently in the estuary would be obtained by using data collected in or after 2000.

The decline in PCB concentrations with distance downstream evident in the pre/post 1999 analysis of fish tissue and sediment samples prompted a more detailed analysis of total PCB concentrations in the water column (2002-2006) and sediments (2000-2005) of the tidal tributaries and mainstem of the Potomac and Anacostia rivers. A longitudinal gradient was observed in water column PCB concentrations from the District of Columbia to the mouth of the Potomac River estuary (Figure A-4A). Concentrations were highest in the District tributaries to the tidal Anacostia River, and declined in tributaries near the District (i.e., Potomac River at Chain Bridge, Northeast and Northwest Branches of the Anacostia River, Virginia tributaries of fairly consistent in Potomac tributaries and mainstem outside of an approximately 40 kilometer radius around the District, except for a few "hotspots." These findings are consistent with those the Potomac in the Washington metro area). Water column PCB concentrations were low and of

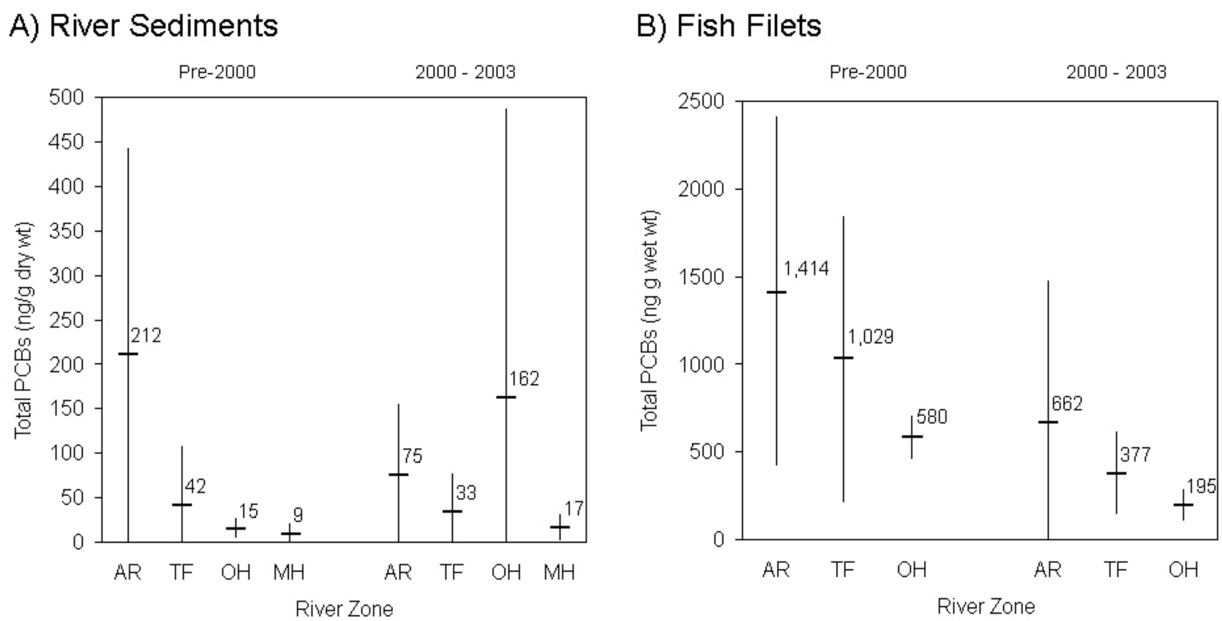
Figure A-2. Tributary, direct drainage, and combined sewer overflow (CSO) watershed segments contributing to the tidal Potomac River in the Chesapeake Bay Watershed Model, Phase 5 (WM5).



other investigators (Velinsky 2006). As might be expected, water column PCB concentration is also correlated with the percent of area classified as urban in the watershed (log-log, $r^2 = 0.36$, $p<0.01$), but the relationship with simple distance is stronger (polynomial, $r^2 = 0.69$, $p<<0.001$). Sediment PCB concentrations also exhibit a longitudinal gradient, with highest concentrations in the Anacostia River estuary (Figure A-4B). Unlike the water column PCBs, total PCB concentrations in sediments remained high for about 100 km downstream of the District, and only began to decline as the river approached Chesapeake Bay. The juxtaposition of the water and sediment patterns suggest a PCB legacy in sediments that is gradually moving downstream.

Based on these results, the Steering Committee decided the least variable and most accurate estimates of PCB concentrations entering the tidal Potomac River via tributaries and direct drainage would be obtained by grouping the data in river zones. Three watershed-based zones characterized by different PCB burdens and PCB-TSS relationships (see below) in the water column were established to estimate daily tributary and direct drainage loads within each zone

Figure A-3A and B. Change in observed PCB concentrations, before and after 2000. Concentrations of 24 PCB congeners common to all laboratory analysis methods were identified in data for estuarine sediments (A) and filets of carp, catfish, and eel (B), and grouped by by river zone. Statistics: minimum, average (value shown), and maximum. Values have been rounded to the nearest whole number. River zone: AR, Anacostia River; TF, tidal fresh Potomac River; OH, oligohaline Potomac River; MH, mesohaline Potomac River.



for the POTPCB model. The zones reflect the longitudinal gradient seen in water column PCBs. The zones are "DC Urban," "Near DC," and "Else." Figure A-5 shows the zone assignments by sub-watershed and tributary as of June 2007. These zone assignments have been updated as additional PCB and TSS data become available.

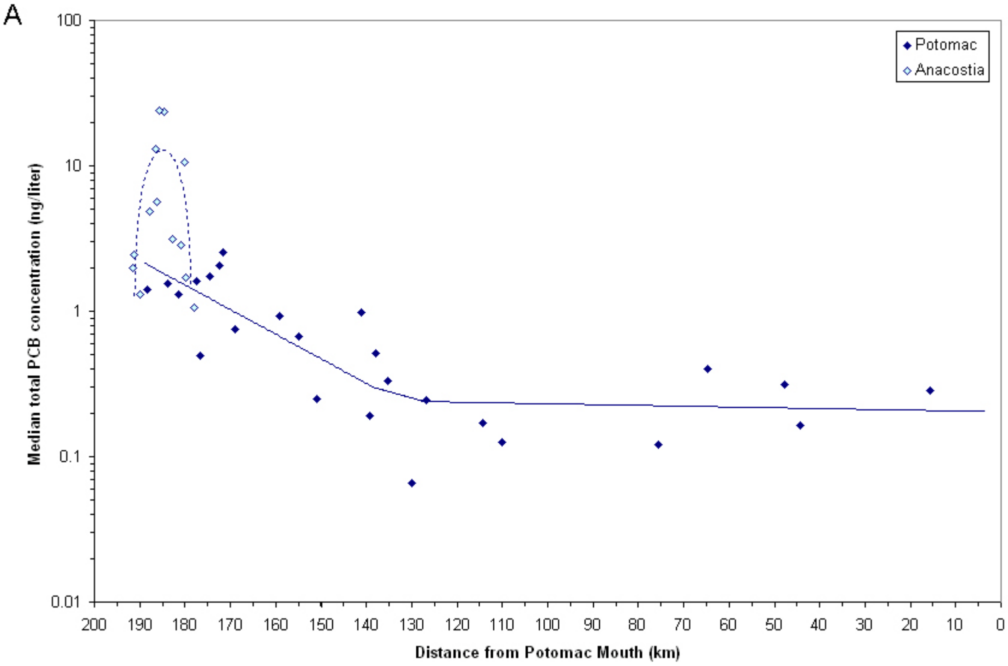
2. Characteristics of Potomac PCB Sources and Choice of PCB3+ as Parameter to Model in POTPCB

The 10 homologs of PCBs, defined by the number of chlorine atoms attached to the biphenyl carbon rings, have different chemical properties and respond differently to environmental conditions. Model based predictions of fate and transport are more accurate and efficient if a limited number of homologs is modeled and those results extrapolated to total PCBs. The choice of which PCB homolog(s) to model must be weighed against the distribution of PCB homologs in the river, and particularly the media that are listed as impaired. In the Potomac estuary, the dominant PCB homologs in the water column and in the tissue of bottom feeding fish are largely responsible for the 303d listing for total PCBs. Hypothetically, these homologs are the best choice for model parameter.

PCB TMDLs based on homolog-specific models have been developed for several locations in the United States, including the Delaware River estuary (DRBC 2003a, b). Pentachlorobiphenyls (penta-PCB) were selected as the model parameter for the Delaware PCB TMDL. Monitoring data at the time suggested penta-PCBs were the dominant homolog in fish tissue, and ambient

Figure A-4A and B. Change in median total PCB concentration with river length. Water column (A) and sediment (B) concentrations in the tidal tributaries and mainstem of the Potomac (◆) and Anacostia (◆) rivers are arranged according to distance from the Potomac mouth. Free-hand trends are shown (Anacostia, dashed line; Potomac; solid line). The District of Columbia downstream boundary is at 169 km. Total PCB (y-axis) is on a log scale. Note: Total PCB data analyzed by CBL were not included in this analysis due to unresolved problems with homolog 1 and 2 measurements (see text for details).

A



B

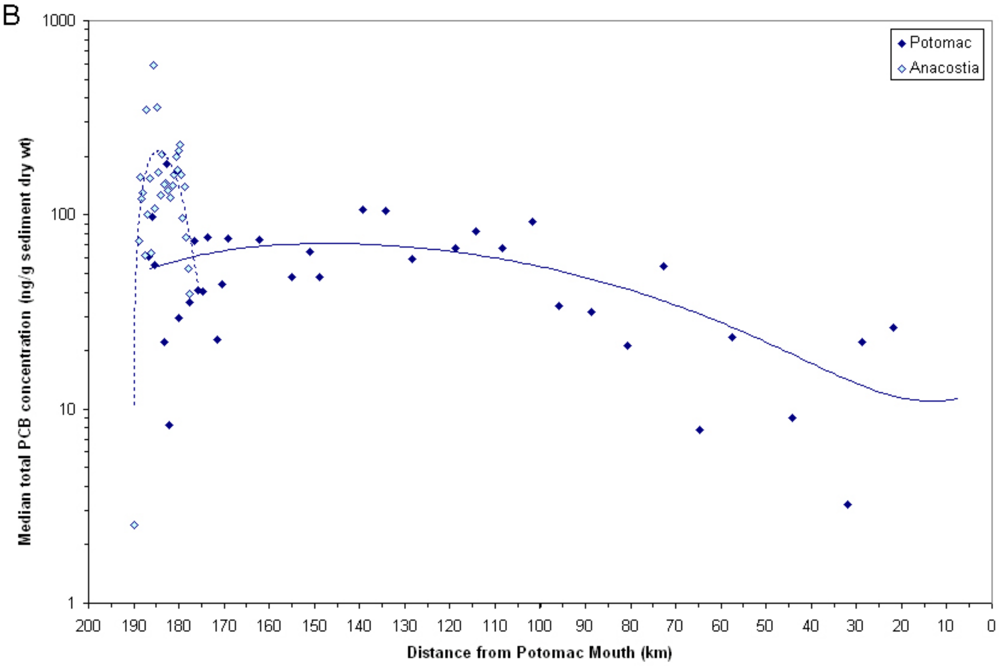
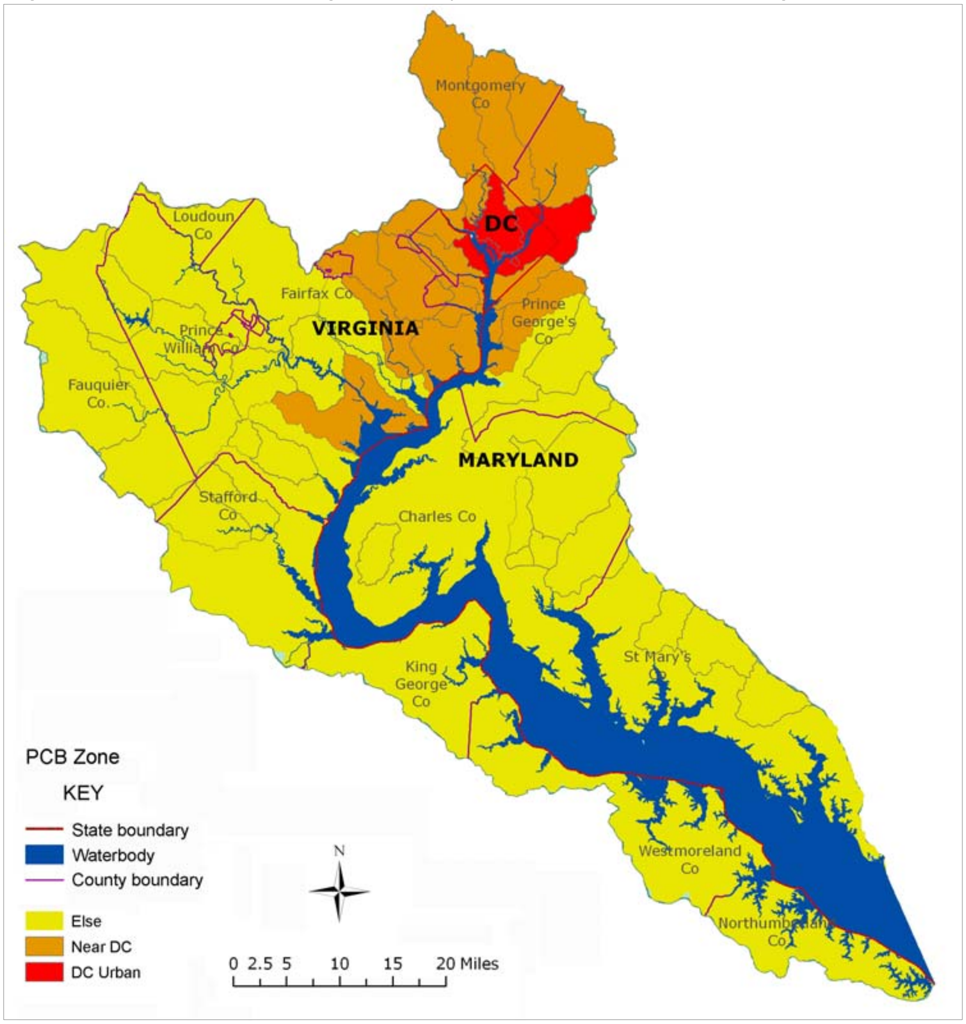


Figure A-5. PCB-zone assignments by WM5 model watershed segment.



data indicated that throughout the estuary this homolog represents approximately 25 percent of the total PCBs present (DRBC 2003a). The Delaware River Basin Commission and LTI developed and calibrated a water quality model based on PCB homolog 5 and used it to extrapolate to total PCBs. This effort was the basis of the Delaware estuary's Stage 1 PCB TMDL (DRBC 2003b).

PCB homolog distributions in different media in the 2000-2006 Potomac River estuary data were analyzed to identify the best homolog for the POTPCB model parameter. Mono- and dichlorobiphenyls (mono-PCB, di-PCB) were excluded from this analysis because one data set (George Mason University) did not include complete measurements for these two homologs and another data set (Chesapeake Biological Laboratory) produced unusually high measurements of these two homologs (see also Appendix B).

The mix of the remaining seven PCB homologs in the Potomac appears to be more complex than in the Delaware. Earlier work by area researchers indicates that significant variability occurs in the homolog distributions. Minor and major congener peaks are frequently found in homologs 1, 4, 5, 6, 7, and 8 (Baker 2006). Comparisons of homolog distributions show an overall peak at homolog 4 in the dissolved and particulate fractions of tidal waters, at homolog 5 and 6 in bottom sediments, and at 6 in fish filets. Peak homologs in tidal waters of the individual tributaries range from 2 to 8 (see also Appendix B).

After considering the varied distributions of PCB homologs in bottom feeding fish, their habitats, and the tributary sources of PCBs to the Potomac estuary, the Steering Committee decided to develop the TMDL model specific to homologs 3-10 rather than just one or two homologs. PCB3+ is more inclusive of all contaminant sources, and the broader congener distribution provides a larger target for the TMDL. Modeling PCB3+ will eventually facilitate reduction strategies among the various source categories, and will minimize concerns about homolog variability at different sites. Finally, it minimizes any potential disconnect between PCB sources and observed ambient data. The decision to model PCB3+ and the approach used to translate model PCB3+ output back to total PCBs is described in more detail in Appendix B.

3. Estimating PCB3+ from Total Suspended Solids Concentration

Estimates of daily PCB loads from each Potomac estuary tributary and direct drainage watershed are needed in the POTPCB Model. Daily PCB loads are not available in any watershed, so an analysis was done to find relationships between PCB concentration and another parameter for which daily values are available from models. PCBs tend to bind to organic particles in suspended sediments. Hence, they are often associated with total organic carbon (TOC), particulate organic carbon (PC), or total suspended solids (TSS), all of which are modeled parameters in the WM5 (TSS is the sum of the model parameters sand, silt, clay and algae). Samples collected at tributary stations near head-of-tide and at Chain Bridge (Potomac River fall-line) were used to derive regressions between total PCB and these water quality parameters. After considering data availability and the WM5 performance in modeling each of the water quality parameters, a set of monitoring-based regressions with TSS was selected and applied to WM5 output data to calculate the needed daily PCB loads from the watershed.

For the analysis, water column samples collected during both base and wet flow conditions between April 2002 and February 2005, and analyzed for PCBs by George Mason University (GMU), Chesapeake Biological Laboratory (CBL), the Academy of Natural Sciences (ANS), and the Geochemical and Environmental Research Group of Texas A&M University (GERG), were used to explore relationships between total PCB and four water quality parameters: PC, dissolved organic carbon (DOC), TOC, and TSS. Relationships between particulate and dissolved PCB fractions and the water quality parameters were also explored where possible. In Fall 2006 when the analysis was done, a total of 81 paired PCB and water quality samples were available for Maryland tributaries to the tidal Anacostia River, 24 for District of Columbia tributaries to the Anacostia River (Hickey Run, Lower Beaverdam Creek, Watts Branch), 12 for multiple Virginia tributaries to the Potomac River, and 6 for the Potomac River at Chain Bridge. The data were grouped and analyzed by laboratory and location in order to minimize possible sources of variance. Total and particulate PCB correlated significantly ($p<0.05$) and strongly (r^2 0.24-0.86) with TSS, TOC, and PC, but did not correlate with DOC. Dissolved PCB did not correlate strongly with any of the water quality parameters (Table A-4). These results confirm the affinity of PCBs for suspended solids, and particularly organic particles.

The possibility of using regressions with flow instead of TSS or carbon to estimate watershed PCB loads was also explored. PCB concentration correlates with flow because TSS concentration correlates with flow. Flow-based and TSS-based estimates of PCB concentrations were compared with observed PCB concentrations. Flow is monitored near PCB sample locations at gaging stations located on the Northeast and Northwest branches of the Anacostia River, Watts Branch, and the Potomac River at Chain Bridge. USGS daily flow data for these gages were downloaded (http://waterdata.usgs.gov/md/nwis/current/?type=flow) and matched to the corresponding PCB samples. TSS-based estimates of PCB concentrations outperformed flow-based estimates in comparisons with observed PCB concentrations for the Northeast and Northwest Anacostia branches and Watts Branch. TSS-based and flow-based estimates of PCB proved to be comparable at Chain Bridge, although only six data points were available (Figure A-6). Multiple linear regressions of the Anacostia data show that TSS (mg/liter) is a better predictor of total PCB (ng/liter) than flow (cfs) in this tributary, and the predictive ability of flow is not significant ($p<0.05$) after adjusting for TSS (Table A-5).

Table A-4. The regression coefficient (r^2) and statistical significance of log-log regressions between dissolved (Diss.), particulate (Part.) and total PCB, in pg/liter, and the water quality parameters dissolved organic carbon (DOC), particulate carbon (PC), total organic carbon (TOC), and total suspended solids/particles (TSS), in mg/liter (**, $p<0.01$; *, $p<0.05$, ns, $p\geq0.05$; –, no data). Sample size indicated in parentheses (zero values or blanks removed from analysis). Laboratories: GMU, George Mason University (Dr. Greg Foster); ANS, Academy of Natural Sciences in Philadelphia (Dr. David Velinsky); CBL, Chesapeake Biological Laboratory (Dr. Joel Baker); GERG, Geochemical and Environmental Research Group at Texas A&M University (Dr. Terry Wade). Sampling locations: Northeast Branch of the Anacostia River, MD; Northwest Branch of the Anacostia River, MD; District of Columbia tributaries to the Anacostia River, DC; Potomac River at Chain Bridge; Virginia tributaries to the Potomac River >20 km away from Washington, DC.

Relationship	GMU Anacostia NE-NW Br.	GMU Anacostia DC	ANS Anacostia NE-NW Br.	CBL Potomac @ CB	GERG "Far" VA tribs
Diss. PCB - DOC	--	--	ns (24)	--	--
Diss. PCB - PC	--	--	ns (25)	ns (6)	--
Diss. PCB - TOC	--	--	ns (24)	--	--
Diss. PCB - TSS	0.14 ** (50)	0.19 * (24)	ns (25)	ns (6)	--
Part. PCB - DOC	--	--	ns (22)	--	--
Part. PCB - PC	--	--	0.7 ** (23)	0.81 * (6)	--
Part. PCB - TOC	--	--	0.70 ** (22)	--	--
Part. PCB - TSS	0.59 ** (54)	0.46 ** (23)	0.83 ** (23)	0.86 ** (6)	--
Total PCB - DOC	--	--	ns (24)	--	0.40 * (11)
Total PCB - PC	--	--	0.24 ** (25)	0.69 * (6)	--
Total PCB - TOC	--	--	0.24 * (24)	--	0.45 * (12)
Total PCB - TSS	0.51 ** (56)	0.63 ** (24)	0.32 ** (25)	0.78 * (6)	0.35 * (12)

Table A-5. Analysis of variance for the multiple linear regression models predicting total PCB concentration from TSS and flow in the NE and NW branches of the Anacostia River. PCB, ng/liter; TSS, mg/liter; flow, cubic feet per sec. Terms added sequentially (first to last).

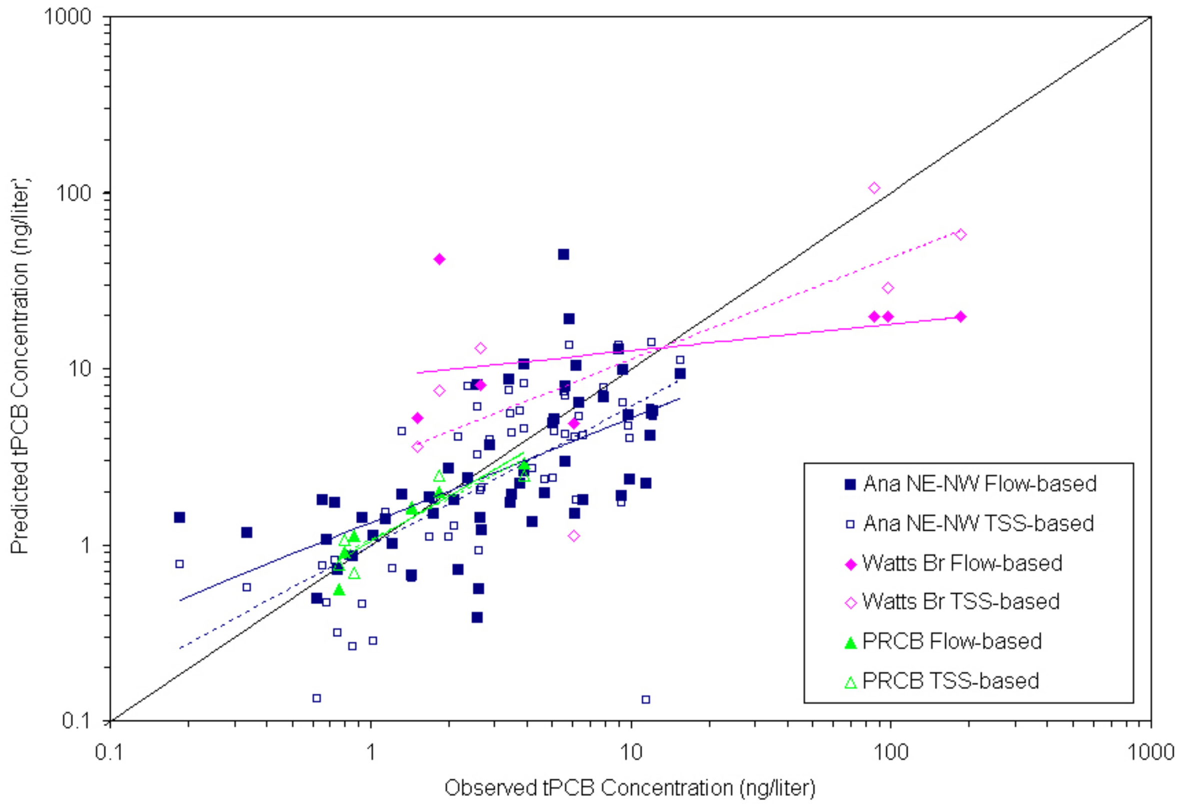
	df	Sum of Sq	Mean Sq	F Value	Pr(F)	
Model (1): PCB = f (TSS, flow)						
TSS	1	206.2165	206.2165	21.40966	<0.0001	highly significant
Flow	1	21.3698	21.3698	2.21864	0.142	not significant
Residuals	53	510.4926	9.6319			
Model (2): log PCB = f (log TSS, log flow)						
log TSS	1	14.19510	14.19510	57.80973	<0.0001	highly significant
log Flow	1	0.38713	0.38713	1.57658	0.215	not significant
Residuals	53	13.01408	0.24555			

The Steering Committee decided to use TSS instead of carbon or flow as a predictor of PCB in lower basin tributaries and direct drainage areas. There are more PCB-TSS data pairs (123 in four geographic zones) than PCB-carbon data pairs (31 particulate carbon or 36 total organic carbon in two zones) from which to build regressions, and the TSS simulation in the WM5 is currently better calibrated than the organic carbon simulation (US EPA, 2006c).

Lower Potomac Basin Tributaries and Direct Drainage Areas

TSS:PCB3+ regressions were generated after the Steering Committee decision to use PCB3+ as the POTPCB model variable. Analysis results indicated the TSS:PCB3+ relationships vary by location. Samples from the District of Columbia had the highest, steepest regression slopes, while samples from most Virginia tributaries located more than 20 km from the District had the lowest, shallowest regression slopes (Giles Run was an exception). After careful examination of the available data, a unique TSS:PCB3+ regression was developed to identify and characterized each of three geographic zones–DC Urban, Near DC, and Else–in late 2006 (Figure A-5). The DC Urban regression is applied to TSS concentrations in two direct drainage watershed segments in and near Washington, DC: PL2_4810_0000, which borders the tidal Anacostia River, and PL7_4940_0000, which borders the Washington Shipping Channel and the Potomac River between Rock Creek and the Anacostia River. The CSO segment in Washington, DC also was assigned to the DC Urban zone. The Near DC regression is currently applied to TSS concentrations in 12 direct drainage watershed segments and tributaries, most of which are within 20 km of Washington, DC: PL0_4510_0001, PL1_4540_0001, PL1_4780_0001, PL7_4910_0000, PL7_4960_0000, PL0_4961_0000, PL7_4980_0000, PL0_5000_0001, PLO_5010_5130, PL0_5090_0000, PL1_5130_0001, PL0_5251_0000. The Else regression is applied to TSS concentrations originating from all other tributaries and direct drainage watershed segments. As more data are collected, watershed segment designations can be updated and the PCB zones changed. A power function, or $y = a \cdot m^b$, accounts for most of the variability in the data (highest r^2). The three geographic zones show distinctly different, non-overlapping regression slopes (Figure A-7). The regressions equations are:

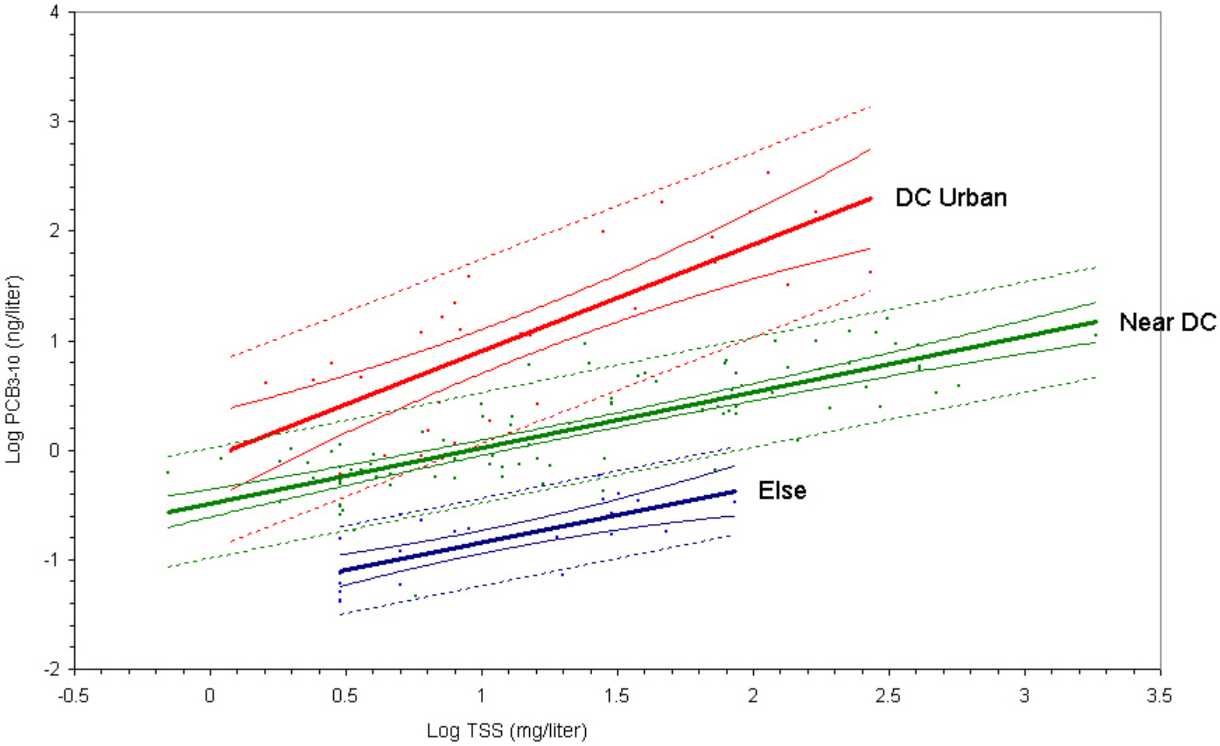
Figure A-6. Comparison of observed total PCB (tPCB) concentrations and predicted concentrations derived from TSS-based and flow-based regressions, for the Anacostia Northeast and Northwest branches (Ana NE-NW), Watts Branch, and Potomac River at Chain Bridge (PRCB). Black line indicates 1:1 correspondence between observed and predicted tPCB concentrations. Dashed colored lines: regressions with TSS-based predicted concentrations. Solid colored lines: regressions with flow-based predicted concentrations. Two extremely low observed concentrations (<0.005 ng tPCB/liter) were excluded from the Anacostia regressions.



<u>Zone</u>	<u>Regression equation</u>	<u>Correlation coefficient</u> (r^2)
DC Urban	$[PCB3+] = 0.855\ [TSS]^{0.9702}$	0.61 (n = 30)
Near DC	$[PCB3+] = 0.3290\ [TSS]^{0.5059}$	0.63 (n = 94)
Else	$[PCB3+] = 0.0458\ [TSS]^{0.5008}$	0.52 (n = 25)

TSS daily concentrations are inherently variable, so estimates of PCB3+ concentrations will consequently be variable. The prediction intervals of the three regressions, or the confidence intervals around the individual data points, are wide. They sometimes overlap at low TSS concentrations (typically associated with low flows) as one would expect, and diverge at high TSS concentrations. The confidence intervals around the regression slopes, however, are tight and the TSS:PCB3+ relationships in the three regions are significant ($p<0.01$) and significantly different from each other.

Figure A-7. The TSS:PCB3+ regressions with their underlying data. Symbols: DC Urban, red squares and thick line; Near DC, green diamonds and thick line; Else, dark blue triangles and thick line; thin solid lines, 90th% confidence interval around the slopes; dashed lines, 90th% confidence intervals around the individual estimates of PCB3+ (prediction interval). See text for details. Note the scale is log-log.



<u>Chain Bridge</u>

A separate TSS:PCB3+ regression was developed for Potomac River loads to the estuary at Chain Bridge. PCB measurements for the six Chain Bridge samples collected in 2006 by one laboratory (CBL) had homolog distributions that differed from those in samples collected by another laboratory (ANS) just downstream of Chain Bridge in 2005 and a third laboratory (Battelle) at Chain Bridge in 2007 (see Appendix B). The 2007 samples confirmed suspicions about problems with the homologs 1 and 2 measurements in the CBL 2006 samples, but indicated that homolog 3-10 (PCB3+) measurements from the different laboratories could be used together. After examining the few Chain Bridge results, and making comparisons to the other TSS:PCB3+ regressions and the downstream ambient data in the District of Columbia, the Steering Committee decided to create a TSS-PCB3+ regression specifically for Chain Bridge that is based on the six CBL, five Battelle, and ninety-four NearDC samples. The Chain Bridge TSS:PCB3+ regression is:

<u>Zone</u>	<u>Regression equation</u>	<u>Correlation coefficient</u> (r^2)
Chain Br	$[PCB3+] = 0.2772\ [TSS]^{0.5178}$	0.58 (n = 105)

The Chain Bridge regression line falls slightly below that of the NearDC regression.

4. Estimating Particulate Carbon Concentration from Total Suspended Solids

The Potomac PCB model simulates sorption dynamics of PCBs to organic carbon in the water column, net solids burial to the sediment layer, and exchange with the atmosphere. Thus fate and transport of PCBs in the model is directly linked to organic carbon, and carbon load inputs to the model must be estimated as well as PCB inputs. DOC concentration is assumed not to vary tremendously with flow, so DOC concentrations in the POTPCB model were specified by LTI (2.71 mg/liter) rather than computed, and daily loads are derived by multiplying the specified DOC concentration by daily flows. PC concentration does vary with flow, hence watershed loads vary non-linearly. Daily PC loads can be calculated as the sum of three WM5 model output variables: bodc (biologically active, labile carbon), refc (refractory carbon), and algc (algal, or living, carbon). Concerns about the accuracy of WM5 carbon load estimates prompted an analysis of available TSS and PC data in the lower Potomac basin, to determine if PC could be predicted from TSS. TSS was once again selected as the model predictor variable because the TSS simulation in the WM5 is currently better calibrated than the organic carbon simulation (US EPA, 2006c).

A TSS:PC regression (power function, $r^2 = 0.58$, $p<<0.001$) was developed using comparable monitoring data collected by Maryland Department of the Environment (MDE) in Maryland tributaries to the Potomac estuary (2000-2002, n = 587), ANS at the Northeast and Northwest branches of the Anacostia River (2002, n = 25), CBL at Chain Bridge (2005, n = 5), USGS at Little Falls and Chain Bridge on the Potomac River (2006, n = 8), and Maryland at Rock Creek and Cabin John Creek (2006, n = 16). Due to collection and filtration methods, the PC values generated for the POTPCB model represent carbon associated with particles greater than 0.45 - 0.7 microns and combustible below 975-1050°C. The Steering Committee adopted this regression-based approach for deriving carbon loads from the watershed. The TSS:PC regression, shown in Figure A-8 with the underlying data, is:

$$[PC] = 0.2768\ [TSS]^{0.6312}$$

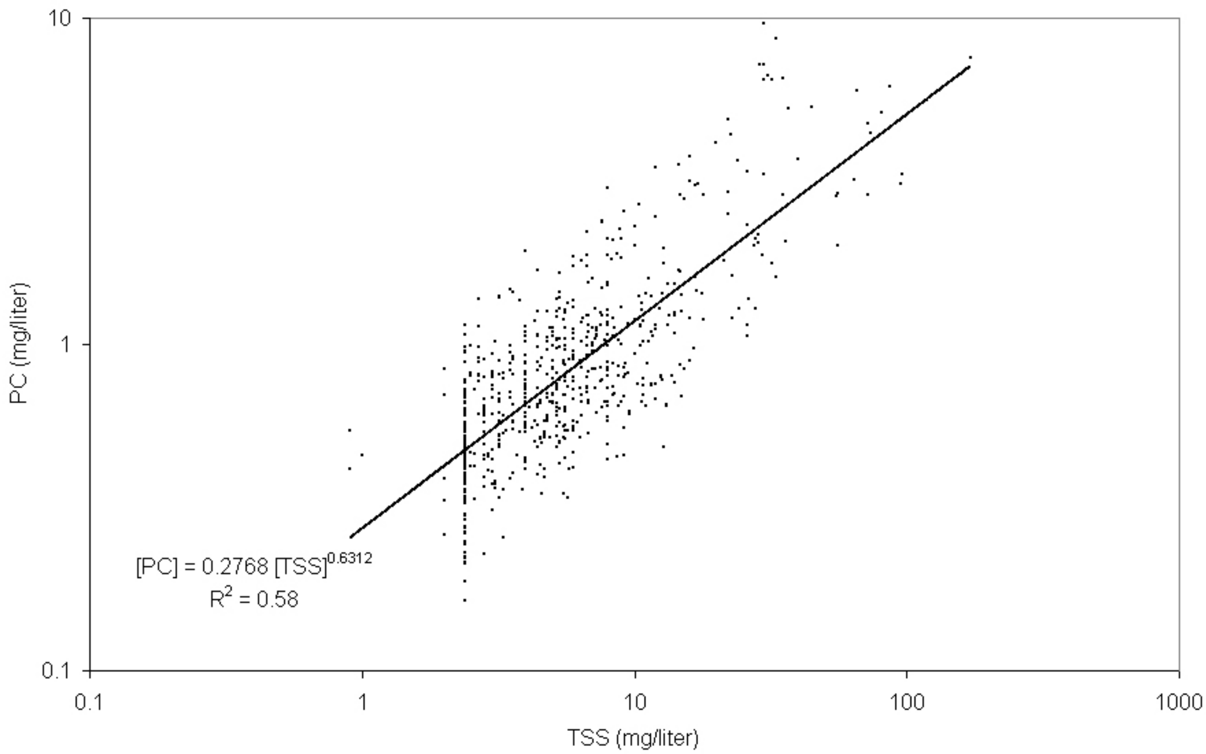
IV. CALCULATION OF EXTERNAL LOADS BY SOURCE CATEGORY

Daily external loads to the POTPCB model were generated by multiplying regression-based PCB3+ and PC concentrations by daily mean flows for each source category.

1. Tributary and Direct Drainage Loads from the Lower Potomac Basin

Output from Chesapeake Bay Watershed Model, Phase 5, or WM5, is used to estimate daily flows and suspended solid loads delivered from the Potomac River watershed to each "DYNHYD" junction, or link-node in a PCB model segment, of POTPCB estuary model. The WM5 model simulates watershed hydrology and nutrient cycles associated with different land uses. It generates daily flows and nutrient and sediment loads to the model cells of the 3-dimensional Chesapeake Hydrodynamic Model (CH3D). The spatial grid of the CH3D model cells generally matches that of POTPCB model segments except in Washington, DC and some

Figure A-8. The TSS:PC regression with the underlying data. See text for details. Note the log-log scale.



tributaries where additional or smaller POTPCB cells were created to provide higher spatial resolution.

Table A-6 shows how WM5 model flows and loads from lower Potomac basin tributaries are delivered to DYNHYD junctions. In most cases, each tributary empties into a single CH3D cell and POTPCB model segment, but there are several cases where more than one tributary is connected to a single CH3D cell. In those cases, the total tributary flow and load is apportioned to POTPCB model segments as indicated by the DH Fraction.

WM5 model flows and loads from the 49 direct drainage watershed model segments are identified only by the CH3D model cell the flow and load go to and not by the watershed model segment that it comes from. In most cases there is a 1:1 relationship between POTPCB model segments and CH3D cells, but in the Anacostia River and some other embayments there are several POTPCB cells to each CH3D cell. Direct drainage flow and load to CH3D cells is apportioned to the DYNHYD junction of the POTPCB model segments by the fractions indicated in Table A-7. The fractions were determined by visual comparison of CH3D and POTPCB cell boundaries and watershed model segment boundaries.

Table A-6. Linkage of the Chesapeake Bay Watershed Model tributaries in the lower Potomac basin to the DYNHYD junction of each POTPCB model segment. Watershed segment and unique ID are tributary designations in the Chesapeake Bay Watershed Model (WM5), one of five linked models in the Chesapeake Bay Environmental Model Package (CBEMP). CH3D is the estuarine model cell designation in the Chesapeake Bay Hydrodynamic Model (CH3D), another component of the CBEMP. DH is DYNHYD junction, which corresponds to a POTPCB model segment. DH Fraction is the flow-based apportionment of tributary loads from CH3D cell. PCB Code refers to the algorithms used to estimate PCB3+ concentrations from TSS concentrations with area-specific TSS:PCB3+ regressions. See text for details.

Tributary Name	Watershed Segment	Unique ID	CH3D model cell	DH junction	DH Fraction	PCB Code
NW Br Anacostia River	PL0_4510_0001	4510	2111	246	0.41	NearDC
NE Br Anacostia River	PL1_4540_0001	4540	2111	247	0.59	NearDC
Rock Creek	PL1_4780_0001	4780	7108	87	1	NearDC
Upper Hunting Creek	PL0_5000_0001	5000	18105	207	1	NearDC
Upper Piscataway Creek	PL0_5070_0001	5070	26114	203	1	Else
Accotink Creek	PL1_5130_0001	5130	30102	199	1	NearDC
Occoquan River	PL0_5250_0001	5250	36096	185	1	Else
Mattawoman Creek	PL1_5230_0001	5230	40116	179	1	Else
Quantico Creek	PL0_5490_0001	5490	44100	173	1	Else
Aquia Creek	PL1_5690_0001	5690	52097	171	1	Else
Nanjemoy Creek	PL0_5720_0001	5720	60114	164	1	Else
Trib. To Zekiah Swamp Run	PL0_5710_0001	5710	78120	150	0.15	Else
Middle Zekiah Swamp Run	PL2_5630_0001	5630	78120	150	0.85	Else
Trib to Upper Wicomico Bay	PL0_5510_0001	5510	79120	150	1	Else
St Clements Creek	PL0_5750_0001	5750	83116	143	1	Else
Upper McIntosh Run	PL0_5830_0001	5830	85117	136	1	Else
St Marys River	PL1_5910_0001	5910	104124	114	1	Else

Tributary and direct drainage flows and loads produced by the WM5 model were imported into MS Access 2003, processed separately, then joined and summed to obtain total watershed flows and loads to each DYNHYD junction. In both the tributary and direct drainage data sets, the WM5 model daily sand, silt, clay, and algae dry weight loads to each CH3D cell were summed to obtain a TSS load, which was divided by the WM5 model daily flow to obtain a daily average TSS concentration. The TSS:PCB3+ regression assigned to each CH3D cell ("PCB Code" in Tables A-6 and A-7) was applied to calculate a PCB3+ concentration in ng/liter. This concentration was multiplied by flow to obtain a daily PCB3+ load to the CH3D cell in g/day. Daily PC load was similarly calculated from the TSS:PC regression. The modeled flow and calculated PCB3+ and PC daily loads to the CH3D cells were apportioned to DYNHYD junctions according to the fractions in Tables A-6 and A-7. Tributary and direct drainage loads to DYNHYD junctions were then summed to create a total daily watershed load to each DYNHYD junction. In a last step, PCB3+ loads to DYNHYD junctions 74, 75, and 207 were

Table A-7. Chesapeake Bay Hydrodynamic Model (CH3D) cells mapped to POTPCB Model DYNHYD (DH) junction. DH fraction indicates the fraction of the direct drainage watershed flow and load entering the CH3D cell that is apportioned to the DH junction. PCB Code refers to one of four TSS-PCB3+ regressions used to estimate PCB3+ concentrations from TSS concentrations (see text for details).

CH3D	DH	Fraction	PCB Code
2106	97	0.5	NearDC
2106	96	0.5	NearDC
2111	247	0	DCUrban
2111	246	0	DCUrban
2111	245	0.25	DCUrban
2111	244	0.25	DCUrban
2111	243	0.25	DCUrban
2111	242	0.25	DCUrban
3106	95	0.5	NearDC
3106	94	0.5	NearDC
3111	239	0.167	DCUrban
3111	236	0.167	DCUrban
3111	238	0.167	DCUrban
3111	240	0.167	DCUrban
3111	241	0.167	DCUrban
3111	237	0.167	DCUrban
4106	93	0.5	NearDC
4106	92	0.5	NearDC
4107	93	0.5	NearDC
4107	92	0.5	NearDC
4108	93	0.5	NearDC
4108	92	0.5	NearDC
4111	235	0.25	DCUrban
4111	234	0.25	DCUrban
4111	232	0.25	DCUrban
4111	233	0.25	DCUrban
5106	90	0.5	NearDC
5106	91	0.5	NearDC
5108	90	0.5	NearDC
5108	91	0.5	NearDC
5111	231	0.333	DCUrban
5111	229	0.333	DCUrban
5111	230	0.333	DCUrban
6106	89	0.5	NearDC
6106	88	0.5	NearDC
6108	89	0.5	NearDC
6108	88	0.5	NearDC
6111	226	0.25	DCUrban
6111	228	0.25	DCUrban
6111	248	0.25	DCUrban
6111	227	0.25	DCUrban
7106	87	0.5	DCUrban
7106	86	0.5	DCUrban
7108	87	1	NearDC
7111	224	0.333	DCUrban
7111	223	0.333	DCUrban
7111	225	0.333	DCUrban
8106	84	0.5	DCUrban
8106	85	0.5	DCUrban

CH3D	DH	Fraction	PCB Code
8108	85	0.5	DCUrban
8108	84	0.5	DCUrban
8111	222	0.25	DCUrban
8111	220	0.25	DCUrban
8111	219	0.25	DCUrban
8111	221	0.25	DCUrban
9106	83	0.5	DCUrban
9106	82	0.5	DCUrban
9108	83	0.2	DCUrban
9108	82	0.1	DCUrban
9108	251	0.7	DCUrban
9111	218	0.2	DCUrban
9111	217	0.2	DCUrban
9111	216	0.2	DCUrban
9111	215	0.2	DCUrban
9111	214	0.2	DCUrban
10106	80	0.5	DCUrban
10106	81	0.5	DCUrban
10108	250	0.65	DCUrban
10108	80	0.05	DCUrban
10108	81	0.1	DCUrban
10108	249	0.2	DCUrban
10111	213	0.333	DCUrban
10111	212	0.333	DCUrban
10111	211	0.333	DCUrban
11106	79	1	DCUrban
11109	79	1	DCUrban
11110	79	1	DCUrban
11111	79	1	DCUrban
12106	78	1	DCUrban
12111	78	1	NearDC
13105	210	1	NearDC
13111	77	1	NearDC
14106	76	1	NearDC
14111	76	1	NearDC
15106	75	1	NearDC
15111	75	1	NearDC
16106	74	1	NearDC
16112	208	1	NearDC
16113	209	1	NearDC
17106	73	1	NearDC
17111	73	1	NearDC
18105	207	1	NearDC
18112	206	1	NearDC
19105	207	1	NearDC
19112	206	1	NearDC
19112	72	0	NearDC
20106	71	1	NearDC
20111	71	1	NearDC

CH3D	DH	Fraction	PCB Code
21106	70	1	NearDC
21111	70	1	NearDC
22106	69	1	NearDC
22112	205	1	NearDC
23106	68	1	NearDC
23111	68	1	NearDC
24106	67	1	NearDC
24111	67	1	NearDC
25106	66	1	NearDC
25111	66	1	NearDC
26104	204	1	NearDC
26105	65	1	NearDC
26112	201	1	Else
26113	202	1	Else
26114	203	1	Else
27105	64	1	NearDC
27111	64	1	Else
28105	63	1	NearDC
28111	63	1	Else
29104	200	1	NearDC
29111	62	1	Else
30102	199	1	Else
30105	61	1	NearDC
30111	61	1	Else
31101	198	1	Else
31102	197	1	Else
31103	196	1	Else
31104	195	1	Else
31111	60	1	Else
32105	59	1	Else
32111	59	1	Else
33105	58	1	Else
33111	58	1	Else
34098	194	0.5	NearDC
34098	186	0.5	NearDC
34103	57	1	Else
34104	57	1	Else
34111	57	1	Else
35098	193	1	NearDC
35103	56	1	Else
35111	56	1	Else
36096	185	0.333	NearDC
36096	192	0.667	NearDC
36097	191	1	NearDC
36098	190	1	NearDC
36099	189	1	NearDC
36100	188	1	NearDC
36101	187	1	NearDC
36102	55	1	Else
36111	55	1	Else
37099	189	1	NearDC
37111	54	1	Else
38099	189	1	NearDC
38100	188	1	NearDC
38101	181	0.05	NearDC
38101	182	0.1	NearDC
38101	183	0.2	NearDC

CH3D	DH	Fraction	PCB Code
38101	184	0.65	NearDC
38111	53	1	Else
39102	52	1	Else
39111	52	1	Else
40101	180	1	Else
40112	175	1	Else
40112	51	0	Else
40113	176	1	Else
40114	177	1	Else
40115	178	1	Else
40116	179	1	Else
41102	50	1	Else
41111	50	1	Else
42102	49	1	Else
42111	49	1	Else
43102	48	1	Else
43112	174	1	Else
44100	173	1	Else
44101	172	1	Else
44111	47	1	Else
45102	46	1	Else
45111	46	1	Else
46101	258	0.95	Else
46101	257	0.05	Else
46111	45	1	Else
47101	44	1	Else
47111	44	1	Else
48101	43	1	Else
48111	43	1	Else
49101	42	1	Else
49111	42	1	Else
50101	41	1	Else
50111	41	1	Else
51101	40	1	Else
51111	40	1	Else
52097	171	1	Else
52098	170	1	Else
52099	169	1	Else
52100	168	1	Else
52111	39	1	Else
53100	168	1	Else
53111	39	1	Else
54101	38	1	Else
54111	38	1	Else
55098	167	1	Else
55099	166	1	Else
55100	165	1	Else
55111	37	1	Else
56101	36	1	Else
56111	36	1	Else
57101	35	1	Else
57111	35	1	Else
58101	34	1	Else
58111	34	1	Else
59101	33	1	Else
59111	33	1	Else
60101	32	1	Else

CH3D	DH	Fraction	PCB Code
60111	32	1	Else
60114	164	1	Else
61101	31	1	Else
61111	31	1	Else
61114	163	1	Else
62101	30	1	Else
62112	160	1	Else
62113	161	1	Else
62114	162	1	Else
63100	29	1	Else
63111	29	1	Else
64100	28	1	Else
64101	28	1	Else
64102	28	1	Else
64112	28	1	Else
65103	27	1	Else
65112	27	1	Else
66103	26	1	Else
66113	156	1	Else
66114	157	1	Else
66115	158	1	Else
66116	159	1	Else
67103	25	1	Else
67110	25	1	Else
67111	25	1	Else
67112	25	1	Else
68099	22	1	Else
68102	24	1	Else
68109	24	1	Else
69099	22	1	Else
69102	23	1	Else
69109	23	1	Else
70097	155	1	Else
70098	154	1	Else
70100	22	1	Else
70101	22	1	Else
70110	22	1	Else
71099	21	1	Else
71111	21	1	Else
72099	256	0.9	Else
72099	255	0.1	Else
72112	21	1	Else
73099	20	1	Else
73112	20	1	Else
74099	20	1	Else
74112	20	1	Else
75097	153	1	Else
75098	152	1	Else
75112	19	1	Else
76099	18	1	Else
76112	18	1	Else
77099	18	1	Else
77112	18	1	Else
78099	17	1	Else
78113	17	1	Else
78114	144	1	Else
78115	145	1	Else

CH3D	DH	Fraction	PCB Code
78116	146	1	Else
78117	147	1	Else
78118	148	1	Else
78119	149	1	Else
78120	150	1	Else
79099	17	1	Else
79114	144	1	Else
79115	145	1	Else
79116	146	1	Else
79117	147	1	Else
79119	149	1	Else
79120	150	1	Else
80099	16	1	Else
80113	16	1	Else
80118	151	1	Else
81099	16	1	Else
81112	16	1	Else
81113	16	1	Else
82099	15	1	Else
82111	15	1	Else
83099	14	1	Else
83112	14	1	Else
83113	140	1	Else
83114	141	1	Else
83115	142	1	Else
83116	143	1	Else
84098	14	1	Else
84112	14	1	Else
85095	139	1	Else
85096	138	1	Else
85097	137	1	Else
85113	132	1	Else
85114	133	1	Else
85115	134	1	Else
85116	135	1	Else
85117	136	1	Else
86097	137	1	Else
86098	13	1	Else
86112	13	1	Else
87099	12	1	Else
87112	12	1	Else
88098	129	1	Else
88113	11	1	Else
89096	131	1	Else
89097	130	1	Else
89098	129	1	Else
89099	11	1	Else
89100	11	1	Else
89113	11	1	Else
90101	10	1	Else
90113	10	1	Else
91101	10	1	Else
91113	10	1	Else
92100	9	1	Else
92113	9	1	Else
93100	9	1	Else
93113	9	1	Else

CH3D	DH	Fraction	PCB Code	CH3D	DH	Fraction	PCB Code
94100	8	1	Else	103118	108	1	Else
94113	8	1	Else	104100	4	1	Else
95101	8	1	Else	104114	104	1	Else
95112	8	1	Else	104115	105	1	Else
95113	8	1	Else	104116	106	1	Else
96101	7	1	Else	104117	107	1	Else
96111	7	1	Else	104119	109	1	Else
97097	128	1	Else	104120	110	1	Else
97100	7	1	Else	104121	111	1	Else
97111	7	1	Else	104122	112	1	Else
98095	125	1	Else	104123	113	1	Else
98096	124	1	Else	104124	114	1	Else
98098	122	1	Else	105100	3	1	Else
98099	121	1	Else	105113	3	1	Else
98112	6	1	Else	105118	120	1	Else
98114	118	1	Else	106100	3	1	Else
99097	123	1	Else	106114	98	1	Else
99098	122	1	Else	106115	99	1	Else
99099	121	1	Else	106116	100	1	Else
99112	6	1	Else	107100	3	1	Else
99114	117	1	Else	107113	3	1	Else
100097	126	1	Else	107115	101	1	Else
100100	5	1	Else	108100	254	0.6	Else
100112	5	1	Else	108100	253	0.3	Else
100114	116	1	Else	108100	252	0.1	Else
101097	127	1	Else	108113	2	1	Else
101100	5	1	Else	109100	2	1	Else
101112	5	1	Else	109113	2	1	Else
101114	115	1	Else	110100	2	1	Else
101117	119	1	Else	110113	2	1	Else
102100	4	1	Else	111100	1	1	Else
102113	4	1	Else	111112	1	1	Else
102115	105	1	Else	112100	1	1	Else
102116	106	1	Else	112112	1	1	Else
102117	107	1	Else	113100	1	1	Else
103098	103	1	Else	113112	1	1	Else
103099	102	1	Else				

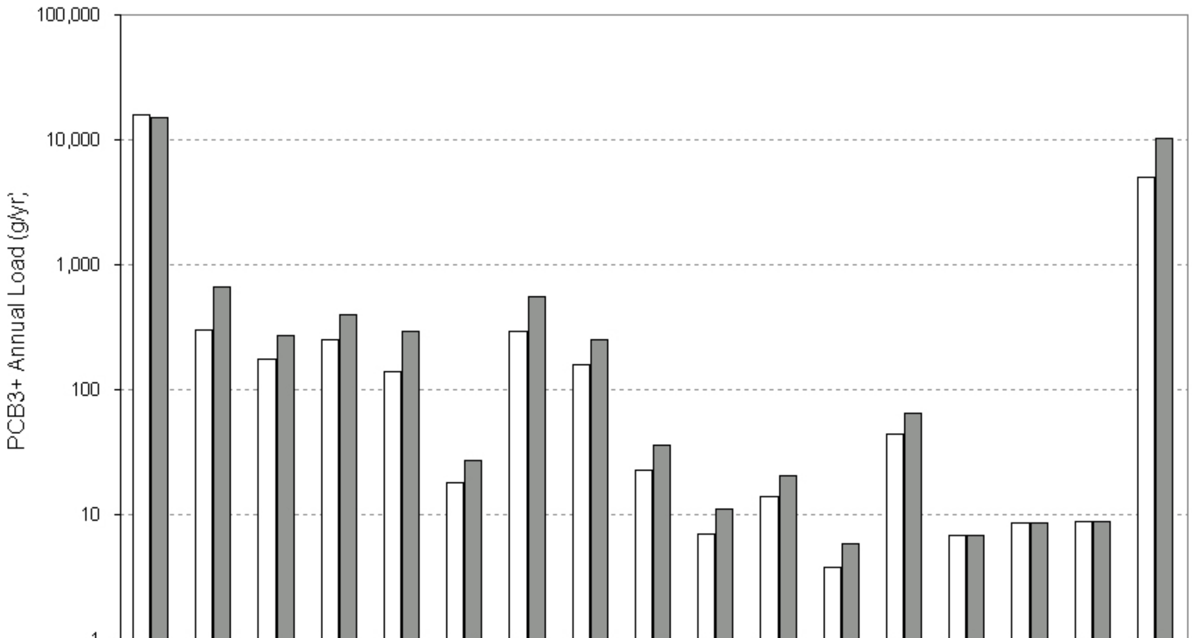
reduced by amounts equivalent to the Alexandria CSO contributions to avoid double counting. Alexandria CSO areas are not excluded in the WM5 model whereas District of Columia CSO areas are excluded.

Figure A-9 shows the calculated PCB3+ annual loads from direct drainage and tributaries to the Potomac River estuary. Direct drainage constitutes the second largest source category of PCB3+ and PC after the non-tidal Potomac River. The median annual PCB3+ loads for 1994 - 2005 were 4,881 g/yr for direct drainage and 1,417 g/yr for all the lower Potomac basin tributaries.

2. Potomac River Loads at Chain Bridge

An alternative modeling approach based on observed daily flows and a flow:TSS regression proved to be superior to the WM5 model for generating tributary daily TSS loads at Chain Bridge, from which PCB and PC loads could be generated. POTPCB model segment 96

Figure A-9. Median and 2005 annual PCB3+ loads from the non-tidal Potomac River at Chain Bridge, lower Potomac basin tributaries, and all direct drainage watersheds. Daily loads are predicted with Chesapeake Bay Watershed Model (WM5) TSS loads and flows and a TSS:PCB3+ regression; annual loads are the sum of all daily loads in each year. The median is calculated on loads estimated for 1994 - 2005. Loads are rounded to 3 significant figures or the nearest whole number. Note the log scale for PCB3+ loads.



	Chain Br	Rock Cr	NW Ana	NE Ana	Up Hunt. Cr	Up Pisc. Cr	Acco. Cr	Occo. R	Matta. Cr	Quan. Cr	Aquia Cr	Nanj. Cr	Zek.-UpWic.	St Clem. Cr	Up McInt.	St. Mary	Dir. Drain
□ Median (1994-2005)	15,830	298	175	252	139	18	293	160	23	7	14	4	44	7	9	9	4,976
■ 2005	15,129	669	274	394	296	27	559	248	36	11	20	6	65	7	9	9	10,174

(equivalent to DYNHYD junction 97) is the most upstream cell of the model's spatial grid, and is bounded by Chain Bridge on its upstream side. It is located close to the Piedmont fall-line and receives ~99.9% of its flow and TSS load from the free-flowing Potomac River, which represents all inputs to the river above the fall-line. The Potomac River has a long-term flow record (1930-present) at the Little Falls gage upstream of cell 96, and TSS is sampled relatively often at Chain Bridge. These characteristics allowed alternative approaches for calculating loads to be examined for this very important model segment (it receives approximately 79% of all watershed freshwater flows to the estuary).

The motivation for examining various modeling approaches for Chain Bridge is that the Potomac River provides much, if not most, of the total PCB load to the estuary, depending on annual hydrology, and that load is delivered into the portion of the tidal river that has the most strict PCB standard, i.e. the District of Columbia. There is no other POTPCB model segment where the magnitude in input flows is so large relative to the volume of the receiving model segment. A consequence of daily streamflow varying over 2-3 orders of magnitude and TSS concentration increasing with flow is that 87% of the annual load of TSS (and PCB and organic carbon) is delivered during about 20% of days. Thus, a small improvement in estimation procedure can have a significant impact on the load of PCBs to the tidal Potomac River.

The approach followed was to develop several regression models of observed TSS concentration as a function of flow, and compare the TSS concentration and loads predicted by these models and the WSM. Regression models and calculations of predicted concentrations and loads were provided by the Loadest program (Runkel, Crawford, and Cohn 2004). Annual loads predicted by WSM and Loadest regression models were also compared to annual loads predicted by the Autobeale model (Richards 1999) See page 58 in Richards for a description of how the Beale Ratio Estimator works. The purpose for using Autobeale is that it produces an unbiased estimate of *annual* load (based on observed data) and it provides confidence limits around that estimate. The WM5 and Loadest model results were compared by examining how often their predicted annual loads fell within the Autobeale prediction confidence limits. Additional evaluations were done to determine the representativeness of the observed TSS data, i.e. are the models based on a biased or unbiased data set. WSM and Loadest regression models were compared on TSS concentration as well as TSS and PCB loads.

Loadest is capable of running any of nine built-in regression models, as well as user-defined models. Loadest regression model #9 proved to fit the data best:

$$\text{Load} = a_0 + a_1 \text{ LnQ} + a_2 \text{ LnQ}^2 + a_3 \sin(2\pi\text{dtime}) + a_4 \cos(2\pi\text{dtime}) + a_5\pi\text{time} + a_6\text{dtime}^2$$

Loadest was run for regression models 1 and 2, and then in automatic mode which evaluates all the built-in model options. In automatic mode, the AIC criterion selected model #9, while the SPCC criterion selected model #6. For all three models, the probability plot correlation coefficient (PPCC) score was high enough to accept the hypothesis that model residuals are normally distributed. Thus, the Adjusted Maximum Likelihood Estimation (AMLE) can be used to estimate instantaneous loads. Based on mean relative error statistics and other comparisons, Loadest model #9 was the best model choice for predicting TSS concentration at Chain Bridge. It may not be the best Loadest regression model for PCB prediction because its seasonality terms are not matched with PCB data across all seasons. However, there are currently so few PCB data points at Chain Bridge that one cannot draw firm conclusions and the differences between models is slight relative to other sources of uncertainty.

To estimate daily PCB3+ and PC loads for the non-tidal Potomac River (Chain Bridge), the TSS:PCB3+ and TSS:PC regressions (above) were applied to the daily TSS concentrations generated by Loadest model #9 and USGS daily flows observed at the Little Falls stream gage. The median annual PCB3+ loads at Chain Bridge was about 15,800 g/yr for 1994-2005 (Figure A-9). The PC median annual load was 24.7 million kg/yr for 1994-2005. Non-tidal Potomac River PCB3+ and PC loads to the estuary are the largest of any source category.

3. Wastewater Treatment Plant Loads

There are more than 60 permitted municipal and industrial wastewater treatment plants (WWTPs) in the Potomac watershed downstream of Chain Bridge. PCB loads were calculated for the 22 WWTPs with the largest annual flow, accounting for approximately 95% of the total WWTP flow in the watershed. Prior to this study no PCB samples had been analyzed using methods with detection limits below the states' water quality standards. For this study one or

Table A-8. PCB3+ concentrations and annual PCB3+ loads from WWTPs. * Facilities are located within tributaries so their load is implicit in the tributary load, which is calculated separately. A load calculation for these facilities is shown here for tracking purposes.

Facility Name	NPDES	County	Flow, 2004 (MGD)	n	mean PCB3+ (ng/l)	2004, gr/yr PCB3+
Blue Plains	DC0021199	District of Columbia	334.24	4	1.569	724.0
La Plata	MD0020524	Charles	1.17	0	0.240	0.4
Beltsville USDA East*	MD0020842	Prince Georges	0.20	0	0.240	0.1
Beltsville USDA West*	MD0020851	Prince Georges	0.09	0	0.240	0.0
NSWC-Indian Head	MD0020885	Charles	0.42	2	3.841	2.3
Piscataway	MD0021539	Prince Georges	22.08	2	0.125	3.8
Mattawoman	MD0021865	Charles	8.12	3	0.125	1.4
Leonardtown	MD0024767	St Marys	0.41	2	0.466	0.3
NSWC-Dahlgren	VA0021067	King George	0.32	2	0.057	0.0
Dale City #8	VA0024678	Prince William	3.00	1	0.020	0.1
Dale City #1	VA0024724	Prince William	3.08	1	0.041	0.2
UOSA*	VA0024988	Fairfax	27.20	1	0.002	0.1
H.L. Mooney	VA0025101	Prince William	12.38	2	0.151	2.6
Arlington	VA0025143	Arlington	28.39	2	0.477	18.7
Alexandria	VA0025160	Alexandria City	37.42	3	0.353	18.2
Noman Cole	VA0025364	Fairfax	41.89	7	0.411	23.8
Colonial Beach	VA0026409	Westmoreland	0.89	1	2.458	3.0
Dahlgren Sanitary District	VA0026514	King George	0.21	0	0.370	0.1
Quantico-Mainside	VA0028363	Prince William	1.09	1	0.071	0.1
Aquia	VA0060968	Stafford	4.39	1	0.081	0.5
TOTAL			527.46			799.9

more samples were collected at 17 facilities and analyzed using Method 1668A (EPA 1999), which provided congener specific detection limits in the range of 2-8 pg/l. Individual samples were used only after passing a review of established decision rules (VA DEQ, 2006). Not enough samples were collected to make any judgement about PCB concentrations varying with season or during wet versus dry flow conditions. Therefore, each facility was assigned a constant PCB3+ concentration based on the mean of all samples collected at that facility or, if no samples were collected, then the mean of all samples in that state was used. (The Maryland mean PCB3+ was calculated excluding NSWC-Indian Head because that facility was deemed not representative). Daily PCB3+ loads are calculated by multiplying the facility concentration by the monthly average or daily (for Blue Plains) flow. Flows were obtained from the Chesapeake Bay Program Point Source Tracking database (Blue Plains flows obtained from DC WASA).

Three facilities, Beltsville USDA East, Beltsville USDA West, and UOSA, are located within WM5 tributary watersheds. As such the PCB load from these facilities is not explicitly added to the external load calculation for the PCB model, rather their load is implicit in the relevant tributary load calculation. These facilities are included in this summary for tracking purposes

Table A-9. BOD and PDC concentrations in WWTPs.

FACILITY	NPDES	Avg BOD5 / CBOD5 (mg/l)	PDC (mg/l)	Source
Blue Plains	DC0021199	2.37	1.66	CBP database
NSWC-Indian Head	MD0003158	5.00	3.50	CBP database
Indian Head	MD0020052	10.64	7.45	CBP database
La Plata	MD0020524	5.34	3.74	CBP database
NSWC-Indian Head	MD0020885	5.39	3.78	CBP database
Piscataway	MD0021539	1.88	1.31	CBP database
Mattawoman	MD0021865	7.15	5.00	CBP database
Leonardtown	MD0024767	5.41	3.79	CBP database
NSWC-dhlgren	VA0021067	1.10	0.77	VADEQ
Dale City #8	VA0024678	2.72	1.90	EPA PCS website
Dale City #1	VA0024724	2.61	1.83	EPA PCS website
H.L. Mooney	VA0025101	2.57	1.80	EPA PCS website
Arlington	VA0025143	2.20	1.54	EPA PCS website
Alexandria	VA0025160	0.12	0.09	EPA PCS website
Noman M. Cole	VA0025364	2.24	1.57	EPA PCS website
Colonial Beach	VA0026409	3.81	2.66	EPA PCS website
Dahlgren (Dahlgren Sanitary District)	VA0026514	4.95	3.47	EPA PCS website
Quantico-Mainside	VA0028363	2.36	1.65	EPA PCS website
Aquia	VA0060968	1.53	1.07	EPA PCS website

Note: facilities located in tributary watersheds are not included.

only. The other 19 facilities are located in direct drainage watershed segments, and their effluent load is assumed to be delivered directly to tidal waters, i.e. a POTPCB model segment. Table A-8 lists the 22 WWTPs being tracked for the POTPCB model, and Figure A-10 provides a spatial reference. Between 1994 and 2005, these facilities delivered median annual load of 704 grams PCB3+ to the tidal Potomac each year, with Blue Plains WWTP accounting for ~92%.

Carbon in WWTP effluent typically is measured as BOD. Average annual BOD5 was estimated from discharge monitoring report data or from the Chesapeake Bay Program Point Source tracking database. This average annual BOD5 was converted to a carbon concentration using these conversions:

$$BOD_5 * 2.84 = BOD_{ult}$$
$$BOD_{ult} * .2475 = Carbon$$
$$\text{Thus, } BOD_5 * 0.7 = Carbon$$

All of this WWTP carbon is assumed to be particulate detrital carbon (PDC). Table A-9 shows the BOD and PDC concentrations assigned to each WWTP facility.

4. Contaminated Site Loads

Sites where PCBs have been used or stored are a potential source of PCB contamination to the Potomac River. Staff at the District of Columbia Department of the Environment (DC DOE),Maryland Department of the Environment (MDE), and Virginia Department of Environmental Quality (VA DEQ) reviewed their records to identify sites of known PCB releases or soil contamination. Samples previously collected provided estimates of PCB concentration in soils at these sites, some of which have already been through a remediation process. Annual soil loss at each site was estimated using the Revised Universal Soil Loss Equation, Version 2 (RUSLE2) methodology (manuals, program, and databases available at http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm).

Of the 21 sites identified as possible sources of PCBs, 13 sites are located in WM5 direct drainage watersheds and eight sites are located within tributary watersheds. Annual PCB loads were estimated for the tributary watershed sites but the loads are not explicitly input to the POTPCB model as they are implicit in the load estimated for the tributary (see section IV(1) above). PCB loads for sites in direct drainage watersheds are input to the POTPCB model as a constant daily load (annual load/365). Tables A-10A and B list the sites and annual PCB load estimates and Figure A-11 provides a spatial reference. The 13 sites that are inputs to the POTPCB model collectively contribute 15.1 g/yr total PCB. The eight additional sites in tributary watersheds are estimated to contribute 6.80 g/yr total PCB.

State agencies have considered other potential contaminated sites, such as spill events at power distribution substations. However, the PCB loading computations for these sources using the RUSLE2 methodology yielded insignificant PCB loadings for inclusion in the model. At this time, only the 13 identified contaminated sites are used in model external load calculations. Calculation of PCB loads from these sites was based on total PCBs rather than PCB3+, so the current these loads may be considered a “conservative” estimate.

5. Atmospheric deposition

No recent Potomac watershed studies of atmospheric deposition of PCBs to surface waters of the estuary are available. (Atmospheric deposition to land surfaces is computed as nonpoint source runoff either through tributary loadings or direct drainage nonpoint source runoff.) Literature review suggests net deposition rates are higher near urban centers compared to rural areas. The Chesapeake Bay Program Atmospheric Deposition Study (CBP, 1999) estimated a net deposition of 16.3 ug/m^2/year total PCB for urban areas and a net deposition of 1.6 ug/m^2/yr total PCB for regional (non urban) areas. In the Delaware estuary, an extensive atmospheric deposition monitoring program found PCB deposition rates ranging from 1.3 (non urban) to 17.5 (urban) ug/m^2/year total PCB (DRBC, 2006). The District of Columbia’s Anacostia PCB TMDL study by the Environmental Health Administration (DC EHA 2003), using the CBP Atmospheric Deposition Study as a reference, used 16.3 ug/m^2/year as the net atmospheric deposition rate in that urbanized watershed.

Table A-10A. Contaminated sites contributing PCB loads to the POTPCB model.

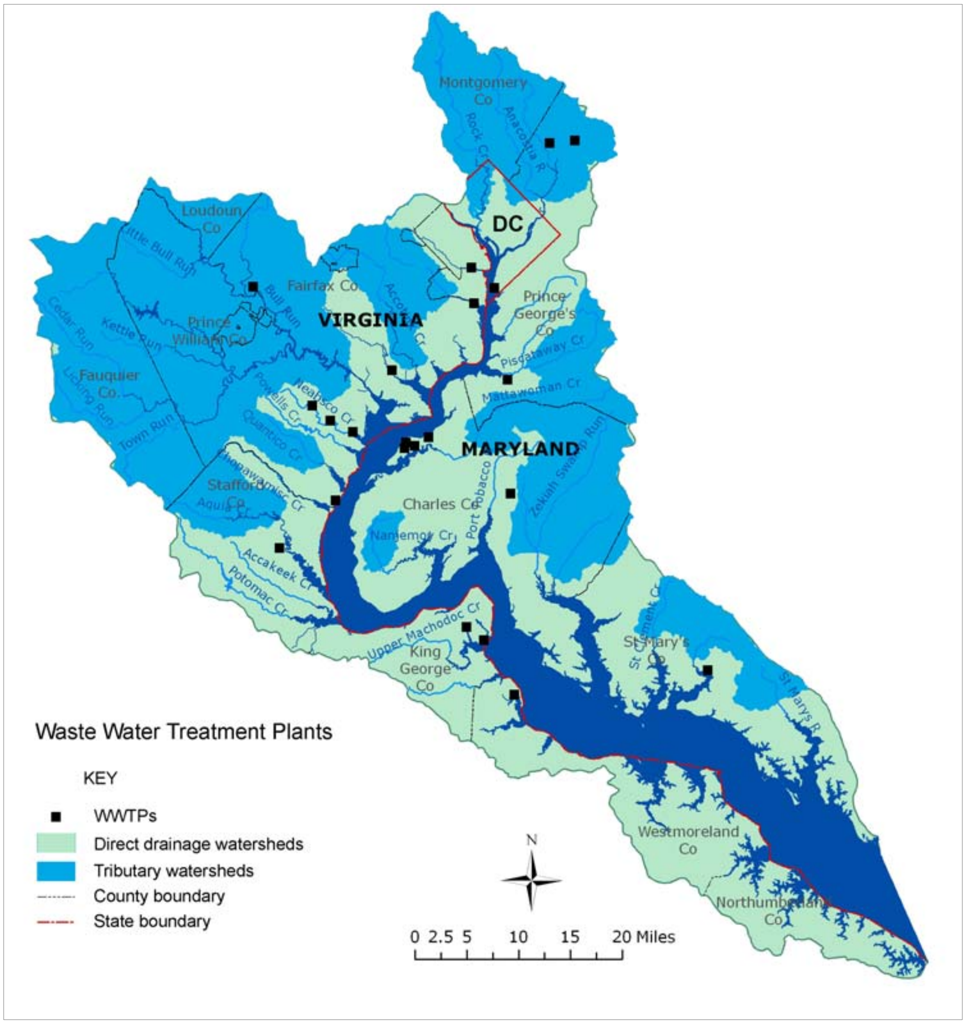
Site Name	State	Latitude (decimal degree)	Longitude (decimal degree)	Total PCBs (g/yr)
Woodbridge-1+2	VA	38.64583	-77.22958	1.24
Davis	VA	38.86530	-77.04911	1.33
CSX	VA	38.80644	-77.07918	0.76
Quantico	VA	38.51222	-77.30000	1.10
Dahlgren-17+19	VA	38.32347	-77.02622	5.39
Ft. Belvoir	VA	38.68579	-77.14056	1.74
Kenilworth Landfill (South)	DC	38.90333	-76.95556	2.34
Kenilworth Landfill (North)	DC	38.90833	-76.95028	0.61
Rogers Electric	MD	38.92000	-76.91200	0.00
Andrews Air Force Base	MD	38.80600	-76.89700	0.00
Blossom Point Proving Ground (no remediation)	MD	38.42000	-77.09444	0.00
Indian Head (no remediation at sub site)	MD	38.59111	-77.17417	0.10
Substations (PEPCO 84) (remediated)	MD	38.77444	-76.95806	0.49
Total annual PCB load				15.1

Table A-10B. Contaminated sites in tributaries, tracked but not explicitly input to the POTPCB model.

Site Name	State	Latitude (decimal degree)	Longitude (decimal degree)	Total PCBs (g/yr)
Atlantic	VA	38.806548	-77.166417	0.17
United Rigging and Hauling	MD	39.049167	-76.893611	0.05
Waldorf (Nike)	MD	38.655000	-76.856111	0.00
White Oak	MD	39.034000	-76.986000	3.05
Beltsville Agricultural Research Center	MD	39.024000	-76.924000	3.41
Brandywine Receiver Station	MD	38.666667	-76.833333	0.00
Brandywine DRMO	MD	38.692000	-76.839000	0.01
St. Mary's Salvage	MD	38.322222	-76.555833	0.12
Total annual PCB load				6.80

For at least initial POTPCB model runs, it was decided to use deposition rates from the CBP 1999 report. Concentrations of only 61 of the 209 congeners were reported in the study, thus homolog distributions in rainwater and air and PCB3+ concentrations could not be calculated. Daily inputs provided to the POTPCB model were for total PCB. The Potomac estuary was divided into 3 zones: Urban, Regional, and Transition. POTPCB model segments in the Urban zone receive an atmospheric deposition of 16.3 ug/m^2/year in equal daily amounts while model segments in the Regional zone receive an atmospheric deposition of 1.6 ug/m^2/year in equal daily amounts. Deposition rates in the Transition zone were linearly interpolated between the Urban and Regional rates. Figure A-12 shows the locations of the three zones. With the Urban

Figure A-10. Location of 22 wastewater treatment plants tracked for loading inputs to the PCB model.

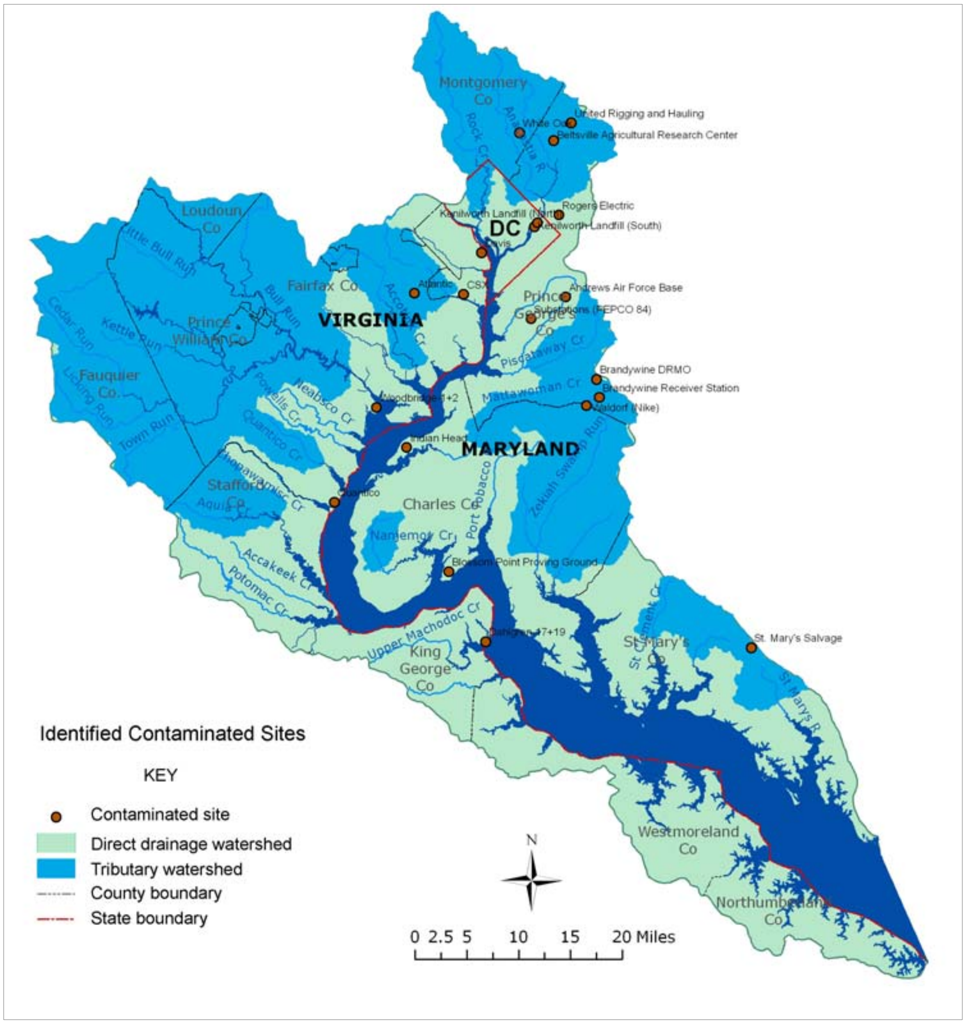


boundary at Hunting Creek and Regional boundary at Chopawamsic Creek, the median annual estimate of net atmospheric deposition directly to Potomac estuary waters is 3,160 g/yr of total PCBs.

6. Combined sewer overflows loads

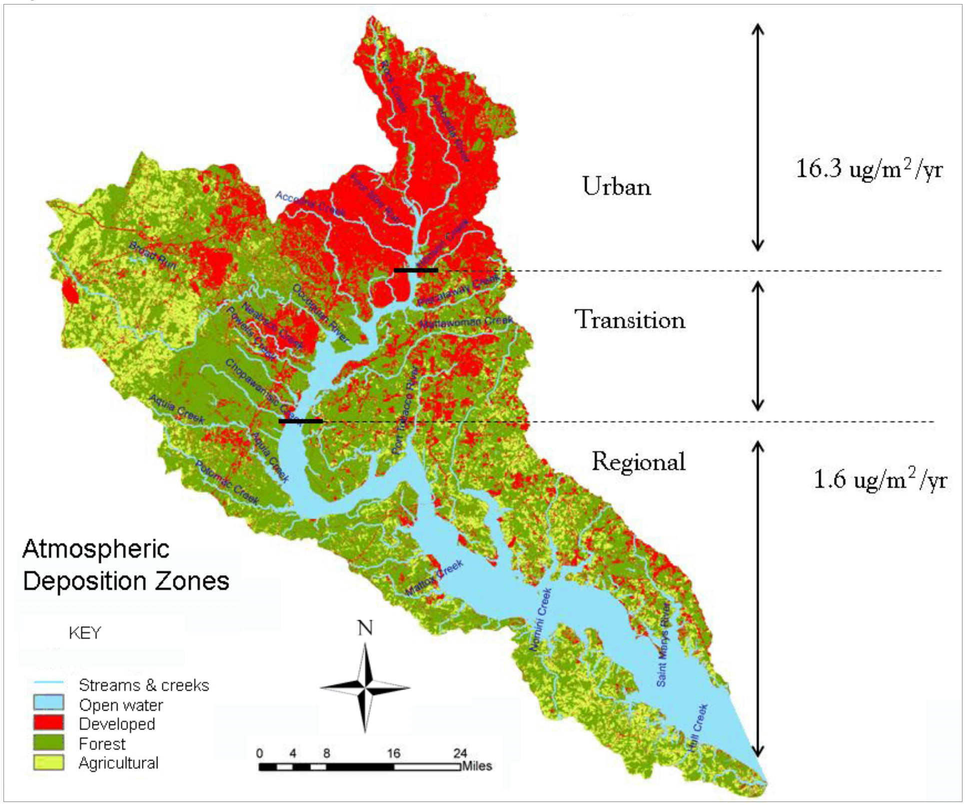
Two areas, approximately 1/3 of the District of Columbia and a smaller area in Alexandria, VA, are served by combined storm and sanitary sewers (Figure A-13). During high precipitation events, when storm water exceeds wastewater treatment plant capacity, the excess flow is diverted to nearby systems (the Anacostia and Potomac rivers, Rock Creek, and Four Mile Run). There are 53 combined sewer outfalls in the District of Columbia and four outfalls in Alexandria. These combined sewer overflows, or CSO, are treated as point source inputs to the POTPCB model. Three parameters need to be estimated: flow, PCB concentration, and carbon.

Figure A-11. Location of PCB contaminated sites. These sites have been identified as potential sources of PCBs. See also Table A-10.



Daily flows for each CSO outfall were obtained from a CSO model developed by LTI for the District of Columbia and Alexandria (LTI, 2006) for the period of January 2002 to December 2005, except for the period of January - March of 2003 for which daily flows were not available. Modeled daily flows were also used for the Alexandria CSO load calculations starting in January 2003. For earlier periods, the monthly total CSO flows reported in the Chesapeake Bay Program Point Source Tracking Database were divided into equal daily increments and total flow apportioned among the CSO outfalls in the same proportion as represented in the LTI model for 2003-2005. PCB concentration was estimated using the DC Urban TSS:PCB3+ regression. The event mean concentration TSS from samples collected for the District of Columbia Long Term Control Plan study (Greeley and Hansen, July 2002) was 156 mg/l. For Alexandria, the median TSS concentration of 65 samples collected in 2002-2003 was 53 mg/l. Inserting these values into the DC Urban TSS:PCB3+ regression equation (above) yields a PCB3+ concentration of 115 ng/liter for District CSOs and 40 ng/liter for Alexandria CSOs. These concentrations were

Figure A-12. Atmospheric deposition zones.



applied uniformly to all CSO flows to compute PCB loads for the POTPCB model. The median annual PCB3+ load for CSOs for 2002-2005 (i.e., the years with modeled flows) was 1,800 g/yr, with approximately 98.6% coming from the District CSOs.

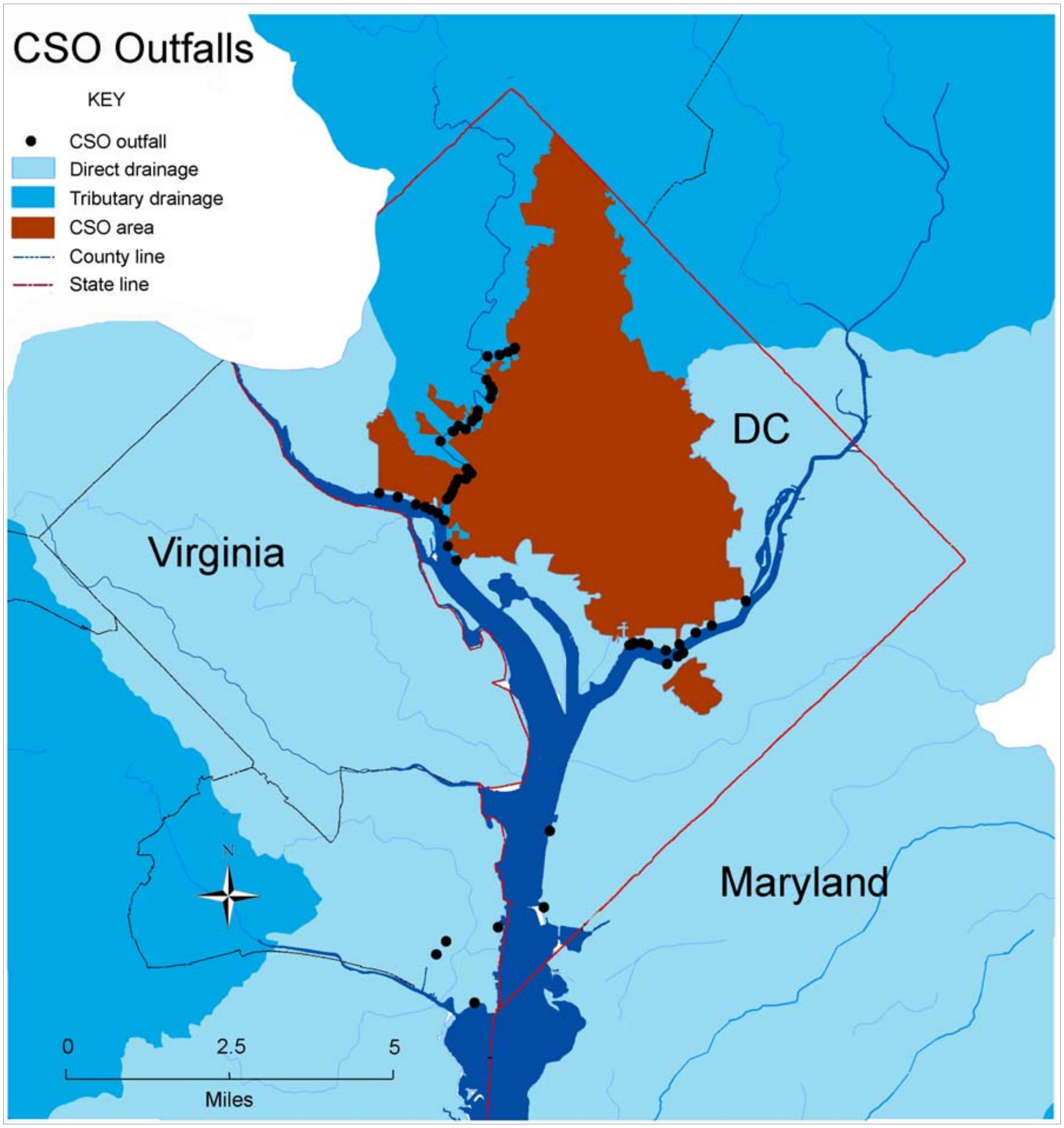
Two samples collected from DC CSOs in the summer of 2006 and analyzed for PCB and TSS support the use of the DC Urban regression. Observed and predicted PCB3+ concentrations are very close:

Sample	TSS, mg/l Observed	[PCB3+], ng/l Observed	[PCB3+], ng/l Predicted
O St.	29.8	23.9	23.0
Main St.	107	64.1	79.6

Seventeen PCB-TSS data pairs collected in District of Columbia in 2001-2002 and analyzed for a subset (82) of the 209 PCB congeners also supports use of the DC Urban regression to estimate CSO loads. The resulting TSS:PCB3+ regression slope closely parallels the DC Urban slope.

Only particulate detrital carbon (PDC) and biotic carbon (BIC) loads need to be computed for input to the POTPCB model. Long Term Control Plan monitoring in 1999-2000 provided measurements of total organic carbon (TOC) and dissolved organic carbon (DOC):

Figure A-13. Location of Combined Sewer Overflow (CSO) system outfalls in the District of Columbia and Alexandria, VA.



TOC = BIC + PDC + DOC

Assuming that BIC is 0 in CSO flow, this equation can be written as:

PDC = TOC - DOC

The TOC event mean concentration in Long Term Control Plan monitoring was 18.2 mg/l, and the DOC event mean concentration was 14 mg/l. Thus, PDC = 4.2 mg/l. This concentration was applied to all CSO flows in both DC and Alexandria. The median annual PDC loads from CSOs for 2002-2005, when daily flow flows were modeled, was 67,141 kg/yr.

V. LOAD INPUTS TO THE POTOMAC PCB MODEL

In a final processing step, DYNHYD junction designations in the load input file for the POTPCB model were equated to POTPCB cell designations (DYNHYD junction number minus 1 is POTPCB model segment number). A map of the POTPCB model segmentation scheme and the location of monitoring stations within the segments is presented in the supplemental section at the end of this Appendix.

External flows and PCB3+ and PC loads generated with the procedures described in this Appendix were used to calibrate the various components of the integrated POTPCB model constructed by LTI. After the Steering Committee selected calendar year 2005 as the hydrologic cycling year for the POTPCB model (Appendix C), flows for 2005 were used in the POTPCB model to make TMDL condition projections and calculate load reductions, and PCB3+ loads for 2005 were used to establish the Baseline condition for the TMDL. Tables of the estimated annual PCB3+ loads by source category are presented in the supplemental section at the end of this Appendix. A summary of the loading results is given below.

1. PCB3+

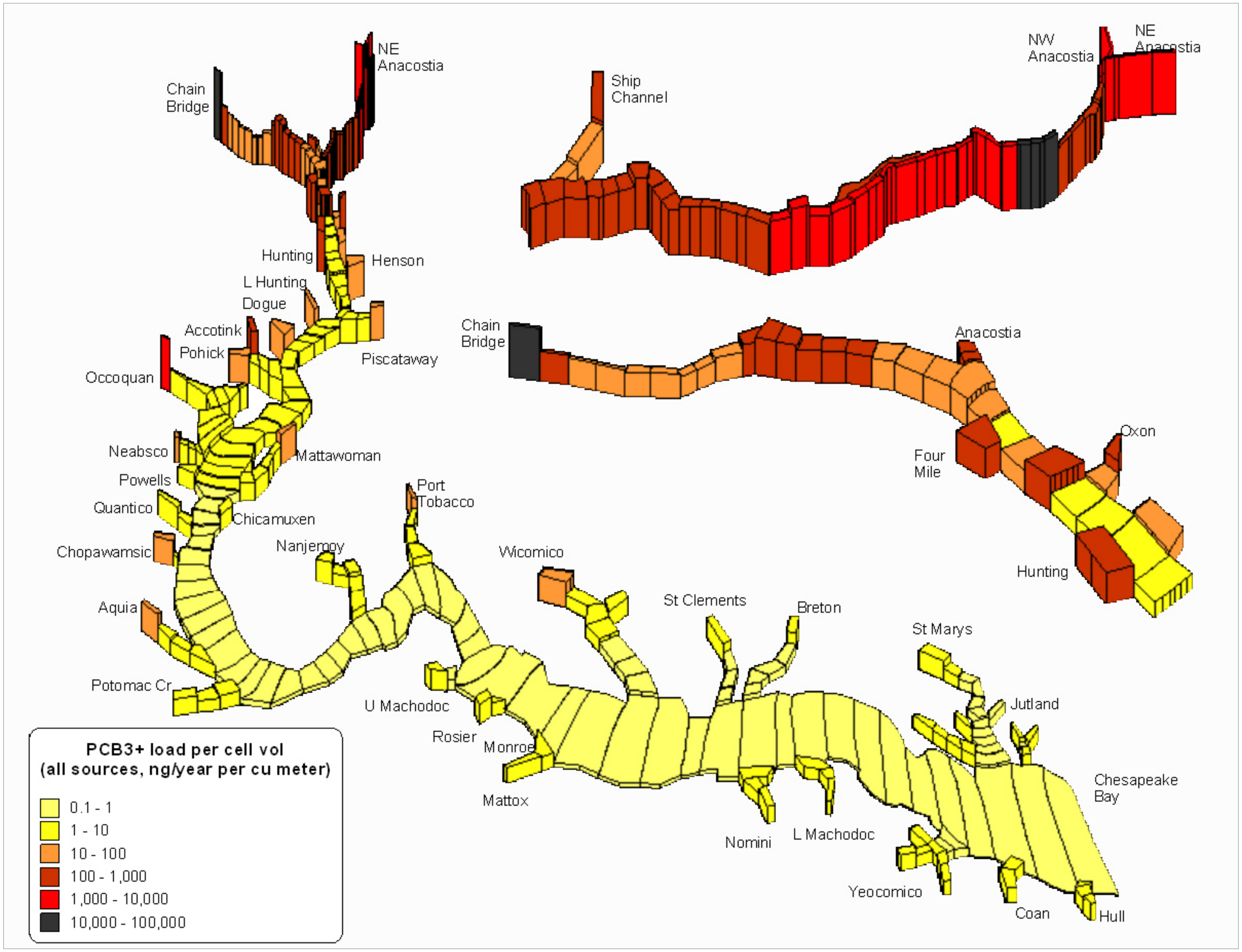
Based on the procedures described in this report, a median annual load of 30.9 kg PCB3+ was delivered to the Potomac estuary during the1994 - 2005 period. Approximately 58% of that load comes from the Potomac River at Chain Bridge. All non-point sources (Potomac River, lower basin tributaries, direct drainage, atmospheric deposition) combined account for approximately 93% of the total PCB3+ load. The remaining 7% comes from CSOs, WWTPs, and the identified contaminated sites. Delivery of non-point source PCBs is highly dependent on annual precipitation and runoff. Annual non-point source loads of PCB3+ in the 1994 - 2005 period ranged from 16.8 kg in 2002, an exceptionally dry year, to more than 128 kg in 1996, an unusually wet year. At Chain Bridge alone, annual PCB3+ loads ranged from 7.7 kg to 113 kg.

Direct drainage comprises about 55% of the lower Potomac watershed area, and contributes about 18.2% of the total PCB3+ load to tidal waters. Waters entering the estuary via the WM5-defined lower basin tributaries come from areas that comprise 45% of the lower Potomac watershed, yet they contribute only about 4.5% of the total PCB load to tidal waters. This may reflect the relative proportions of the higher PCB3+ loading rate zones in direct drainage and tributaries segments. Recalling that PCB loads are predicted based on regressions with TSS, it could also reflect higher TSS loads per unit area generated by the Chesapeake Bay Watershed Model in direct drainage areas, as compared to tributaries.

These estimates indicate that non-point sources are by far the major source of PCBs for the entire Potomac estuary. However, there are particular localities for which a significant fraction the total external PCB3+ load to a single PCB model segment comes from other source categories (WWTPs, CSOs, contaminated sites).

A review of total PCB3+ loads to each POTPCB model segment (Figure A-14) shows that the cells with the highest annual PCB loads per model segment volume ($ng/m^3/yr$) tend to be in the

Figure A-14. PCB3+ total load to each model segment, expressed as ng PCB3+/m^3/year. The polygons represent POTPCB model segments. The entire tidal system is shown in the larger figure. The two figures at the upper right show the Anacostia and the upper Potomac at an expanded scale for better resolution of model segments. Segment color and prism height indicate the annual PCB3+ load per segment volume, ng/m^3/yr.



upper estuary, in the District of Columbia and certain embayments in Maryland and Virginia. This should not be surprising since historical data show a strong gradient in PCB concentration away from DC and the load estimating methods used here are based on that data. Finding load reductions to meet water quality standards will be especially challenging because the District of Columbia has the lowest PCB standard while having the highest non-point source loading rates measured to-date.

2. Total PCBs

The POTPCB model TMDL scenarios produce output in PCB3+ units. Conversion factors are applied to the PCB3+ output to obtain the total PCB (tPCB) values needed for load allocation purposes. These conversion factors and a description of how they were developed are given in Appendix B. After conversion factors are applied to model output, it is evident that the general patterns of PCB3+ and tPCB loads are very similar. Loads of tPCBs from the non-tidal Potomac River are the largest source of PCBs, followed by direct drainage, atmospheric deposition, and the lower basin tributaries. These four, non-point source categories contribute approximately 93% of both the PCB3+ and tPCB annual loads. The median PCB3+ and tPCB loads for 1994-2005, by source category, are compared in Table A-11.

Table A-11. Median annual loads of PCB3+ and total PCBs (tPCBs) to the tidal Potomac River for 1994-2005, by source category. Values are rounded to nearest whole number. Notes: [1] 2002-2005 only; [2] equivalent to tPCB load. Waste water treatment plant loads do not include three facilities located in WM5-defined tributary watersheds (the two Beltsville USDA facilities and the UOSA facility). Annual load at these three facilities (total for all three) is estimated to be about 0.3 g/yr PCB3+ and is part of the tributary loads from those watersheds. Contaminated site loads do not include eight known contaminated sites located in tributary watersheds. The median annual loads from these eight sites (total for all eight) is estimated to be about 7.8 g/yr total PCBs and is part of the tributary loads from those watersheds.

Source Category	PCB3+ Load (g/yr)	tPCB Load (g/yr)
Non-tidal Potomac R at Chain Br	15,830	17,206
Direct drainage	4,976	5,409
Atmospheric deposition[2]	3,134	3,134
Lower basin tributaries	1,417	1,540
Combined sewer overflows[1]	1,190	1,239
Waste water treatment plants	704	765
Contaminated sites[2]	15	15

3. Particulate Carbon and Flow

The median annual PC load from all sources to the Potomac estuary for 1994 - 2005 was estimated to be 35.9 million kg/yr. The Potomac River at Chain Bridge accounted for approximately 75% of the overall PC load with a median value of 27.4 million kg/yr. All the lower basin tributaries and direct drainage accounted for 21%, WWTPs accounted for 3%, and CSOs accounted for <1%.

The median annual flow from all surface sources to the Potomac estuary for 1994 - 2005 was approximately 12,660 million m^3/yr. The median annual flow from the non-tidal Potomac River at Chain Bridge was 9,270 million m^3/yr, or roughly 3.4-fold greater than the median annual flow estimated for the direct drainage segments and WM5-defined tributaries in the lower basin. Annual flows from CSOs and WWTPs constitute between 2.4% and 7.7% of the total annual flow, depending on whether the year was dry or wet. The median annual flow for CSOs and WWTPs for 1994-2005 was 5.4%.

Table A-12. Average and median of the 1994 - 2005 annual particulate carbon (PC) load and flows for the different source categories for which PC and flow loads were calculated. Notes: [1] for 2002-2005 only.

Source Category	Median Annual PC Load (million kg/yr)	Median Annual Flow (million m^3/yr)
Non-tidal Potomac R at Chain Br	24.7	9,270
Direct drainage	3.92	1,532
Lower basin tributaries	5.26	1,168
Waste water treatment plants	1.06	668
Combined sewer overflows[1]	0.044	10

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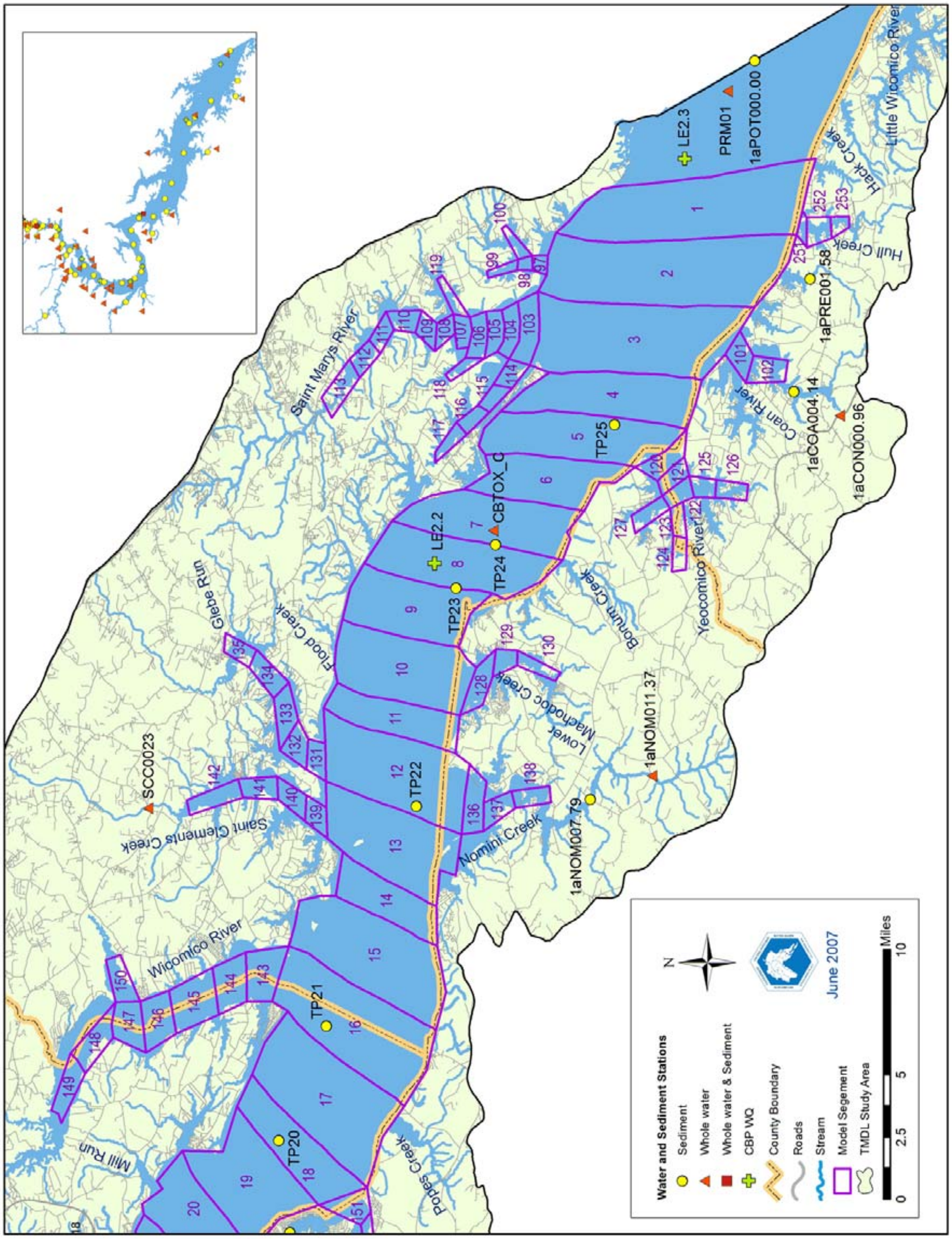
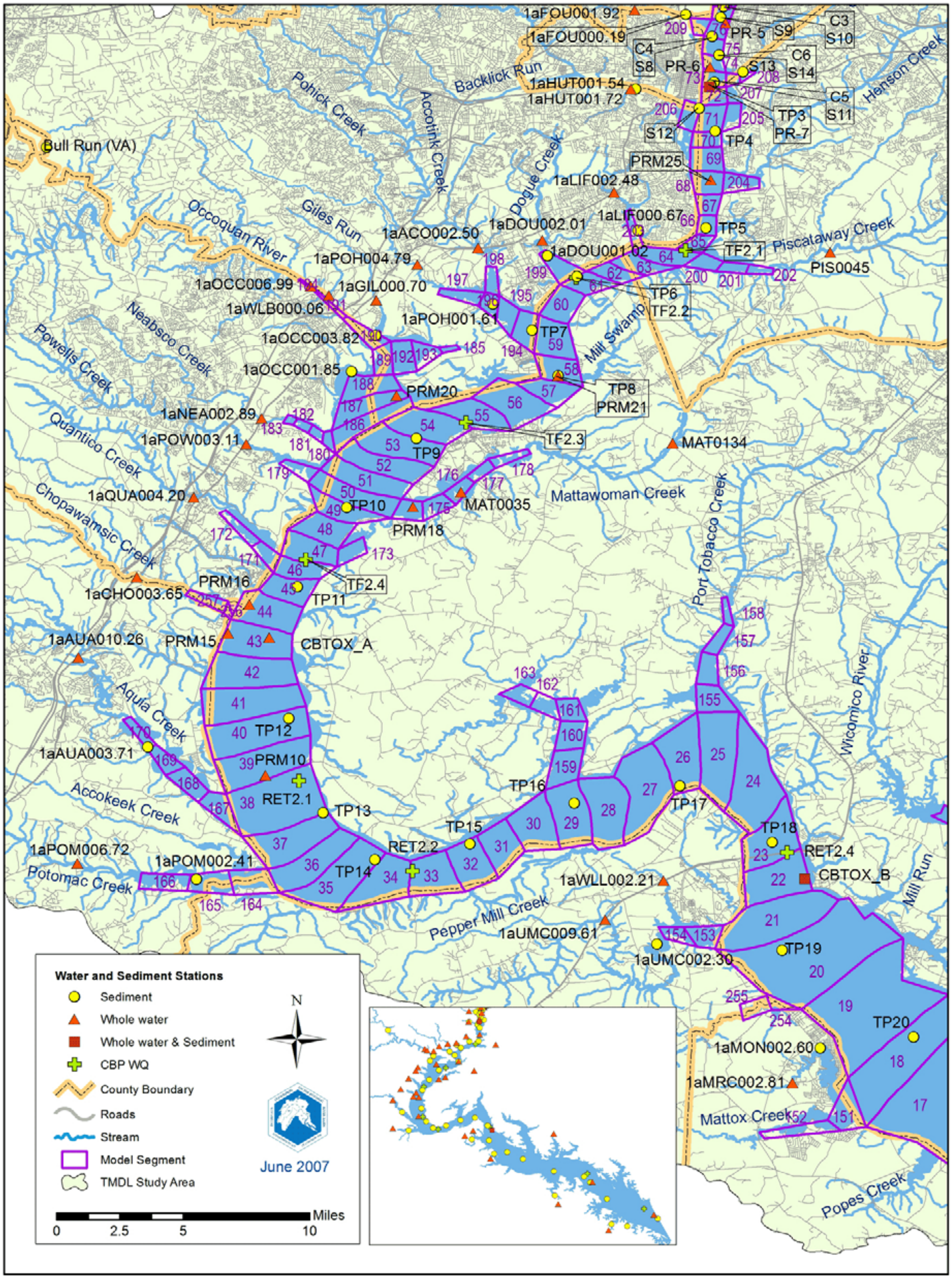
VII. SUPPLEMENTAL FIGURES AND TABLES

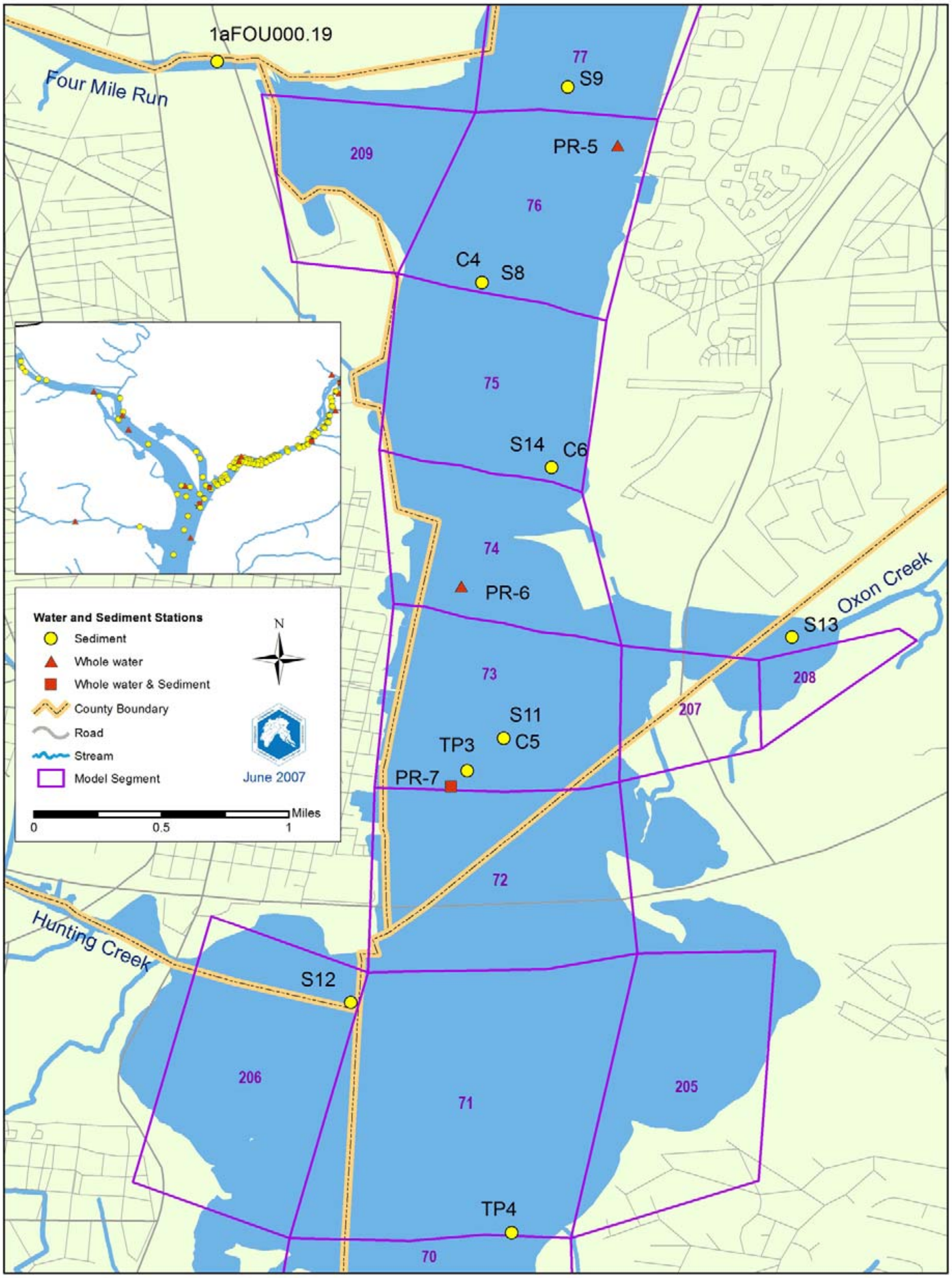
Figure A-15A - A-15G. POTPCB model spatial grid and adjacent watershed landmarks. Numbers indicate model segment designations. Symbols are sampling station locations.
A. Lower Potomac estuary



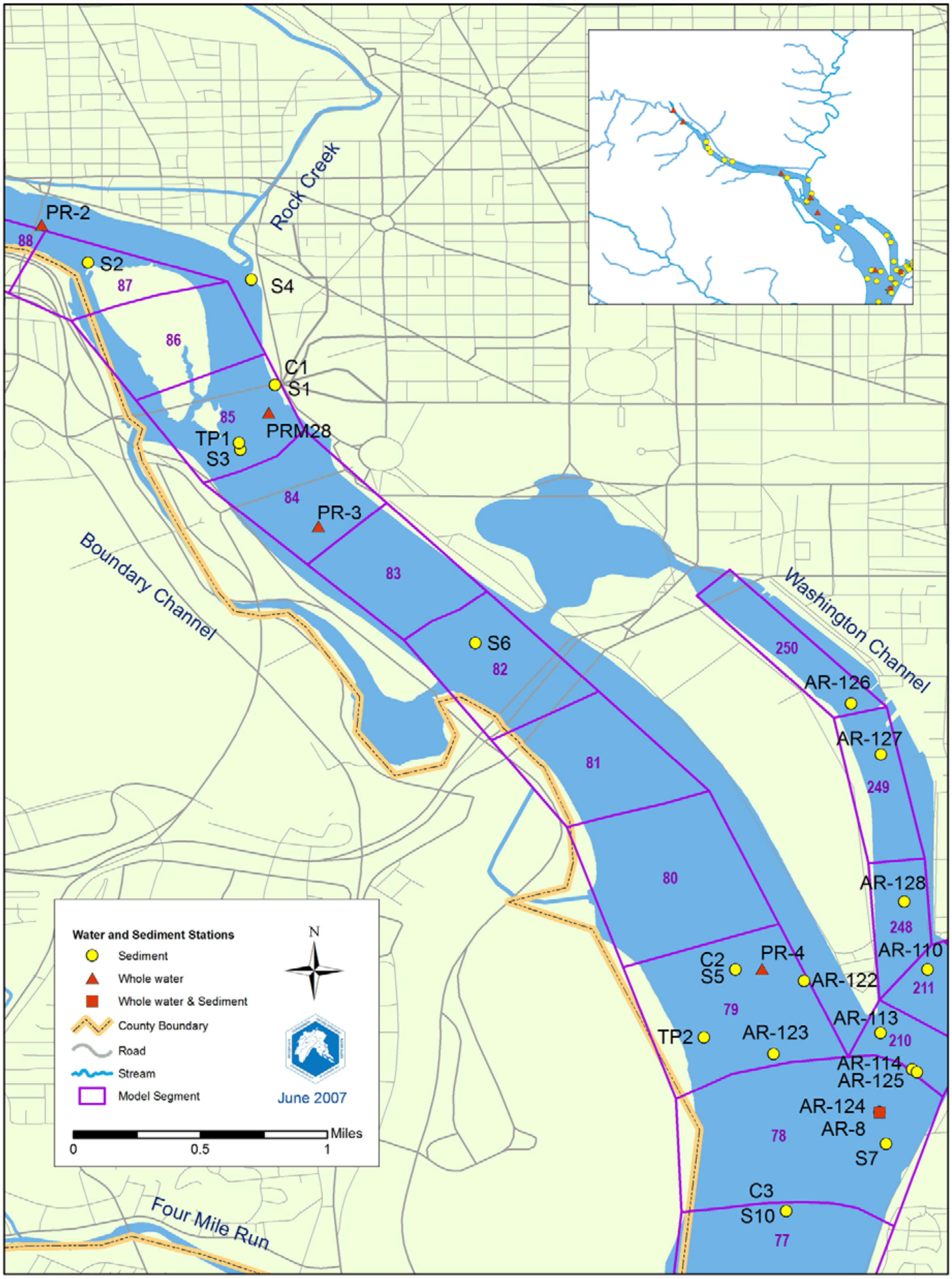
B. Middle Potomac



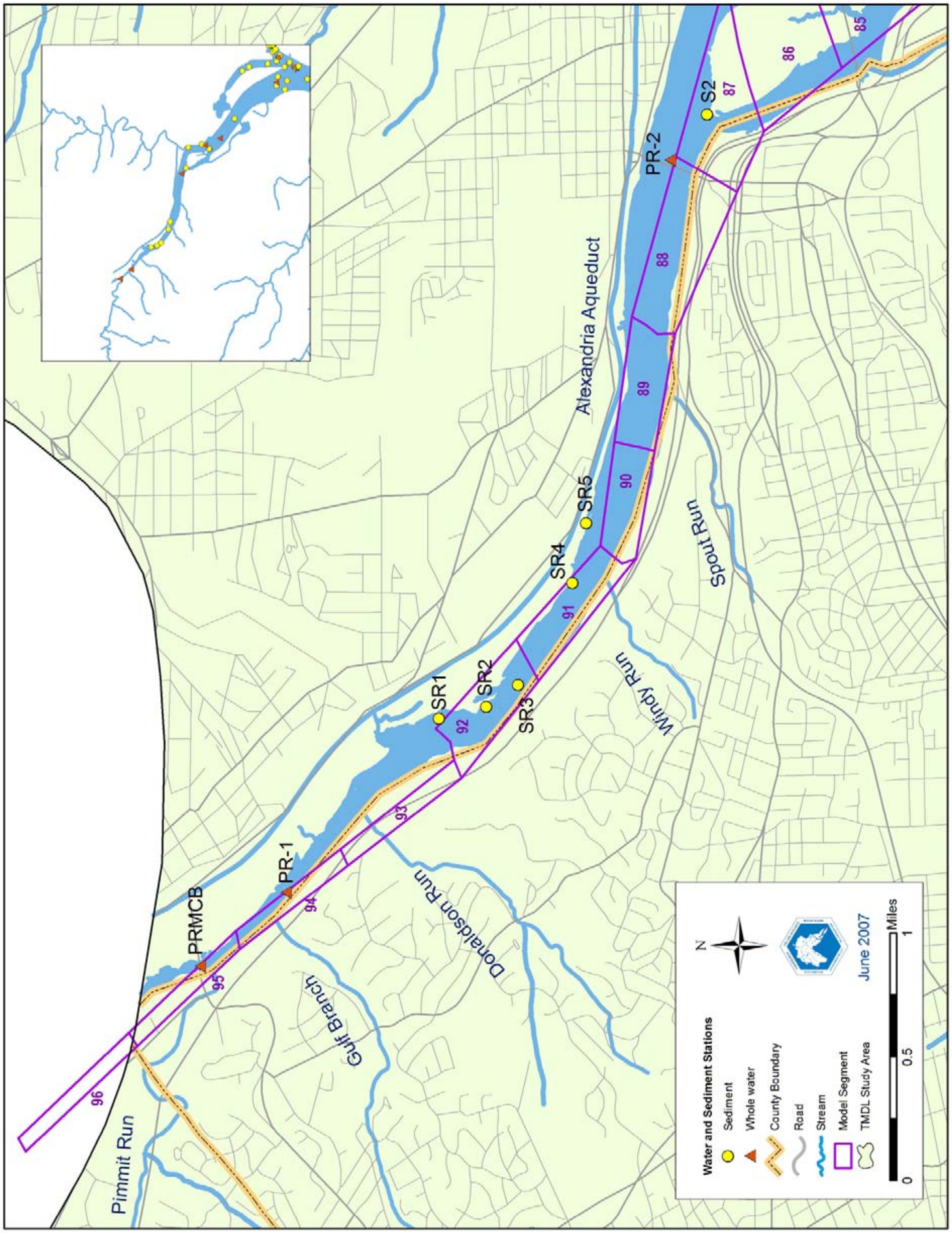
C. Tidal fresh Potomac below District of Columbia



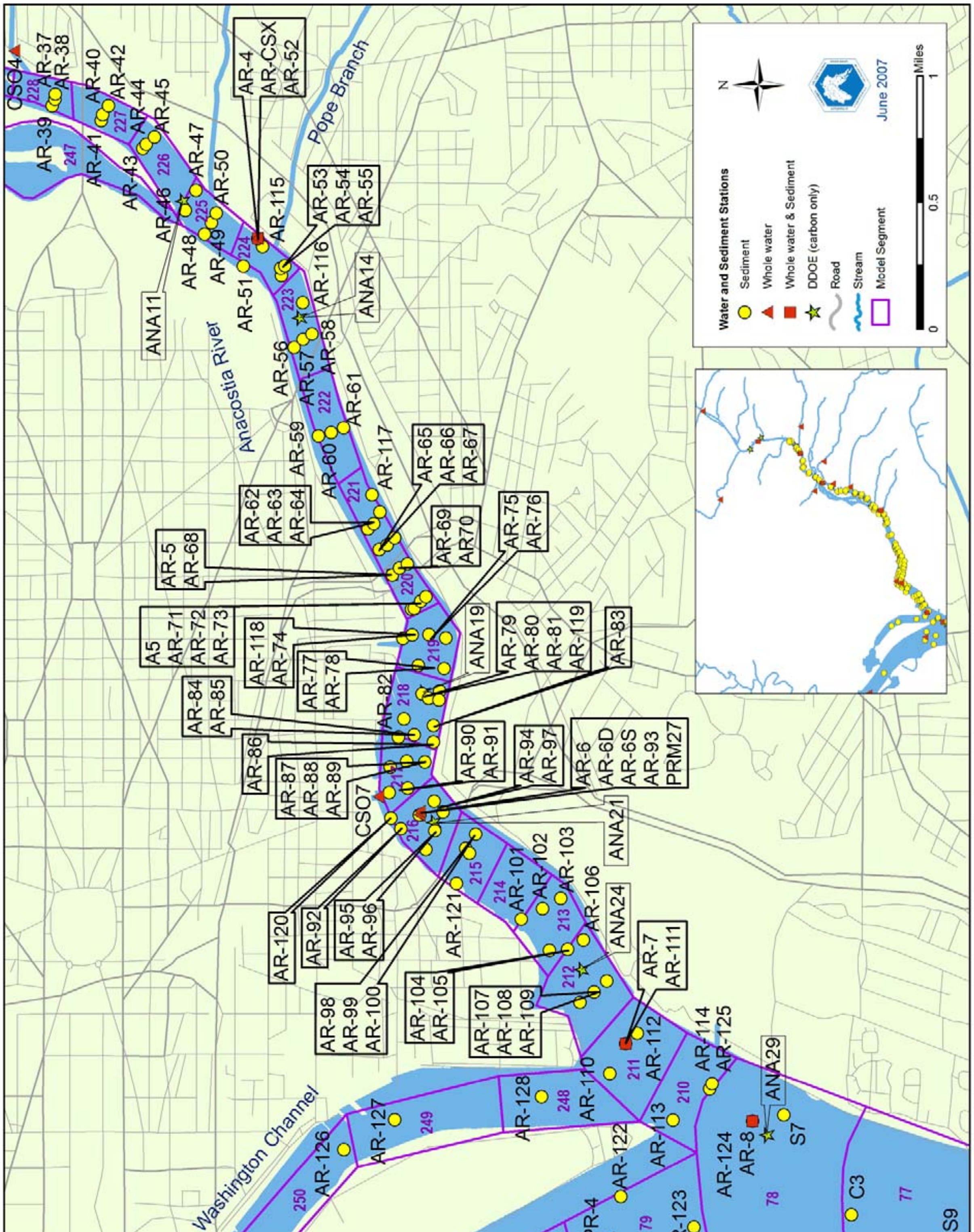
D. Tidal fresh Potomac between Roosevelt Island and Hains Pt in District of Columbia.



E. Tidal fresh Potomac above Roosevelt Island in the District of Columbia.



F. Lower Anacostia River.



G. Upper Anacostia River

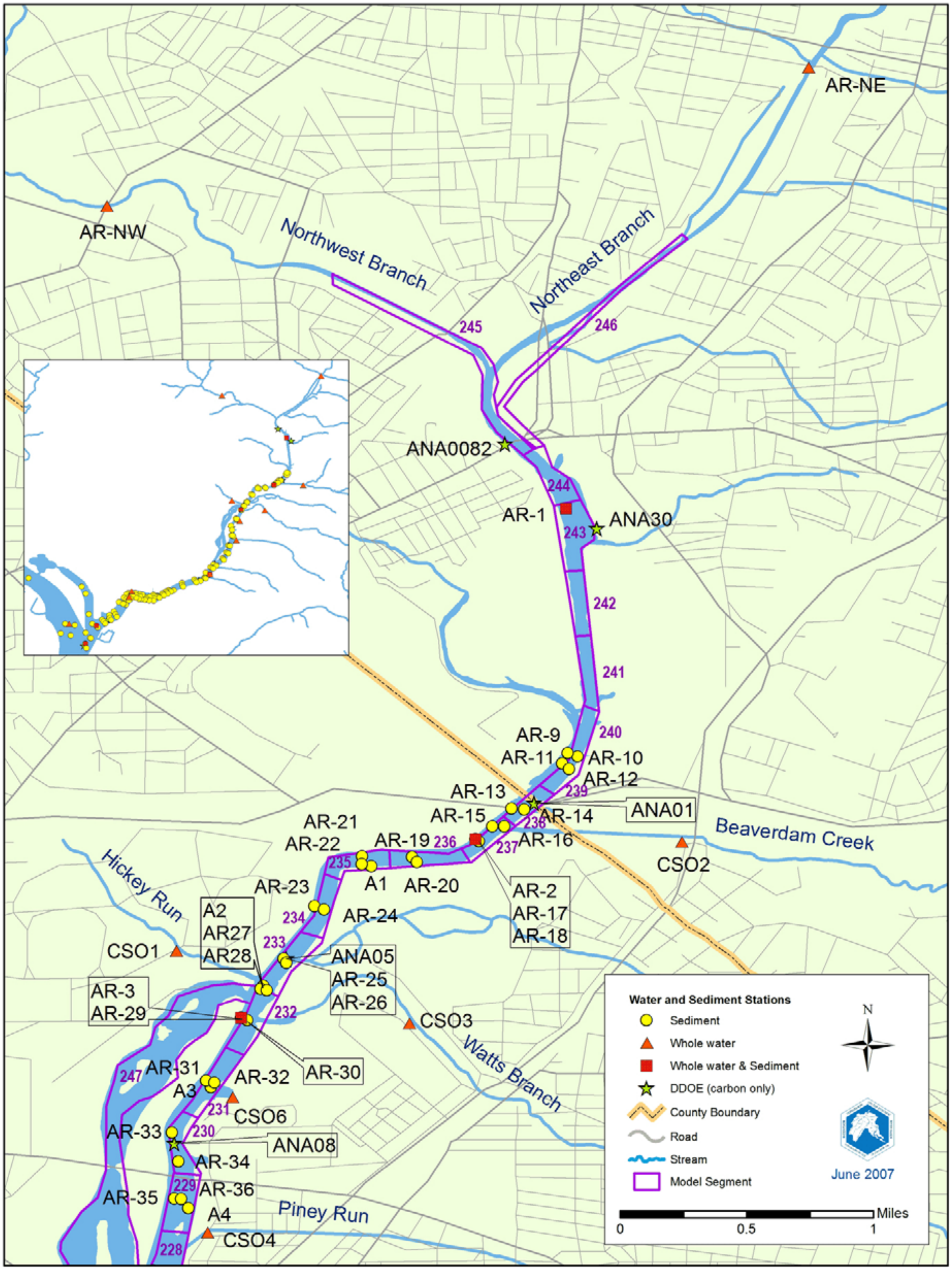


Table A-13. PCB3+ annual load (g/yr). Values are rounded to the nearest whole number. *Note: total PCB (homologs 1-10) annual load estimates for direct drainage, tributaries (includes Chain Bridge), WWTPs, and CSOs are obtained by applying the conversion factors described in Appendix B to the values in this table.* [1] statistics are for 2002-2005 only. [2] total PCB load (approximates PCB3+ load, see text for details). [3] The year 1996 included several extremely high flow events that were well outside the range of observed data used to develop the Flow:TSS relationship at Chain Bridge, so the TSS concentrations and the PC and PCB loads derived from those TSS values are not considered reliable.

	Direct drainage	Chain Bridge	Lower basin tributaries	WWTPs	CSOs[1]	Atmos.[2]	Contam. sites[2]	Sum of all source categories
1994	4,854	37,818	1,888	711	1,127	3,134	15	49,547
1995	4,975	13,850	1,207	671	1,190	3,134	15	25,042
1996[3]	8,617	112,707	3,257	736	1,193	3,142	15	129,668
1997	4,480	16,530	1,090	709	1,190	3,134	15	27,149
1998	4,978	47,978	1,823	707	1,190	3,134	15	59,824
1999	6,238	7,652	1,418	668	1,190	3,134	15	20,314
2000	4,176	9,959	1,075	695	1,195	3,142	15	20,257
2001	4,219	9,432	1,213	693	1,191	3,134	15	19,897
2002	3,763	8,958	905	679	624	3,134	15	18,078
2003	12,056	71,466	3,918	821	2,453	3,134	15	93,862
2004	6,330	27,234	1,415	732	1,148	3,142	15	40,017
2005	10,174	15,129	2,628	701	2,901	3,134	15	34,682
min	3,763	7,652	905	668	624	3,134	15	18,078
max	12,056	112,707	3,918	821	2,901	3,142	15	129,668
median	**4,976**	**15,830**	**1,417**	**704**	**1,800**	**3,134**	**15**	**30,916**
average	6,238	31,559	1,820	710	1,782	3,136	15	44,862

Table A-14. PCB3+ load as a percent of total load (see heading above for details).

	Direct drainage	Chain Bridge	Lower basin tributaries	WWTPs	CSOs[1]	Atmos.[2]	Contam. sites[2]	Sum of all source categories
1994	9.8%	76.3%	3.8%	1.4%	2.3%	6.3%	0.0%	100.0%
1995	19.9%	55.3%	4.8%	2.7%	4.8%	12.5%	0.1%	100.0%
1996	6.6%	86.9%	2.5%	0.6%	0.9%	2.4%	0.0%	100.0%
1997	16.5%	60.9%	4.0%	2.6%	4.4%	11.5%	0.1%	100.0%
1998	8.3%	80.2%	3.0%	1.2%	2.0%	5.2%	0.0%	100.0%
1999	30.7%	37.7%	7.0%	3.3%	5.9%	15.4%	0.1%	100.0%
2000	20.6%	49.2%	5.3%	3.4%	5.9%	15.5%	0.1%	100.0%
2001	21.2%	47.4%	6.1%	3.5%	6.0%	15.8%	0.1%	100.0%
2002	20.8%	49.6%	5.0%	3.8%	3.5%	17.3%	0.1%	100.0%
2003	12.8%	76.1%	4.2%	0.9%	2.6%	3.3%	0.0%	100.0%
2004	15.8%	68.1%	3.5%	1.8%	2.9%	7.9%	0.0%	100.0%
2005	29.3%	43.6%	7.6%	2.0%	8.4%	9.0%	0.0%	100.0%
min	6.6%	37.7%	2.5%	0.6%	0.9%	2.4%	0.0%	
max	30.7%	86.9%	7.6%	3.8%	8.4%	17.3%	0.1%	
median	**18.2%**	**58.1%**	**4.5%**	**2.3%**	**3.9%**	**10.3%**	**0.0%**	
average	17.7%	60.9%	4.7%	2.3%	4.1%	10.2%	0.0%	

Table A-15. PC annual load (million kilograms per year). Values rounded to the second decimal place. Notes: [1] statistics are for 2002-2005 only. [2] The year 1996 included several extremely high flow events that were well outside the range of observed data used to develop the Flow:TSS relationship at Chain Bridge. As a result, the TSS concentrations and the PC and PCB loads derived from those TSS values are not considered reliable.

	Direct drainage	Chain Bridge	Lower basin tributaries	WWTPs	CSOs[1]	Sum of all source categories
1994	4.15	63.56	7.77	1.06	0.04	76.60
1995	3.41	21.30	4.43	1.01	0.04	30.20
1996[2]	5.65	232.13	12.08	1.12	0.04	251.03
1997	2.10	26.13	3.47	1.06	0.04	32.81
1998	3.76	82.68	7.22	1.07	0.04	94.77
1999	4.32	10.99	4.99	1.00	0.04	21.34
2000	3.21	14.57	3.70	1.04	0.04	22.56
2001	2.84	13.94	3.98	1.03	0.04	21.83
2002	1.86	13.16	2.61	1.01	0.02	18.67
2003	7.15	127.07	14.43	1.23	0.09	149.97
2004	4.09	43.97	5.53	1.10	0.04	54.74
2005	5.28	23.32	9.18	1.07	0.11	38.96
min	1.86	10.99	2.61	1.00	0.02	18.67
max	7.15	232.13	14.43	1.23	0.11	251.03
median	**3.92**	**24.72**	**5.26**	**1.06**	**0.07**	**35.88**
average	3.99	56.07	6.62	1.07	0.07	67.79

Table A-16. PC load as a percent of total load (see heading above for details).

	Direct drainage	Chain Bridge	Lower basin tributaries	WWTPs	CSOs[1]	Sum of all categories
1994	5.4%	83.0%	10.1%	1.4%	0.1%	100.0%
1995	11.3%	70.5%	14.7%	3.4%	0.1%	100.0%
1996	2.2%	92.5%	4.8%	0.4%	0.0%	100.0%
1997	6.4%	79.6%	10.6%	3.2%	0.1%	100.0%
1998	4.0%	87.2%	7.6%	1.1%	0.0%	100.0%
1999	20.3%	51.5%	23.4%	4.7%	0.2%	100.0%
2000	14.2%	64.6%	16.4%	4.6%	0.2%	100.0%
2001	13.0%	63.8%	18.2%	4.7%	0.2%	100.0%
2002	10.0%	70.5%	14.0%	5.4%	0.1%	100.0%
2003	4.8%	84.7%	9.6%	0.8%	0.1%	100.0%
2004	7.5%	80.3%	10.1%	2.0%	0.1%	100.0%
2005	13.6%	59.8%	23.6%	2.8%	0.3%	100.0%
min	2.2%	51.5%	4.8%	0.4%	0.0%	
max	20.3%	92.5%	23.6%	5.4%	0.3%	
median	**8.7%**	**75.1%**	**12.3%**	**3.0%**	**0.1%**	
average	9.4%	74.0%	13.6%	2.9%	0.1%	

Table A-17. Annual freshwater flow (million m^3/year). Excludes precipitation directly to estuary surface. Values rounded to the nearest million m^3. Notes: [1] statistics are for 2002-2005 only. [2] The year 1996 included several extremely high flow events that were well outside the range of observed data used to develop the Flow:TSS relationship at Chain Bridge. As a result, the TSS concentrations and the PC and PCB loads derived from those TSS values are not considered reliable.

	Direct drainage	Chain Bridge	Lower basin tributaries	WWTPs	CSOs[1]	Sum of all source categories
1994	1,981	14,900	1,718	669	10	19,277
1995	1,235	8,275	1,006	636	11	11,163
1996 [2]	2,324	24,898	2,241	704	11	30,177
1997	1,298	9,090	1,063	667	11	12,129
1998	1,745	16,273	1,559	677	11	20,264
1999	1,250	5,712	961	633	11	8,566
2000	1,458	6,834	1,007	659	11	9,969
2001	1,225	6,298	928	655	11	9,116
2002	926	6,053	685	637	6	8,307
2003	2,818	22,805	2,671	776	22	29,091
2004	1,608	13,856	1,273	694	10	17,441
2005	1,616	9,451	1,430	672	25	13,195
min	926	5,712	685	633	6	8,307
max	2,818	24,898	2,671	776	25	30,177
median	**1,533**	**9,270**	**1,168**	**668**	**16**	**12,662**
average	1,624	12,037	1,378	673	16	15,725

Table A-18. Annual freshwater flow as a percent of total source category flows (see heading above for details). Excludes direct precipitation to estuary surface.

	Direct drainage	Chain Bridge	Lower basin tributaries	WWTPs	CSOs	Sum of all categories
1994	10.28%	77.29%	8.91%	3.47%	0.05%	100.00%
1995	11.07%	74.13%	9.01%	5.70%	0.09%	100.00%
1996	7.70%	82.51%	7.43%	2.33%	0.03%	100.00%
1997	10.71%	74.94%	8.76%	5.50%	0.09%	100.00%
1998	8.61%	80.31%	7.69%	3.34%	0.05%	100.00%
1999	14.59%	66.68%	11.22%	7.39%	0.12%	100.00%
2000	14.62%	68.55%	10.10%	6.61%	0.11%	100.00%
2001	13.44%	69.09%	10.18%	7.18%	0.12%	100.00%
2002	11.14%	72.87%	8.24%	7.67%	0.07%	100.00%
2003	9.69%	78.39%	9.18%	2.67%	0.07%	100.00%
2004	9.22%	79.45%	7.30%	3.98%	0.06%	100.00%
2005	12.24%	71.63%	10.84%	5.10%	0.19%	100.00%
min	7.7%	66.7%	7.3%	2.3%	0.0%	
max	14.6%	82.5%	11.2%	7.7%	0.2%	
median	**10.9%**	**74.5%**	**9.0%**	**5.3%**	**0.1%**	
average	11.1%	74.7%	9.1%	5.1%	0.1%	

APPENDIX B

USE OF PCB3+ IN POTOMAC PCB MODELING AND PCB3+ CONVERSION TO TOTAL PCB

This appendix provides the rationale and justification for the selection of PCB homologs 3-10 (PCB3+) as a surrogate for total PCBs in modeling the transport and fate of PCBs in the Potomac estuary. It also explains the approach used to convert PCB3+ model out to total PCBs.

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Appendix B

Use of PCB3+ in Potomac PCB Modeling and PCB3+ Conversion to Total PCB

I. BACKGROUND

The Potomac River estuary was listed as impaired under Section 303(d) of the Clean Water Act due to the levels of total polychlorinated biphenyls (tPCBs) in the tissues of several fish species. PCBs are a class of synthetic compounds that were typically manufactured through the progressive chlorination of batches of biphenyl to achieve a target percentage of chlorine by weight. PCBs are not a unique chemical compound. Individual PCB compounds called congeners can have up to 10 chlorine atoms attached at different sites to a basic biphenyl structure consisting of two connected rings of six carbon atoms each. There are 209 patterns in which chlorine atoms may be attached, resulting in 209 possible compounds, or congeners. These congeners can be grouped into “homologs” defined by the number of chlorine atoms attached to the carbon rings. For example, PCB compounds that contain five chlorine atoms comprise a homolog referred to as pentachlorobiphenyls or penta-PCBs.

The Water Quality Standards (WQS) that form the basis for the PCB TMDLs in DC, MD and VA waters are for total PCBs, or the sum of all 209 congeners. The WQS are expressed as total PCB concentrations in the water column, as are the fish tissue screening thresholds. This is consistent with the EPA human health national criteria for PCBs which are expressed in terms of total PCBs, applied to both water and fish consumption. Although there may be differences in homolog distributions among sources, ambient conditions and impacted resources in a particular system, the current EPA criteria are still based on total PCBs.

II. TECHNICAL ISSUES

From a regulatory standpoint, all that matters is total PCBs. However, from a transport and fate modeling standpoint, it is not practical to model all 209 individual congeners. It is possible to represent total PCBs as a single variable by taking the grand averages of the physical-chemical properties of all 209 congeners and assigning them to a single state variable in the model. This approach would be scientifically unsound because these physical-chemical properties (e.g., octanol-water partition coefficients) can vary over four orders of magnitude from mono-PCBs to deca-PCBs. Consequently, such a “total PCB” state variable could only be characterized with a very large range of uncertainty.

One alternate approach is to aggregate the 209 congeners into 10 homologs, model each homolog, and then sum the results to form total PCBs. This would substantially decrease the range of uncertainty because the physical-chemical properties of individual homolog groups could be defined much more precisely than those of total PCBs. While technically feasible, this approach would involve 10 separate models and would be extremely intensive in terms of data, resources and schedule.
Another approach is to identify a surrogate homolog or group of homologs for total PCBs. In the ideal case, the concentrations of the surrogate would be proportional to total PCB concentrations

and it would include a small enough number of homologs so that the physical-chemical properties of the grouping could be reasonably well characterized. The feasibility of this approach is highly site-specific and depends on the spatial-temporal distributions of the various homolog groups among the sources, ambient conditions and the impacted resources, and the adequacy of the database. This is the approach used for the Potomac PCB model.

III. EXCLUSION OF HOMOLOGS 1 AND 2

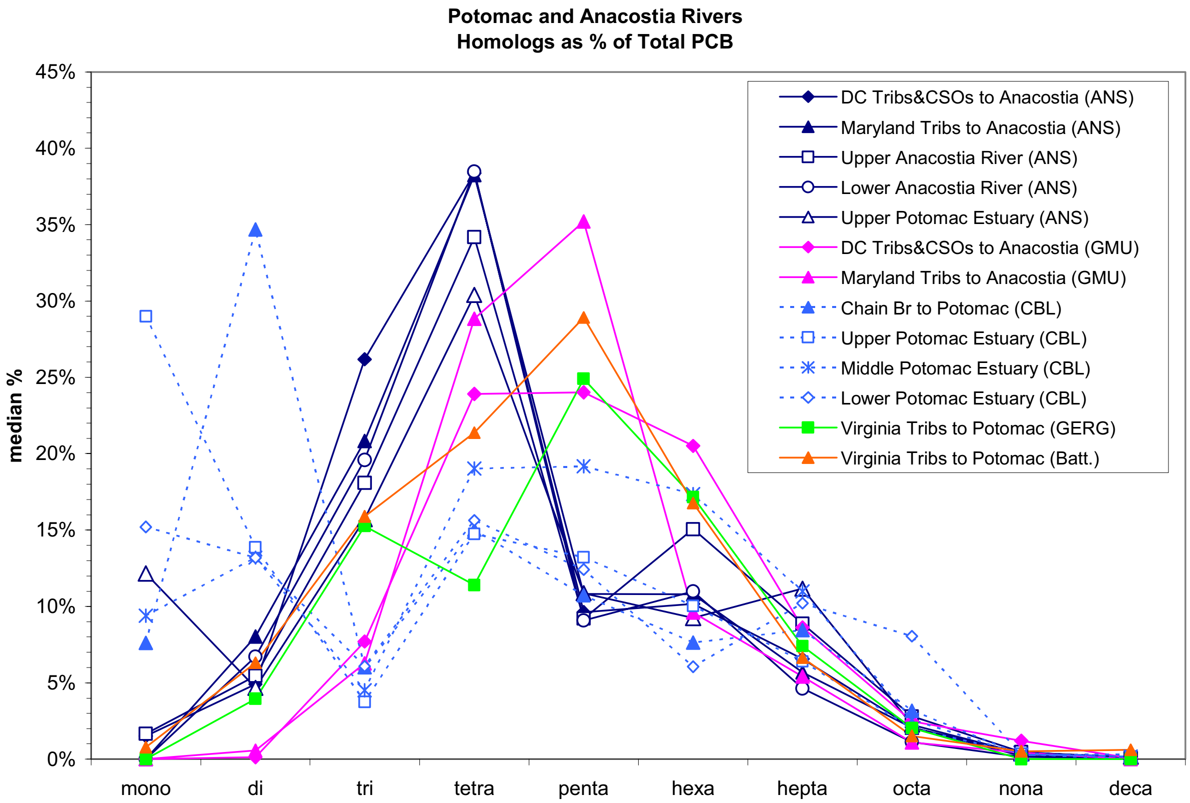
Only PCB data collected in or after 2000 were used so that the most recent, least variable, and most accurate estimates of PCB concentrations would be used to estimate external loads and characterize ambient conditions (Appendix A). The resulting pool of available data comes from five laboratories: Academy of Natural Sciences (ANS) in Philadelphia, George Mason University (GMU), Chesapeake Biological Laboratory (CBL), Geochemical and the Environmental Research Group of Texas A&M University (GERG), and Battelle Laboratories (Batt.). This time period decision is complicated by the fact that one of the laboratories, GMU, did not perform complete measurements of homologs 1 and 2. Inter-lab comparisons also reveal inconsistencies in homologs 1 and 2 data for the water column dissolved fraction in samples collected by CBL. Homologs 1 and 2 comprise more than 20% of total PCBs in the CBL data and usually less than 10% in data from all the other laboratories (Figure B-1). A comparison of samples collected at or near Chain Bridge and analyzed by CBL and ANS, and further illustrates the differences (Figure B-2). The particulate fraction shows a broad peak at homologs 5-7 in both the CBL and ANS data whereas the dissolved fraction has a sharp peak at homolog 2 (di-) in the CBL data and homolog 4 (tetra-) in the ANS data.

The PCB TMDL Steering Committee decided that it would not be technically sound to include homologs 1 and 2 in a surrogate for total PCBs. Due to their physical-chemical properties, homologs 1 and 2 behave differently than other homolog groups. They have lower partitioning to solids and higher volatility compared to other homologs, and thus do not accumulate to significant levels in fish tissue (~0.2 % of total PCBs in Potomac fish tissue samples). The Steering Committee believed it was reasonable to exclude homologs 1 and 2 since PCB concentrations in fish tissue are the underlying reason for the Potomac PCB TMDL. Any surrogate used for PCB modeling purposes should at least reflect fish tissue PCB homologs. In addition, there were inconsistencies in surrogate concentrations among the laboratories with respect to homologs 1 and 2.

IV. RATIONALE FOR SELECTION OF HOMOLOGS 3-10 (PCB3+) AS MODEL PARAMETER

The modeling objective of selecting a surrogate for total PCB that represents all sources (BFL tributaries, WWTPs), ambient conditions (sediments, whole water, suspended particulates) and impacted resources (filets of bottom feeding fish) is complicated by the great variability in the distributions of homologs 3-10 in the Potomac estuary and its tributaries. Peaks in the homolog distributions are apparent in homologs 3-7, depending on the media, with lower percentages occurring in the tails of the distribution.

Figure B-1. Distributions of PCB homologs in the water column. The median value of each homolog expressed as a percent of total PCBs is shown. Data were collected between 2002 and 2005, and are grouped by location and laboratory. ANS, Academy of Natural Sciences in Philadelphia; GMU, George Mason University; CBL, Chesapeake Biological Laboratory; GERG, Geochemical and the Environmental Research Group of Texas A&M University; Battelle, Battelle Laboratories.

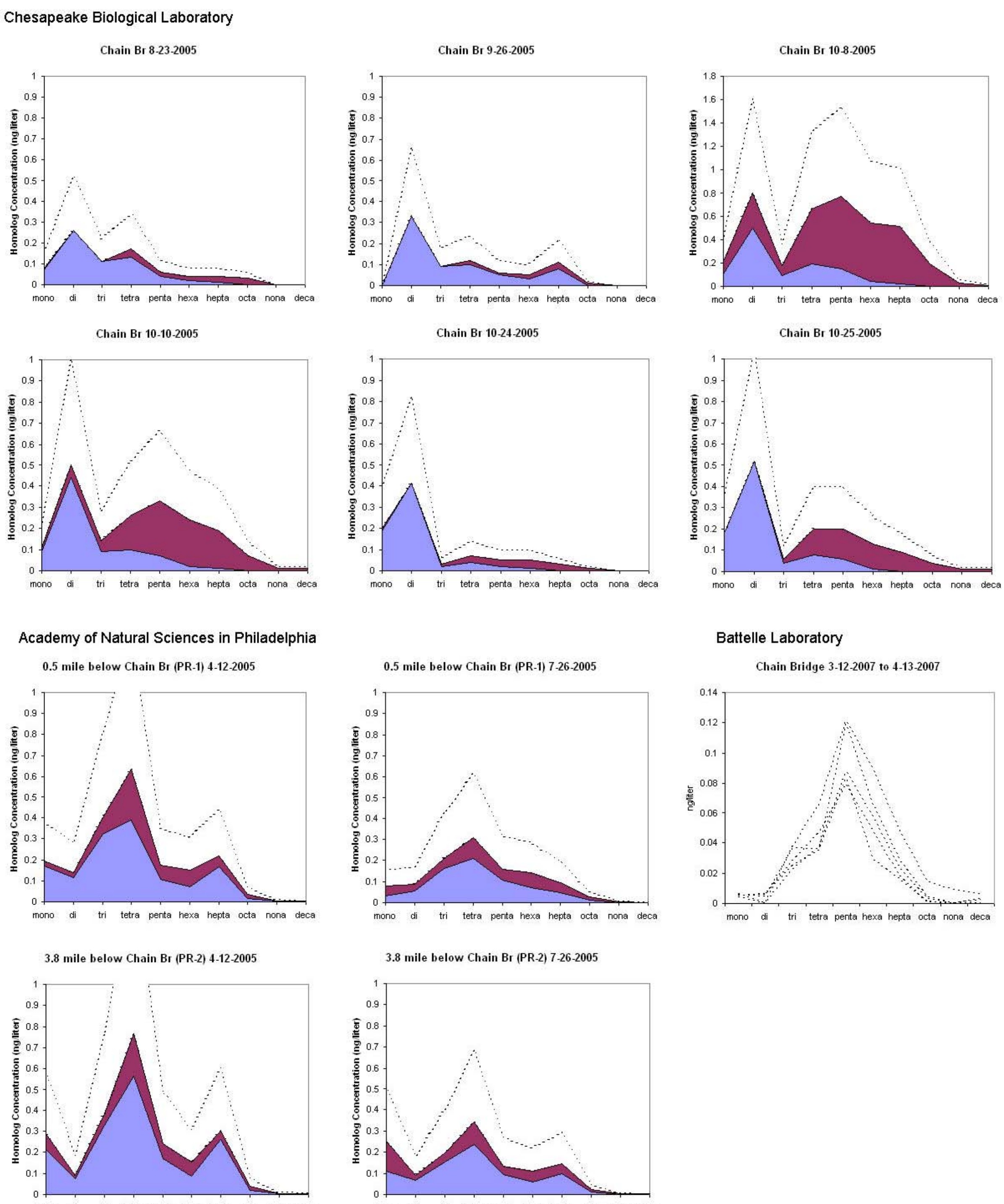


PCB homologs 5-7 (i.e., penta-, hexa-, and hepta-PCBs) are the dominant homologs measured in filets of bottom feeding estuarine fish, with peak concentrations occurring in homolog 6. Homologs 5-7 comprise about 77% of PCB3+ in the fish tissue, while lower weight (3-4) and higher weight (8-10) homologs make up approximately 17% and 6% of PCB3+, respectively (Figure B-3).

The homolog distribution in bottom sediments, the habitat of the invertebrate food organisms of these fish, is somewhat different (Figure B-4). Homologs 5-7 make up about 68% of PCB3+ and show a broad peak. Sources of bottom sediment are tributary runoff, including the sediment loads at Chain Bridge, and resuspension of existing bottom sediments. Homologs 4-7 are the dominant PCB forms in suspended particulates in the water column, with a tetra-PCB peak (Figure B-5). They comprise about 84% of the PCB3+, with lower weight (3) and higher weight (8-10) homologs each making up 8% of PCB3+.

Homologs 3-4 are the dominant PCB forms dissolved in the estuarine water column, also with a tetra-PCB peak (Figure B-6). They comprise about 65% of PCB3+, and higher weight (5-10)

Figure B-2. Distribution of PCB homologs at or below Chain Bridge. The concentrations (ng liter^{-1}) of each PCB homolog in the dissolved and particulate fractions of whole water are shown for samples collected in 2005 at Chain Bridge by Chesapeake Biological Laboratory and 0.5 and 3.8 miles below Chain Bridge by Academy of Natural Sciences. Total PCB homolog concentrations (ng liter^{-1}) are shown for samples collected at Chain Bridge in 2007 by VADEQ and analyzed by Battelle Laboratories. Key: ■, dissolved; ■, particulate; ---, total.



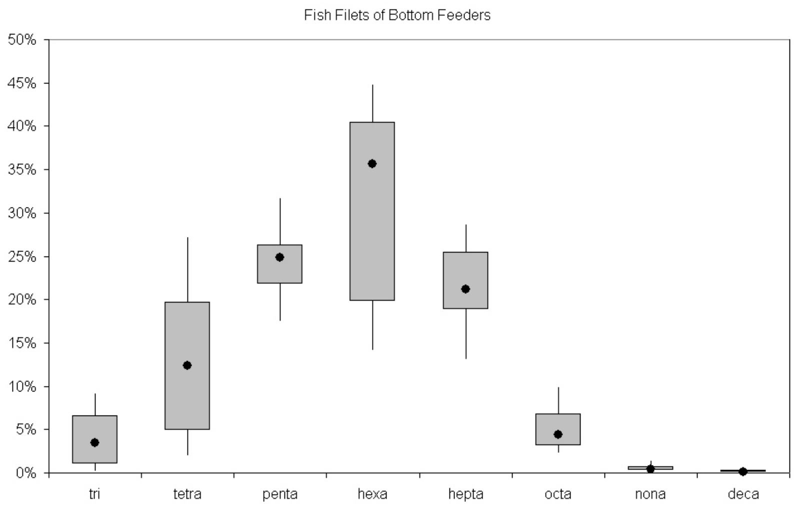


Figure B-3. Distribution of PCB homologs in filets of bottom feeding fish, as percent of PCB3+. Bars and whiskers indicate 5th%, 25th%, 75th %, and 95th % and solid circle indicates 50th% of 53 samples collected 2000-2003 and analyzed for the MDE Fish Tissue Monitoring Program, VADEQ Routine Tributary Sampling, and US F&WS District of Columbia monitoring project. Percentages are calculated from homolog totals as reported by the laboratories (no correction for sample blanks. Collection sites range from the tidal fresh Potomac and the upper Anacostia River to Maryland Pt.

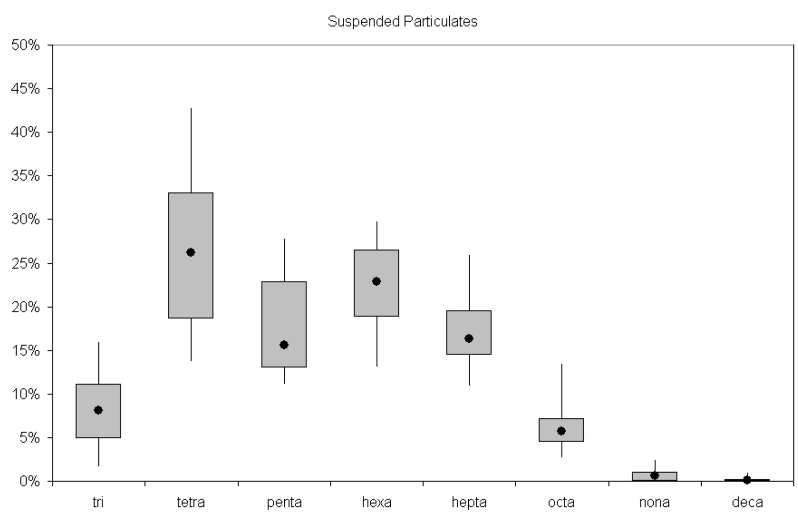


Figure B-4. Distribution of PCB homologs in bottom sediments, as percent of PCB3+. 308 samples collected 2000-2005 and analyzed by George Mason University (Dr. Greg Foster), the Academy of Natural Sciences in Philadelphia (Dr. David Velinsky), or Chesapeake Biological Laboratory (Dr. Joel Baker) for multiple agencies. Collection sites range from the tidal fresh Potomac and the upper Anacostia River to the mouth of the Potomac estuary. See Figure B-3 heading for details.

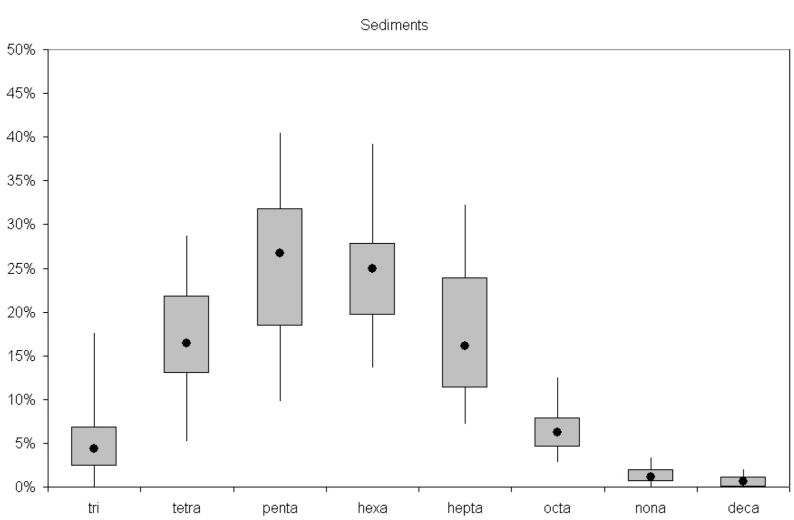


Figure B-5. Distribution of PCB homologs in suspended particulates, as percent of PCB3+. 76 samples collected 2002-2005 and analyzed by the Academy of Natural Sciences in Philadelphia (Dr. David Velinsky) or Chesapeake Biological Laboratory (Dr. Joel Baker). Collection sites range from the tidal fresh Potomac and the upper Anacostia River to the mouth of the Potomac estuary. See Figure B-3 heading for details.

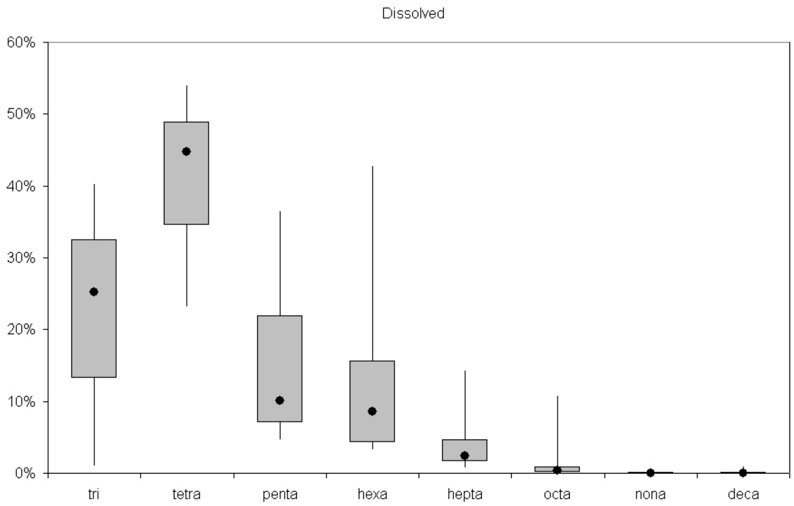


Figure B-6. Distribution of PCB homologs dissolved in estuarine waters, as percent of PCB3+. Bars and whiskers indicate 5^{th}%, 25^{th}%, 75^{th}%, and 95^{th}% and solid circle indicates 50^{th}% of 80 samples collected 2002-2005 and analyzed by the Academy of Natural Sciences in Philadelphia (Dr. David Velinsky) or Chesapeake Biological Laboratory (Dr. Joel Baker). Collection sites range from the tidal fresh Potomac and the upper Anacostia River to the mouth of the Potomac estuary. See Figure B-3 heading for details.

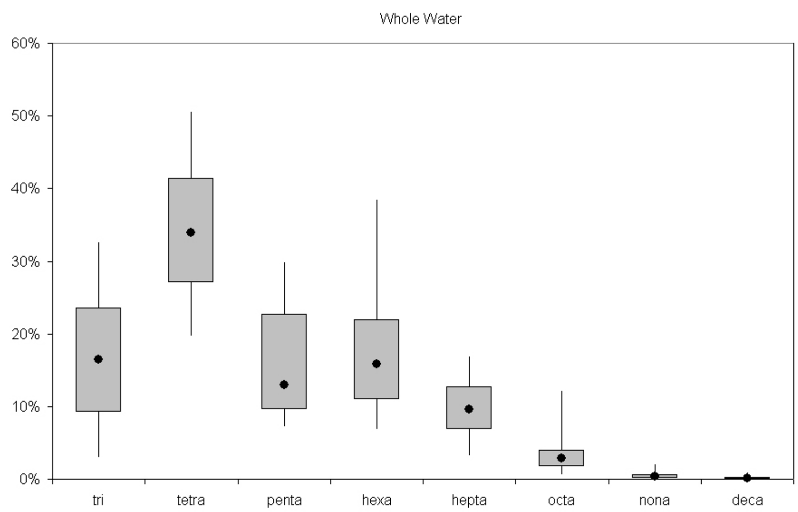


Figure B-7. Distribution of PCB homologs in whole water (particulate + dissolved) from the Potomac River estuary, as percent of PCB3+. Bars and whiskers indicate 5^{th}%, 25^{th}%, 75^{th}%, and 95^{th}% and solid circle indicates 50^{th}% of 81 samples collected 2002-2005 and analyzed by the Academy of Natural Sciences in Philadelphia (Dr. David Velinsky) or Chesapeake Biological Laboratory (Dr. Joel Baker). Collection sites range from the tidal fresh Potomac and the upper Anacostia River to the mouth of the Potomac estuary. See Figure B-3 heading for details.

homologs are 35% of PCB3+. Comparisons of the particulate and dissolved PCB homolog distributions in the water column suggest that the heavier homologs have a higher affinity for particulates. Particulate matter includes suspended sediments, detrital organic matter, and living phytoplankton and zooplankton, all of which are filtered out of the water column by suspension feeding bottom invertebrates or eventually settle onto bottom sediments where they are consumed by deposit-feeding infauna. Thus, bottom invertebrates are feeding on particles dominated by homologs 4-7 or on sediments with a mixture of homologs. The dominance of homologs 5-7 in tissues of bottom-feeding fish suggests bottom invertebrates and/or the fish are preferentially accumulating the penta-, hexa-, and hepta-PCBs in their tissues.

Homolog distributions of PCBs in whole water (particulate + dissolved) are dominated by tetra-PCBs but have a broad representation of the other homologs (Figure B-7). Whole water samples of PCBs in tributaries to the Potomac estuary also exhibit variability in their homolog distributions (Table B-1). Homolog peaks in samples collected from below fall-line tributaries

Table B-1. Average percentage of each homolog in PCB3+ in whole water (dissolved + particulate) for tributaries to the Potomac estuary. Highlighted values are the dominant homolog(s). Percentages are calculated from homolog totals as reported by the laboratories. No attempt was made to correct for congener level contaminants as indicated by sample blanks.

State/Tributary		n	tri	tetra	penta	hexa	hepta	octa	nona	deca
DC	Hickey Run	11	10%	25%	26%	24%	11%	3%	1%	0%
DC	Little Beaverdam Creek	9	13%	51%	21%	10%	4%	1%	1%	0%
DC	Watts Branch	8	8%	25%	35%	21%	7%	2%	2%	0%
DC	Misc. DC Tributaries	15	17%	31%	17%	19%	11%	4%	1%	0%
MD	Anacostia NE Branch	44	12%	31%	29%	17%	9%	2%	1%	0%
MD	Anacostia NW Branch	40	19%	36%	27%	9%	6%	2%	1%	0%
MD	Mattawoman Creek	2	19%	24%	28%	18%	6%	2%	2%	1%
MD	Piscataway Creek	2	26%	21%	25%	16%	7%	2%	1%	1%
MD	Potomac @ Chain Bridge	6	14%	27%	21%	16%	16%	5%	1%	0%
VA	Aquia Creek	2	21%	8%	29%	26%	10%	6%	0%	0%
VA	Chopawamsic Creek	3	31%	13%	24%	26%	6%	0%	0%	0%
VA	Coan Mill Stream	2	14%	23%	35%	18%	6%	1%	1%	2%
VA	Dogue Creek	2	17%	19%	30%	21%	9%	2%	1%	1%
VA	Four Mile Run	2	9%	17%	45%	17%	9%	2%	1%	0%
VA	Giles Run	3	30%	17%	17%	22%	11%	2%	0%	0%
VA	Hunting Creek	3	25%	19%	31%	15%	6%	3%	1%	0%
VA	Little Hunting Creek	2	22%	22%	25%	20%	9%	2%	1%	0%
VA	Monroe Crk. (1aMRC002.81)	2	9%	17%	33%	24%	8%	3%	3%	3%
VA	Occoquan River	1	13%	20%	27%	15%	11%	4%	3%	7%
VA	Pohick Creek	2	10%	12%	30%	19%	5%	15%	5%	4%
VA	Potomac Creek	2	12%	8%	24%	19%	16%	19%	0%	2%
VA	Quantico Creek	3	24%	10%	35%	13%	8%	11%	0%	0%
VA	Upper Machodoc Creek	2	7%	8%	24%	21%	4%	32%	0%	3%
VA	Williams Creek	2	3%	11%	41%	33%	3%	7%	1%	2%

range from homolog 2 to 8, with the majority of peaks occurring in homolog 4 or 5. The peak homologs comprise from 22% to 51% of PCB3+.

After considering the varied distributions of PCB homologs in bottom feeding fish, their habitats, and the tributary sources of PCBs to the Potomac estuary, the Steering Committee decided to develop the TMDL model specific to homologs 3-10 (PCB3+) rather than just one or two homologs. PCB3+ is more inclusive of all contaminant sources, and the broader congener distribution provides a larger target for the TMDL. Modeling PCB3+ will eventually facilitate reduction strategies among the various source categories, and will minimize concerns about homolog variability at different sites. Finally, it minimizes any potential disconnect between PCB sources and observed ambient data. It could be argued that homologs 9 and 10 should also be excluded because of their small contributions to sources, ambient conditions and impacted resources. As a practical matter, however, this would involve additional data processing steps beyond excluding homologs 1 and 2, and would not significantly affect the results.

A disadvantage of PCB3+ is that there will be more uncertainty in specification of physical-chemical properties than with a smaller group of homologs. This does not mean it will be impossible to develop a scientifically credible model. For example, PCB3+ was the surrogate variable for total PCBs in the transport and fate model for the Upper Hudson River RI/FS, and results from this model were approved by an Expert Panel of independent scientists and accepted by EPA Region 2.

V. CONVERSION OF PCB3+ MODEL OUTPUT TO TOTAL PCBS

The PotPCB model was run with different load scenarios to determine what PCB load reductions are needed to meet target water column and sediment concentrations (Appendix D). These targets, which are derived from fish tissue threshold concentrations, are defined for total PCBs; however, the source load inputs to the PCB model and the model outputs are both expressed as PCB3+. Equations were developed to translate model source load inputs and sediment and water column outputs expressed as PCB3+ into total PCBs, in order to compare them to the PCB sediment and water column targets.

1. Translating PCB3+ Model Output for Ambient Conditions to Total PCBs

PCB homolog data from the Academy of Natural Sciences (ANS) in Philadelphia, Texas A&M GERG, and Battelle Laboratories were used to develop a conversion factor for translating PCB3+ model output to total PCBs (Table B-2 and B-3). Samples analyzed by these three laboratories come from the Anacostia NE and NW branches, the Anacostia estuary mainstem and minor tributaries, the upper Potomac estuary mainstem between Chain Bridge and Alexandria, and the Virginia tributaries along the length of the Potomac mainstem to the mouth. Samples were limited to those collected between 2000 and 2006. George Mason University data cannot be used because mono- congeners were not measured. Chesapeake Biological Laboratory data was not used because of unresolved technical problems with their mono- and di- homolog measurements. Analysis of PCB data indicate that the median PCB3+ fraction is 91.9% (IQR 85.8%-94.4%), or an average 89.8% (SD 8.0%), of total PCBs in the water column (n = 142). Samples were collected across a wide range of TSS concentrations, the parameter used to estimate PCB loadings from direct drainage and tributaries (Figure B-8). Analysis of Potomac and Anacostia river sediment samples indicate that the median PCB3+ fraction is 89.9% (IQR 80.8% - 94.0%), or an average 85.7% (SD 12.5%), of total PCBs (n = 163). These samples were collected across a wide range of sediment carbon concentrations (Figure B-9). The median

Table B-2. Water column PCB3+ as percent of total PCBs, by laboratory, for samples collected 2002-2006. The 5th, 25th, median (50th), 75th and 95th percentiles are given. Based on these results, the steering committee selected a conversion factor of 92% for water column PCB3+.

Laboratory (n)	5th%	25th%	50th%	75th%	95th%	Locations (Year)
Battelle (26)	81.0%	89.8%	93.3%	95.7%	100.0%	Virginia and Maryland tribs (2005-2006)
GERG (25)	70.8%	91.7%	93.6%	100.0%	100.0%	Virginia tribs (2006)
ANS (91)	74.5%	85.2%	91.1%	93.3%	96.4%	Anacostia (2002), upper Potomac (2005)
CBL (36)	34.7%	52.4%	67.7%	80.1%	87.2%	Chain Br (2005), Potomac (2003, 2005)
Composite (142)	74.1%	85.8%	91.9%	94.4%	100.0%	Battelle + GERG + ANS

Table B-3. Surface sediment PCB3+ as percent of total PCBs, by laboratory, for samples collected 2002-2006. The 5th, 25th, median (50th), 75th and 95th percentiles are given. Based on these results, the steering committee selected a conversion factor of 90% for sediment PCB3+.

Laboratory (n)	5th%	25th%	50th%	75th%	95th%	Locations (Year)
ANS (163)	61.6%	80.8%	89.9%	94.0%	97.4%	Anacostia (2002), upper Potomac (2005)
CBL (34)	73.7%	80.5%	84.2%	89.7%	98.4%	Potomac and VA tribs (2003, 2005)

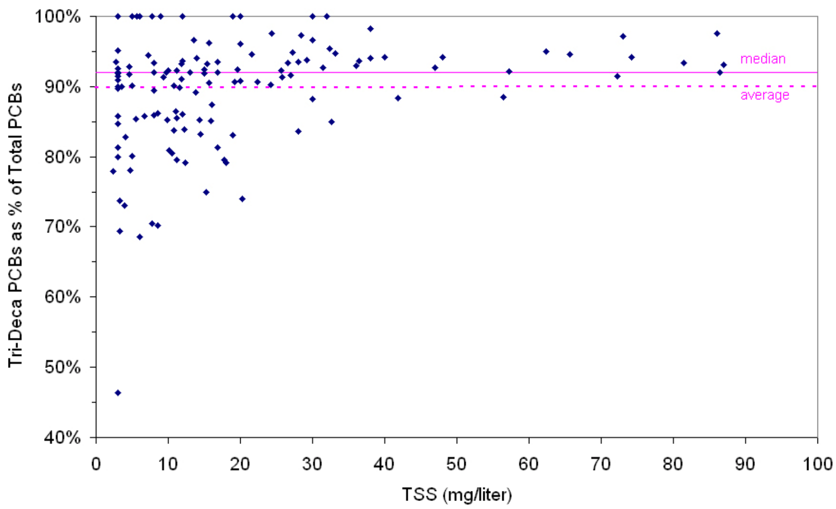


Figure B-8. %PCB3+ in water column *versus* total suspended solids (TSS). PCB analysis was done by ANS, GERG, and Battelle. The overall median (solid line) and average (dashed line) are shown.

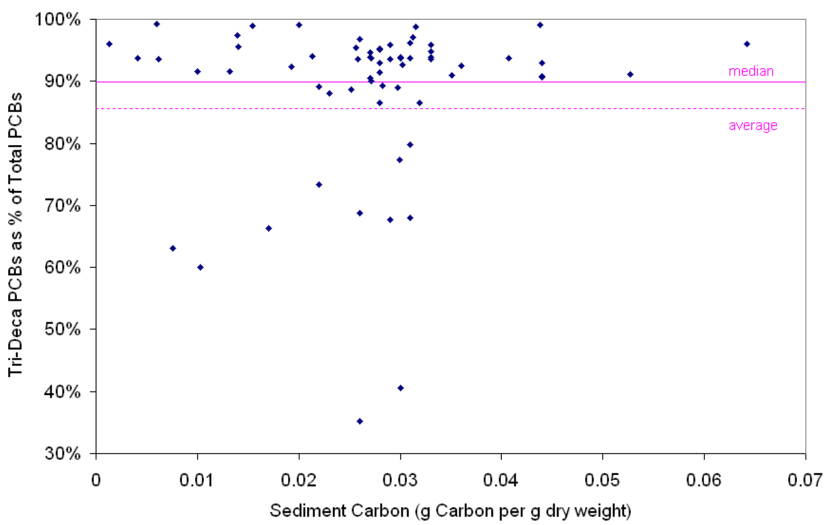


Figure B-9. %PCB3+ in surface sediments versus sediment carbon content. PCB analysis was done by ANS, GERG, and Battelle. The overall median (solid line) and average (dashed line) are shown.

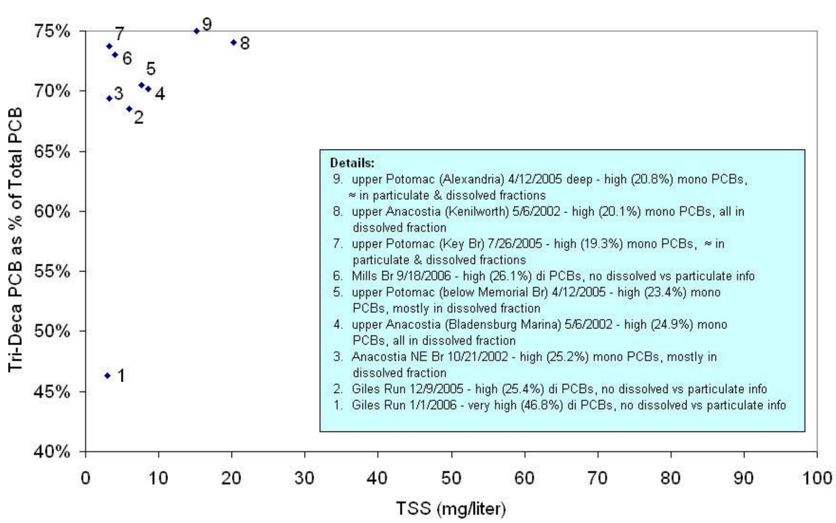


Figure B-10. Records with the lowest %PCB3+ in water column in Figure B-8. PCB analysis was done by ANS, GERG, and Battelle.

rather than the average is a better statistic to describe the central tendency of PCB3+ percentage because the percentages are not normally distributed.

There is high variability in the water column PCB3+ percentage at low TSS concentrations. Figure B-10 identifies those records with unusually low PCB3+ percentages ($\leq$75%) at low TSS concentrations. Most had either high mono- or high di- homolog concentrations, but not both, and these high mono- and di- concentrations occurred most often in the dissolved PCB fraction. Records with high PCB3+ percentages (>75%) typically had low mono- and di- concentrations in both the dissolved and particulate fractions, regardless of TSS concentration. The unusual mono- and di- content of water column samples with low PCB3+ percentages, compared to samples from comparable locations and dates, suggests these locations have PCB sources with distinctly different PCB "signatures" from other sources.

The Steering Committee reviewed this information and concluded:

a) the median rather than the average PCB3+ percentage should be used to derived a PCB3+-to-total PCB conversion factor because the percentages are not normally distributed;

b) CBL data should not be used to develop conversion factors for either water column or sediment because of unresolved issues regarding CBL homolog distributions;

c) model-predicted PCB3+ concentrations in the estuary water column and surface sediments will be converted to equivalent ambient total PCB concentrations by dividing water column PCB3+ (ng liter^{-1}) by 0.92 and sediment PCB3+ (ng g^{-1} sediment dry weight) by 0.90;

d) PCB3+ target concentrations for model scenarios will be derived by multiplying the water column total PCB target by 0.92 and the sediment total PCB target by 0.90.

The Steering Committee discussed the usefulness of measuring both the dissolved and particulate PCB fractions as a future approach to characterizing potential PCB sources.

2. Translating Source Loads Expressed as PCB3+ Back to Total PCBs

Source load allocations derived with the PCB model are expressed in terms of PCB3+ but TMDL load allocations should be set in terms of total PCBs for consistency with standards and criteria. A conversion factor was therefore identified for each source load.

Tributary sample data for the water column were included in the PCB3+-to-tPCB calculations in V (1) above, so the same conversion factor (0.92) was used to calculate TMDL load allocations for tPCBs from PCB3+ model load inputs. Tributary PCB3+ load allocations are divided by 0.92 to obtain tPCB loads.

Direct drainage load estimates were developed for the PotPCB model with the TSS:PCB3+ regressions generated from tributary PCB3+ and TSS water column data. The assumption was made that TSS concentrations in direct drainage waters have the same relationships with PCB3+ as TSS in tributary waters. In lieu of any independent information on the %PCB3+ in direct drainage runoff, the Steering Committee decided to use the tributary conversion factor (0.92). Direct drainage PCB3+ load allocations were divided by 0.92 to obtain tPCB loads.

Waste water treatment plants (WWTPs) effluent samples contained PCBs that were 35% to 100% PCB3+, with a median of 93.2%, in results that were not blank-adjusted (n = 33). WWTP load inputs to the PotPCB model, however, were blank-adjusted at the request of the WWTPs. The median percent of PCB3+ in the blank-adjusted sample results was 92.2%. WWTP PCB3+ load allocations derived with the PotPCB model were divided by 0.92 to obtain total PCB loads. Not enough samples were available to develop reliable site-specific conversion factors.

Combined sewer overflow (CSO) discharges in Washington, DC and Alexandria are poorly sampled. Only two recent samples are available that were analyzed for the full suite of congeners (GERG). The %PCB3+ of these two samples is 96.2%. In lieu of additional data, modeled CSO PCB3+ load allocations were divided by 0.96 to obtain tPCB loads.

Atmospheric deposition inputs to the PotPCB model were tPCB loads derived from a Chesapeake Bay Program Atmospheric Deposition Study (CBP 1999) because more recent data for the Potomac region are lacking (Appendix A). Atmospheric deposition in the PotPCB model comes from PCBs in precipitation (wet deposition) and the particulate phase of dry deposition. The assumption was made that homologs 1-2 are a negligible fraction of tPCBs in both precipitation and particulate deposition. Hence, no PCB3+-to-tPCB conversion factor was necessary and atmospheric PCB3+ loads are approximately equal to tPCB loads.

This assumption is based on the results of an extensive atmospheric deposition study for the Delaware PCB TMDL (DRBC 2006, C. App personal communication). The Delaware results indicate PCB3+ were close to 100% of the reported tPCBs in both precipitation and the particulate phase. These percentages were approximate because homolog 1 was not measured in the Delaware study, and homolog 2 was analyzed in some samples at just two sites, Camden (n=85) and Cape May/Delaware Bay (n=36). The Camden site is representative of a highly impacted urban area, and had the highest atmospheric loads of any of the sites monitored. The median proportions of homolog 2 were 0.9% in particulate (0% - 10.4%) and 1.0% in precipitation (0.2% - 8.0%). The Cape May site is probably representative of regional background values and somewhat similar to the lower Potomac estuary. This site had relatively low atmospheric loads of PCB. Homolog 2 was not detected in the particulate phase.

It is difficult to make conclusive statements about the percentages of homologs 1 and 2 in atmospheric deposition since the Delaware monitoring program did not include homolog 1 as part of the monitoring program and has limited homolog 2 data. However, there is enough data, when considered along with the properties of homologs 1 and 2, to support the assumption that there is very little homolog 1 or 2 in the particulate phase of dry deposition or in precipitation, even in heavily impacted sites. PCB3+ approximates tPCB concentrations in precipitation, or wet deposition.

Contaminated and remediated sites information provided by the states contains no data about the %PCB3+. PCB3+ loads were treated as equivalent to total PCB loads for this source. The magnitude of this load relative to other sources is very small, so the impact of this approximation is insignificant.

VI. REFERENCES

CBP (Chesapeake Bay Program). May 1999. Chesapeake Bay Basin Toxics Loading and Release Inventory. EPA 903-R99-006. U.S. EPA Chesapeake Bay Program, Annapolis, MD.

DRBC (Delaware River Basin Commission). 2006. Revised Calibration of the Water Quality Model for the Delaware Estuary For Penta-PCBs and Carbon. Delaware River Basin Commission, Trenton, NJ.

APPENDIX C

SELECTING THE HYDROLOGIC DESIGN YEAR FOR THE TIDAL POTOMAC PCB TMDL

This appendix provides the rationale and justification for the selection of 2005 as the hydrologic design year for the POTPCB model.

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Appendix C

Selecting the hydrologic design year for the tidal Potomac PCB TMDL

I. BACKGROUND

Prior studies have shown that PCB concentrations in the sediment layer reach equilibrium with changed loading inputs only after decades (EPA 2000, 2003). Therefore, models intended to show what loading inputs will meet water quality standards at equilibrium must simulate a multi-year long time series. The usual procedure is to select a short time series (e.g., one year) of hydrologic and load inputs, representing a critical flow condition and desired load scenario, and cycle that short time series repeatedly. The US EPA recommends using the harmonic mean flow as the critical flow condition for TMDLs for substances whose human health impact is derived from lifetime exposure (EPA 1991). Harmonic mean flow is calculated as

$$H = n / \Sigma(1/Q_i)$$

Where H = harmonic mean flow, cfs

n = number of observations

Q_i = daily mean flow for day i

Early estimates of PCB loads to the tidal Potomac suggest that the contribution of the non-tidal Potomac River, and tributaries and direct drainage to the estuary varies from 58% to 89% (average 77%) of the total annual PCB load, depending on annual hydrology. Thus the selection of the hydrologic conditions to be simulated in TMDL scenarios will have a significant impact on TMDL loads. After reviewing several options, the Steering Committee selected calendar year 2005 (1/1/2005 – 12/31/2005) as the hydrologic cycling year for the tidal Potomac PCB model.

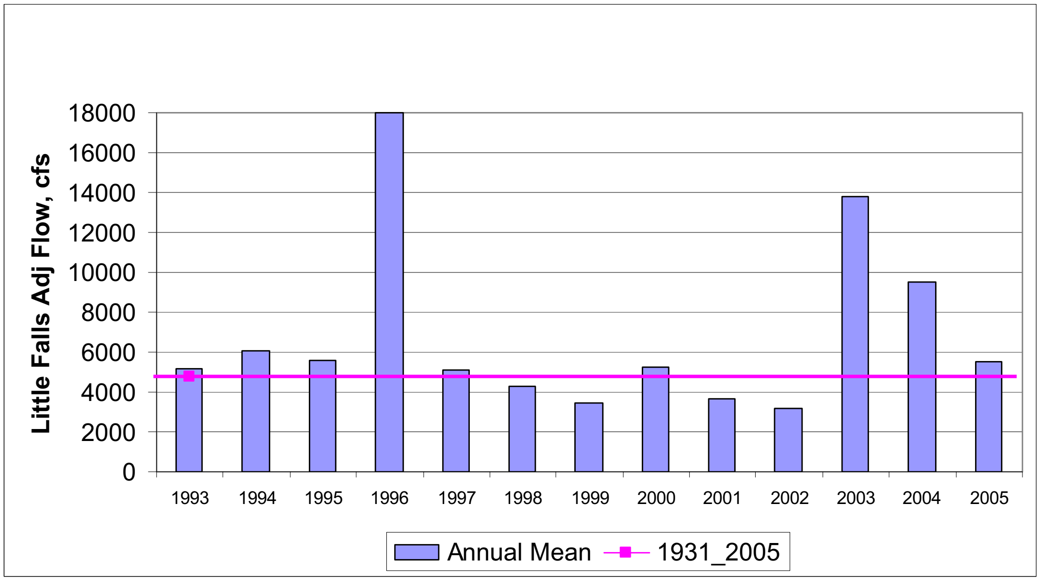
II. DATA AVAILABILITY

The most extensive and best documented water column and sediment PCB data for the tidal Potomac has been collected after 2002, and the POTPCB model is calibrated on 2002-2005 data. To facilitate model calibration, it is desirable to select a hydrologic year from within this period. December 31, 2005 was the most recent date for which flow, PCB, and carbon inputs to the POTPCB model, so this marks the latest possible date for a simulation year.

III. HYDROLOGIC YEAR OPTIONS

Assessment of hydrologic input to the tidal Potomac is based on the Potomac River gage at Little Falls. This gage is at the end of the free flowing Potomac River and captures approx. 80% of freshwater flow to the tidal Potomac. The adjusted daily flow gage (USGS gage 01646502) record was used, where “adjusted” refers to adding back the flow upstream water supply withdrawals by Washington area water utilities. The adjusted record is used for long term statistical analysis because the unadjusted record is distorted by water supply withdrawals that have become progressively greater over time. For POTPCB model scenarios, daily flow and

Figure C-1. Calendar year harmonic mean daily flow, Potomac River.



loads are derived from a model that is calibrated to the unadjusted flow record (USGS gage 01646500), which represents actual flows.

Figure C-1 shows calendar year harmonic mean flows for the period 1993-2005, compared to the long term, 1930-2005, harmonic mean flow of 4,760 cfs. This figure illustrates the pattern of alternating wet and dry periods of the 1990s and shows that 2003-2005 has been wetter than the long term average. Figure C-2 plots rolling 365 day harmonic mean flows for the period Dec 31, 1993 to December 31, 2005, illustrating hydrologic year options other than a calendar year. Values plotted are for the year ending on that date. It can be seen that there is no period wholly within 2003-2005 with harmonic mean flow equal to the long term harmonic mean. The year ending July 5, 2003, however, is very close to the long term harmonic mean and is half within the desired time range. The year ending December 31, 2005 is the 365 day period wholly within 2003-2005 that is closest to the long term harmonic mean. Those two years are considered the principal flow year options and are considered further below.

IV. FLOW DISTRIBUTION CHARACTERISTICS

Figure C-3 compares flow quartiles and Figure C-4 is a cumulative frequency plot for the period of record and the two flow years under consideration (quartile data listed in Table C-1). These figures show that, while the year ending July 5, 2003 has a harmonic mean flow almost identical to that for the long term record, its other flow distribution characteristics are quite atypical. Included in that twelve month period are some of the driest summer months (2002) and some of the wettest spring months (2003) on record. The alternative, the year ending December 31, 2005, has distribution characteristics reasonably characteristic of the long term record even though the harmonic mean is higher.

V. SELECTION OF CALENDAR YEAR 2005

Of the two flow sequences considered for the modeling cycling year, calendar year 2005 has a relatively high harmonic mean flow (15% higher than the long term harmonic mean), but its

Figure C-2. Harmonic mean flow in the Potomac River at Little Falls flow gage for year ending.

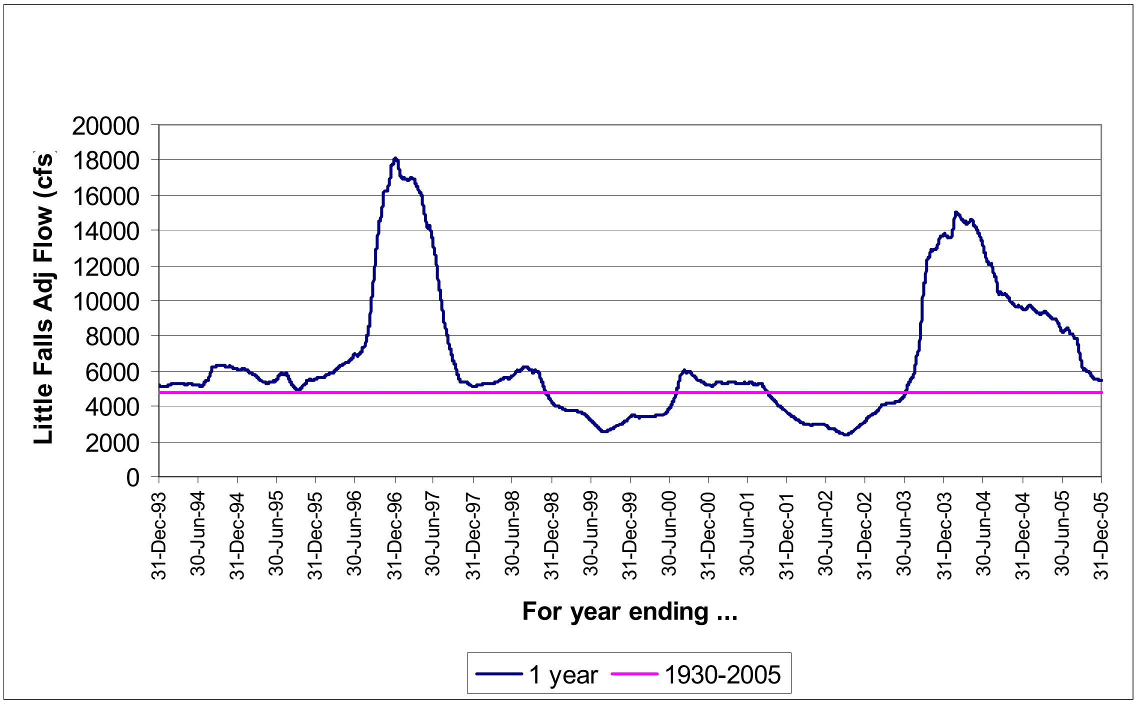


Figure C-3. Little Falls adjusted flow quartiles.

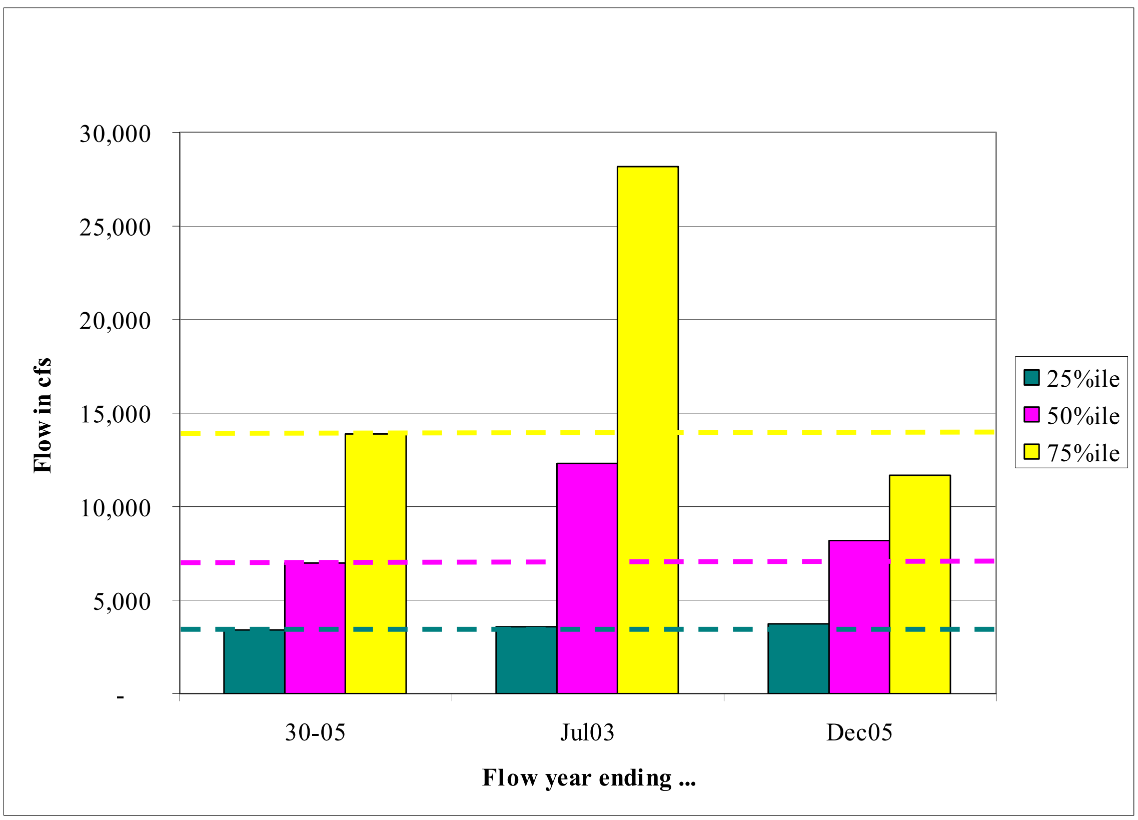


Figure C-4. Cumulative frequency distribution of Little Falls adjusted daily flow.

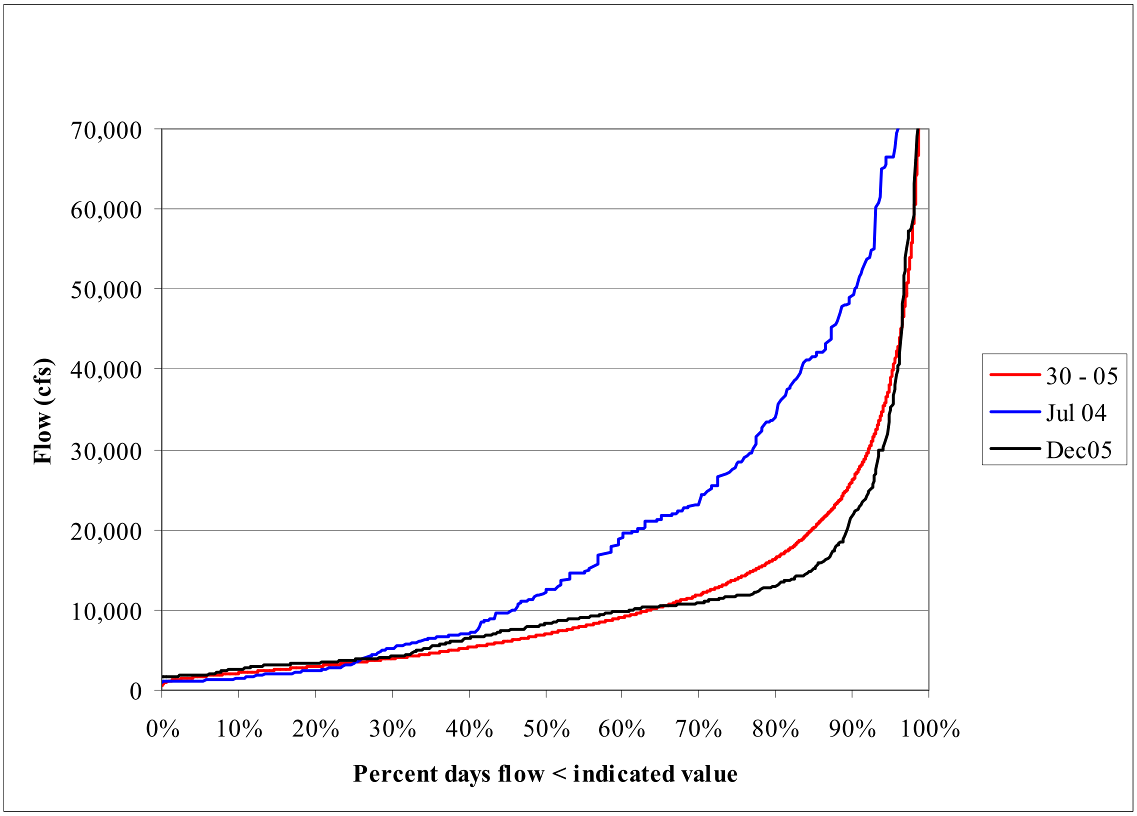


Table C-1. Potomac River mean, harmonic mean, and quartiles of daily flow for 1930-2005 and for 12 month periods ending 7/5/2003 and 12/31/2005, in cubic feet per second.

Statistic	1930-2005	7/6/02 – 7/5/03	1/1/05 – 12/31/05
Harmonic mean	4,700	4,747	5,485
Mean	11,886	19,755	11,203
25^{th}%	3,408	3,550	3,760
50^{th}%	6,960	12,300	8,210
75^{th}%	13,900	28,200	11,700

other flow distribution characteristics more closely resemble the long term record and it is a period that fits better with the available field data. Based on these last two considerations, the Steering Committee selected the hydrologic time series from calendar 2005 to be used as the modeling cycling year and as the basis for TMDL scenarios.

VI. PCB LOAD IMPLICATIONS IN THE POTOMAC OF HYDROLOGIC CYCLING YEAR 2005

Tributary and direct drainage are the two largest source categories for PCB loads, so selection of the hydrologic year to model has a significant impact on simulated total PCB loads to the estuary. Variability in the 1994 – 2005 modeled annual PCB3+ loads from the Potomac River and the sum of all tributaries and direct drain areas below the fall-line illustrates this impact, with loads ranging 9-fold, from 13,600 g/yr in 2002 to 126,000 g/yr in 1996. Annual PCB3+ load statistics are shown in Table C-2 and discussed in more detail in the TMDL document. While calendar year 2005 has a high harmonic flow, the year's load estimates are lower than the 1994-2005 annual average and approximately equal to the1994-2005 median year.

Table C-2. Annual PCB3+ loads (g/yr) from the Potomac River, all other tributaries, and all direct drain areas. Values rounded to three significant figures.

Year	PCB3+ Loading (g/yr)
1994	44,600
1995	20,000
1996	126,000
1997	22,100
1998	54,800
1999	15,300
2000	15,200
2001	14,900
2002	13,600
2003	87,400
2004	35,000
2005	27,900
1994-2005 avg annual	39,700
1994-2005 min calendar year	13,600
1994-2005 max calendar year	126,000
1994-2005 median calendar year	25,000
Jul 2002-Jul 2003	56,100
Jan -Dec 2005 (calendar year 2005)	27,900

VII. PCB LOAD IMPLICATIONS IN THE ANACOSTIA OF HYDROLOGIC CYCLING YEAR 2005

Hydrologic cycling year 2005 was used to model PCB loads for all lower Potomac watersheds even though it was based on Potomac River flows at Little Falls. Flows at Little Falls do not necessarily mirror those in the lower Potomac basin because of differences in rainfall patterns and flows from other sources. In most of the Coastal Plain (below fall-line) tributaries to the Potomac estuary, this is not of concern because PCB loads are relatively small. PCB loads to the Anacostia River, however, are of particular concern because the tributary has some of the highest PCB loadings in the Potomac system and the lowest PCB water quality standard. The PCB load implications of choosing hydrologic cycling year 2005 is potentially significant in modeling Anacostia loads.

A repeating cycle of wet and dry periods has occurred since 1994, with flows continually above the harmonic mean since June 2003. The Anacostia harmonic mean flow for 2005 was above the harmonic mean for the 1961-2006 period of record (Figure C-5). This prompted the suggestion that a combination of dry, wet, and "average" years might provide a record closer to harmonic mean flow of the period of record. Specifically the suggestion was to look at a combination of calendar 2002 (dry), 2004 (wet), and 2005 (moderately wet) years. Data available for calibration

Figure C-5. Harmonic mean flow in the Anacostia River (Northeast and Northwest branches combined) for year ending.

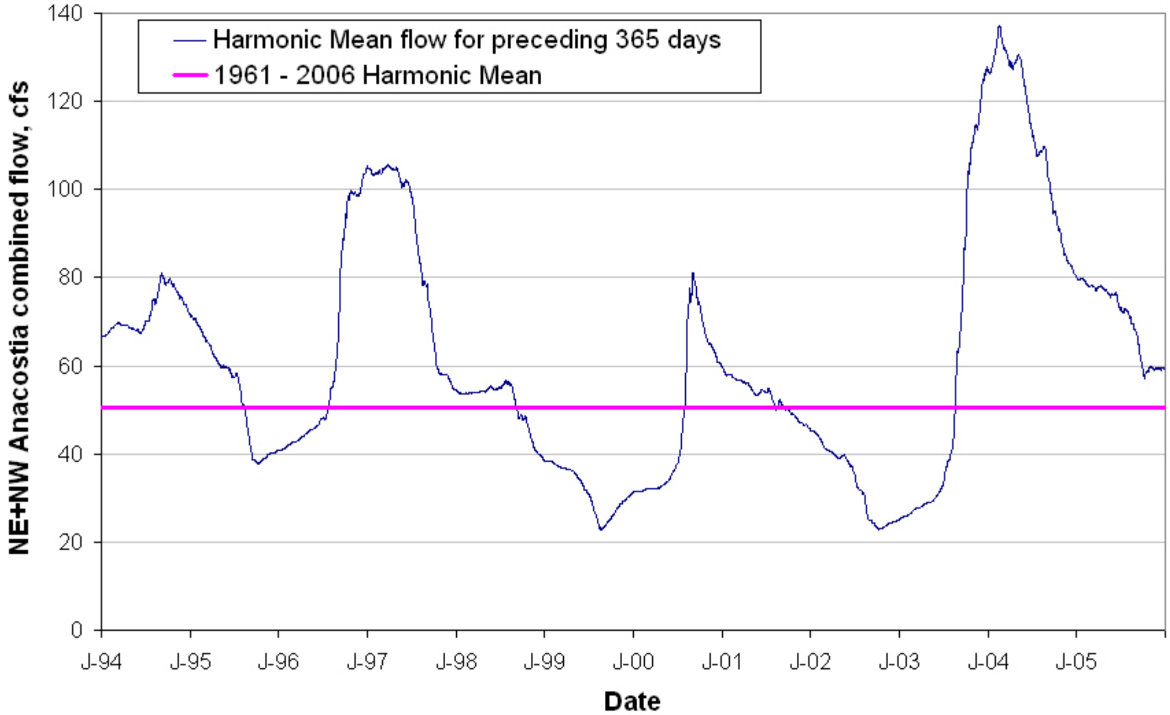
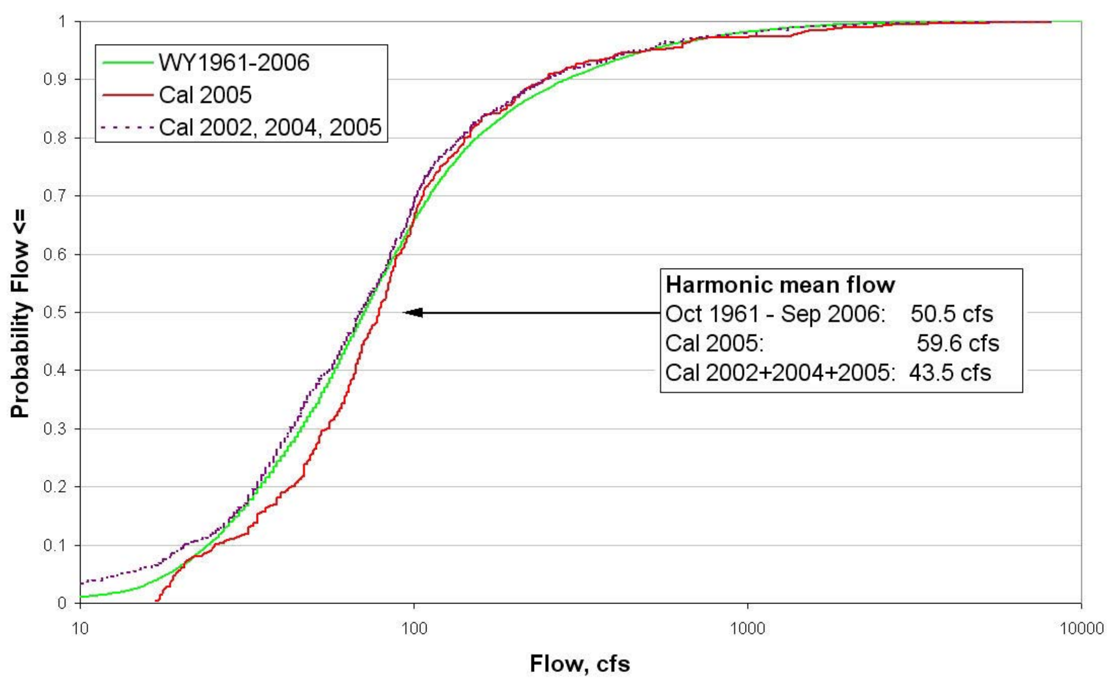


Figure C-6. Cumulative distribution of Anacostia River daily flows (Northeast and Northwest branches combined).



restrict the choices to the 2002-2005 period. A comparison of flow cumulative distribution frequencies (CDFs) for the period of record, calendar 2005, and a record composed of calendar 2002, 2004, and 2005 confirms that 2005 was wetter than the long term harmonic mean and shows that the three year combination was dryer than the long term harmonic mean (Figure C-6). The two flow periods vary from the long term by almost the same amount. The proportions of the total PCB load from the major sources are also approximately the same: direct drainage was 77% in 2005 and 79% in the 3-year combination; tributary load was 8% for both periods, and CSOs load was 15% in 2005 and 13% in the 3-year combination.

The Steering Committee observed that with respect to all PCB loads to the Anacostia River system, the combined Northeast and Northwest branches are small contributors (8%). Exploring alternative flow models such as Loadest for estimating TSS (and PCB) loads from tributary sources is unlikely to have any significant impact on total loads to the Anacostia. Year 2005 does have a higher load than the annual average for the 3-year combination; however, three quarters of that increased load is in direct drainage and not from the tributaries. The Steering Committee decided to apply the hydrologic cycling year 2005 to the Anacostia River estuary.

VIII. REFERENCES

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APPENDIX D

DERIVATION OF WATER COLUMN AND SURFACE SEDIMENT PCB TARGETS

This appendix describes how species-specific bioaccumulation factors (BAFs) were derived from observed total PCB concentrations in fish tissue samples and nearby water column and surface sediment samples, and how these BAFs were used to establish water quality and sediment targets for the Potomac PCB model that achieve allowable total PCB concentrations in the consumable tissue of fish.

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Appendix D

Derivation of Water Column and Surface Sediment PCB Targets

I. INTRODUCTION

Water column and surface sediment targets for allowable PCB concentrations can be derived by dividing a jurisdiction's fish tissue criteria or screening threshold by some factor that represents the fish's ability to absorb and retain PCBs. The 1980 EPA national guidelines for ambient water quality criteria recommended using a bioconcentration factor, which is the ratio of a chemical's observed concentration in an organism's wet tissue to its observed concentration in water in situations where the organism is exposed to the chemical *only through water*. The revised EPA guidelines (EPA 2000, 2003) recommend using a bioaccumulation factor (BAF) instead of a bioconcentration factor for persistent, hydrophobic chemicals such as PCBs. This factor, called the "total" BAF, is also the ratio of the PCB concentration in an organism's wet tissue to its concentration in water. However, it is measured in situations *where both the organism and its food and environment are exposed to PCBs*. Another BAF (SedBAF) can be used to relate PCB concentration in an organism's tissue to PCB concentration in the surface sediment when ambient conditions are relatively stable and do not change substantially over time.

This appendix of the Potomac PCB TMDL report describes how species-specific total BAFs and SedBAFs for the Potomac estuary were derived from observed PCB concentrations in fish tissue samples and nearby water column and surface sediment samples. Results are presented for both individual species and trophic levels (planktivore, benthivore-generalist, and predator). Baseline BAFs (total BAFs normalized to freely dissolved PCBs in the water and lipid content of the fish tissue) and biota-sediment bioaccumulation factors, or BSAFs (SedBAFs normalized to the sediment % organic carbon and the lipid content of the fish tissue), were calculated to identify those species most susceptible to accumulating and maintaining PCBs. These normalized BAFs were used to derive total BAFs and SedBAFs adjusted to a common condition for comparison purposes. Finally, the section describes how the BAFs were used to establish water quality and sediment targets for the PotPCB model that achieve allowable PCB concentrations in the consumable tissue of fish.

II. DATA

Observation-based total BAFs and SedBAFs were calculated for 23 and 21 species, respectively, from the available fish tissue (2000-2005), water column (2002-2006), and surface sediment (2000-2005) PCB data collected in the Potomac River estuary and tidal tributaries. Each fish species was assigned a trophic level of 2 (planktivore), 3 (benthivore-generalist), or 4 (piscivore) and a home range of 2, 5, or 10 miles depending on the species characteristics (Table D-1). Each fish sample was associated with all water column and sediment PCB data in the species home range centered around the fish sample location (Figure D-1). Total PCB (tPCB) concentrations in fish were used as reported; all water column and sediment total PCB concentrations were

Table D-1. Species food guilds and approximate home range radius (buffer). Habitats: migratory, spend part of life cycle outside the Potomac estuary; tribs, primarily inhabits non-tidal low-order streams and rivers; trib&tidal, inhabits both non-tidal streams and rivers and tidal waters. Trophic level: predator, is primarily piscivorous; planktivore, consumes phyto- and/or zooplankton; benth/gen, benthivore-generalist, or opportunistic forager, consuming primarily stream "drift" (insects, worms) and benthic invertebrates in shallow non-tidal waters and benthic invertebrates in tidal waters (diet can contain some fish). * , pre-migratory striped bass, or individuals less than 560 mm, which typically have not begun to migrate out of Chesapeake Bay nursery areas (Setzler-Hamilton and Hall, 1991).

Common_Name	Scientific Name	Habitat	Trophic Level	Buffer (mi)
American Eel	Anguilla rostrata	migratory	predator	5
American Shad	Alosa sapidissima	migratory	planktivore	10
Atlantic Croaker	Micropogon undulatus	migratory	benth/gen	10
Black Crappie	Pomoxis nigromaculatus	tribs	predator	2
Blue Catfish	Ictalurus furcatus	trib&tidal	predator	10
Bluefish	Pomatomus saltatrix	migratory	predator	10
Bluegill Sunfish	Lepomis macrochirus	tribs	planktivore	2
Brown Bullhead Catfish	Ameiurus nebulosus	trib&tidal	benth/gen	5
Channel Catfish	Ictalurus punctatus	trib&tidal	benth/gen	5
Common Carp	Cyprinus carpio	trib&tidal	benth/gen	2
Fallfish	Semotilus corporalis	tribs	predator	2
Flathead Catfish	Pylodictis olivaris	tribs	predator	5
Gizzard Shad	Dorosoma cepedianum	trib&tidal	planktivore	2
Green Sunfish	Lepomis cyanellus	tribs	benth/gen	2
Grey Trout (Weakfish)	Cynoscion regalis	migratory	predator	10
Largemouth Bass	Micropterus salmoides	trib&tidal	predator	2
Longear Sunfish	Lepomis megalotis	tribs	benth/gen	2
Mummichog	Fundulus heteroclitus	trib&tidal	benth/gen	2
Northern Hogsucker	Hypentelium nigricans	tribs	benth/gen	2
Pumpkinseed Sunfish	Lepomis gibbosus	trib&tidal	benth/gen	2
Rainbow Trout	Oncorhynchus mykiss	tribs	predator	2
Redbreasted Sunfish	Lepomis auritus	tribs	benth/gen	2
Redear Sunfish	Lepomis microlophus	tribs	benth/gen	2
Redhorse Sucker	Moxostoma (macrolepidotum?)	tribs	benth/gen	2
Rock Bass	Ambloplites rupestris	tribs	predator	2
Smallmouth Bass	Micropterus dolomieu	tribs	predator	2
Spot	Leiostomus xanthurus	migratory	benth/gen	10
Striped Bass	Morone saxatilis	migratory	predator	10
Striped Bass pre-migratory*	Morone saxatilis	resident	predator	10
Walleye	Stizostedion vitreum	tribs	predator	5
White Catfish	Ameiurus catus	trib&tidal	benth/gen	5
White Perch	Morone americana	migratory	predator	10
White Sucker	Catostomus commersoni	tribs	benth/gen	2
Yellow Bullhead Catfish	Ameiurus natalis	tribs	benth/gen	5
Yellow Perch	Perca flavescens	trib&tidal	benth/gen	2

Table D-1References

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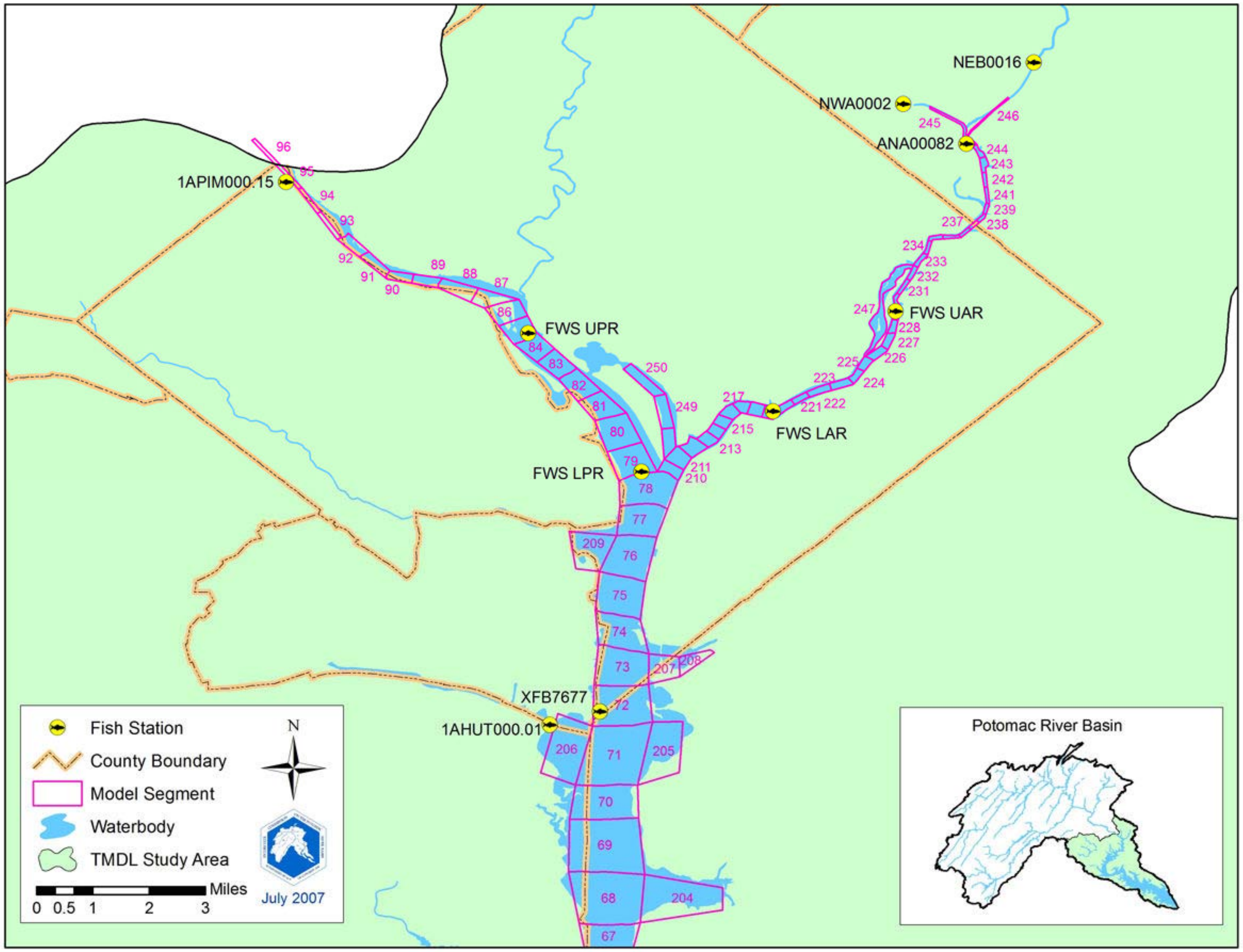
derived by dividing the reported PCB3+ concentrations by 0.92 (water column) or 0.90 (sediments) in order to avoid problematic measurements of homologs 1 and 2 in some of the observed data but still use the homolog 3-10 data. To avoid unintentionally weighting the water and sediment tPCB data, the median value of all tPCB values in each PotPCB model cell in the species home range was calculated (most model cells with data had just 1-3 samples), and then the average of all model cell values in the species home range was determined.

Total BAFs and SedBAFs were also computed with water column and sediment PCB concentrations generated by the PotPCB model for the 2002-2005 calibration period. Cross-checking the observation-based and model-based factors provided a quasi-independent validation of the model. Median values for model-generated daily sediment PCB3+, water PCB3+, and suspended particulate organic carbon concentrations, and surface sediment % organic carbon were obtained from LimnoTech for each PotPCB model cell for 2002-2005. tPCB was derived from values by dividing by 0.92 (water) or 0.90 (sediments). Fish sample data were matched with the average of all model cell median values in the appropriate home range.

Figure D-1. Location of fish samples used to determine BAFs and SedBAFs. A, upper Potomac estuary; B, lower Potomac estuary. Species samples were collected between 2000 and 2005.

A. Upper Potomac estuary



B. Lower Potomac estuary.

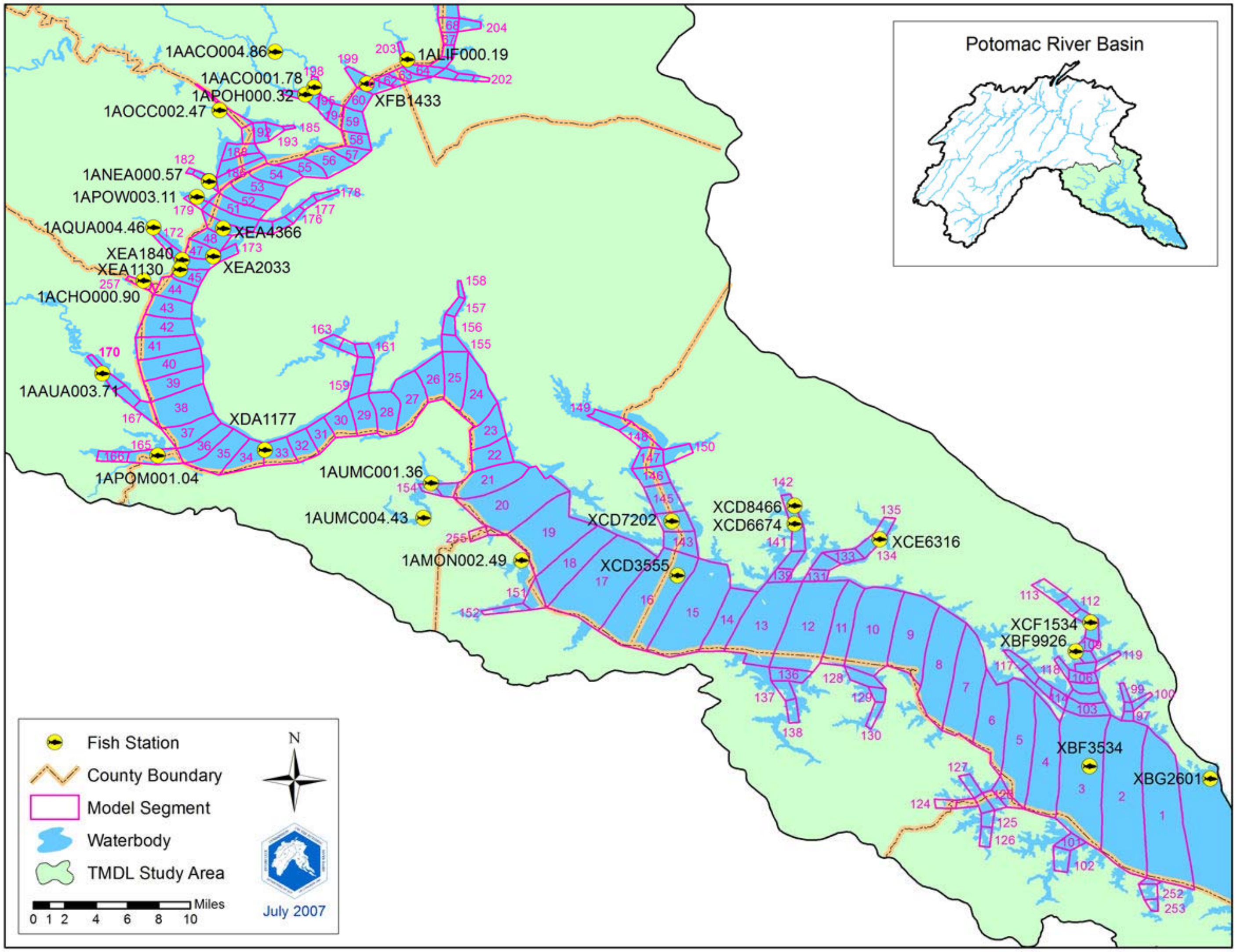
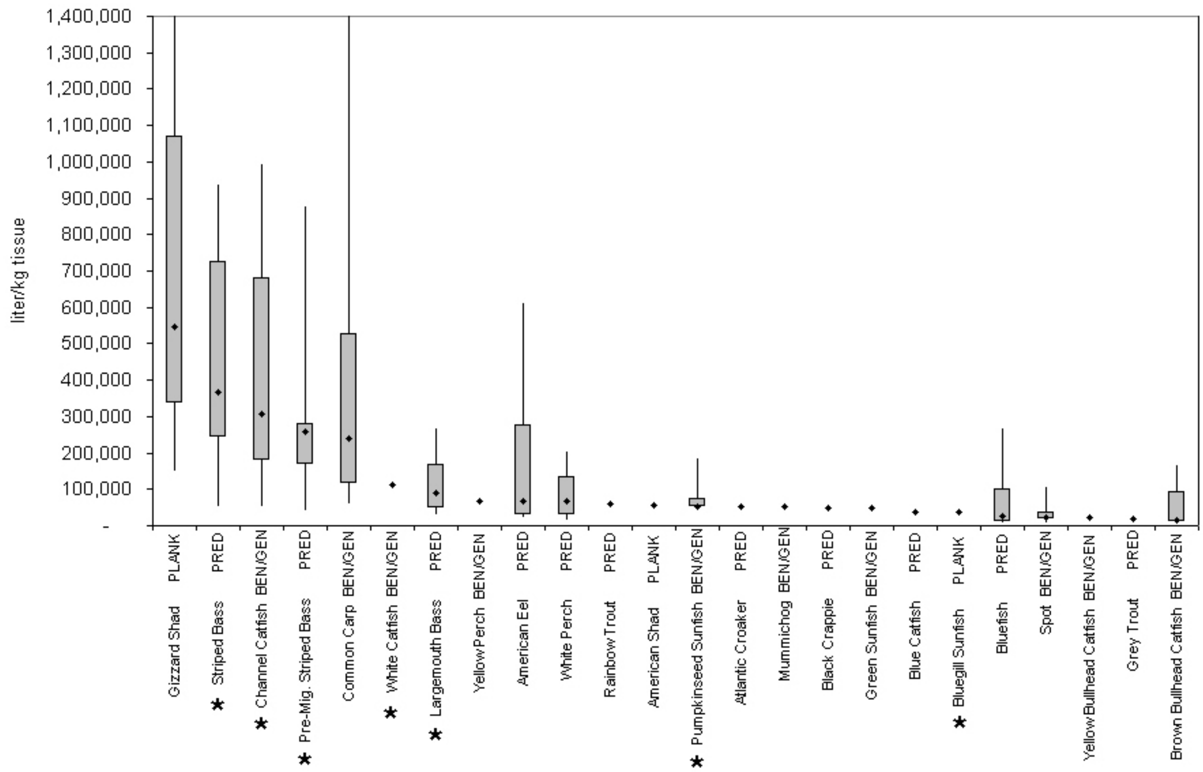


Figure D-2. Species-specific observed total BAFs. Median, quartiles, 5th% and 95th% of each species' observed total BAFs are shown for sample n $\geq$ 5; only median values are shown for sample n < 5. Median values are given in Table D-2. *, indicates species with high baseline BAF values, meaning they more readily absorb and maintain PCBs (see Figure D-3).



III. TOTAL ("FIELD-MEASURED") BAFS

Total BAFs (sometimes called "field-measured" BAFs) were calculated from observed and modeled data using Equation 2-2 in EPA (2003):

$$\text{total BAF} = \frac{[\text{tPCB}]_{\text{tissue}}}{[\text{tPCB}]_{\text{water}}} \qquad (1)$$

where $[\text{tPCB}]_{\text{tissue}}$ = concentration of tPCB in fish wet tissue (ng/kg)
$[\text{tPCB}]_{\text{water}}$ = water column tPCB concentration in the fish species home range (ng/liter)

Species-specific total BAFs derived from the observed Potomac estuary fish and water column PCB concentrations are highly variable, with BAF values for a species ranging as much as 40-fold (Figure D-2). This variability within species is to be expected given day-to-day fluctuations in PCB loadings to the water column. Median total BAF values for the various species range from 16,200 (yellow bullhead catfish) to 548,000 (gizzard shad). Overall, Potomac estuary total BAFs are proving to be approximately three times higher than the default bioconcentration value

(31,200) recommended in the 1980 EPA guidelines for 304(a) PCB criteria. Species with the highest total BAFs were gizzard shad, striped bass (pre-migratory, all), channel catfish, common carp, white catfish, and largemouth bass. Median total BAF values for each species as well as for the three trophic levels are shown in Table D-2. Trophic level BAFs were determined by pooling the species samples by trophic level and calculating the geometric means of all the samples, regardless of species.

These observation-based total BAFs (BAF_{obs}) are slightly higher than model-based total BAFs (BAF_{mod}) overall. Some of this difference is due to the model generating slightly lower water values. Species with less than 5 samples generally showed the biggest differences between column tPCB concentrations in the Anacostia and upper Potomac rivers as compared to observed BAF_{obs} and BAF_{mod}. Species with 10 or more samples showed smaller differences, i.e., the

Table D-2. Species and trophic level total BAFs. Total BAFs are derived with observed fish tissue tPCB data and observed water column tPCB data (BAF_{obs}) or modeled water column tPCB data (BAF_{mod}). Species BAFs are the median of all sample-based BAFs for that species for individuals collected in tidal waters. Trophic-level BAFs are the geometric mean of all sample-based BAFs for the trophic level. The geometric mean is the statistic recommended for trophic level calculations by EPA (2003). All values rounded to three significant digits.

Trophic Level	Species	BAF_{obs} (median)		BAF_{mod} (median)	
		liter/kg tissue	n	liter/kg tissue	n
predator	American Eel	66,600	7	149,000	9
planktivore	American Shad	54,700	3	43,500	3
benth/gen	Atlantic Croaker	51,500	4	63,900	4
predator	Black Crappie	48,900	1	7,430	1
predator	Blue Catfish	38,700	3	69,700	3
predator	Bluefish	24,900	8	43,500	8
planktivore	Bluegill Sunfish	38,600	3	43,500	3
benth/gen	Brown Bullhead Catfish	16,200	6	40,000	6
benth/gen	Channel Catfish	306,000	37	284,000	40
benth/gen	Common Carp	240,000	17	161,000	17
planktivore	Gizzard Shad	548,000	12	345,000	12
benth/gen	Green Sunfish	47,900	1	2,290	1
predator	Grey Trout (Weakfish)	18,400	1	95,600	1
predator	Largemouth Bass	91,300	19	69,000	19
benth/gen	Mummichog	50,900	3	37,400	3
benth/gen	Pumpkinseed Sunfish	53,800	5	62,000	5
predator	Rainbow Trout	61,700	1	18,100	1
benth/gen	Spot	23,500	9	27,200	9
predator	Striped Bass (Pre-Mig)	259,000	13	237,000	13
predator	Striped Bass (All)	366,000	26	285,000	26
benth/gen	White Catfish	112,000	2	114,000	3
predator	White Perch	65,500	26	66,000	26
benth/gen	Yellow Perch	69,000	2	27,300	2
benth/gen	Yellow Bullhead Catfish	22,500	2	20,000	2
	Planktivores	220,400	18	122,800	18
	Benthivore-Generalists	128,500	92	126,900	88
	Predators	99,600	94	94,400	92

interquartile ($25^{th}\%$ - $75^{th}\%$) range of the BAF_{obs} values overlapped the median value of the BAF_{mod}. Hence, BAF_{mod}'s for these species appear to adequately represent BAF_{obs}.

IV. BASELINE BAFS

Total BAFs for PCBs vary depending on the food habits and lipid concentrations each fish species and on the concentration of freely-dissolved PCBs in the water column. EPA recommends calculating a "baseline" BAF for the purpose of extrapolating between different species and bodies of water (US EPA 2000). These BAFs are also useful in identifying the species most susceptible to accumulating and retaining PCBs. The baseline BAF is the total BAF normalized to the fish tissue lipid content and the freely-dissolved PCB concentration in the water (Equation 2-3 in EPA 2003):

$$\text{baseline BAF} = \frac{[PCB]_{fish} / \%lipid}{[PCB]_{water} \cdot \%fd} \qquad (2)$$

$$= \left[\frac{totalBAF}{\%fd} - 1\right] \cdot \frac{1}{\%lipid} \qquad (3)$$

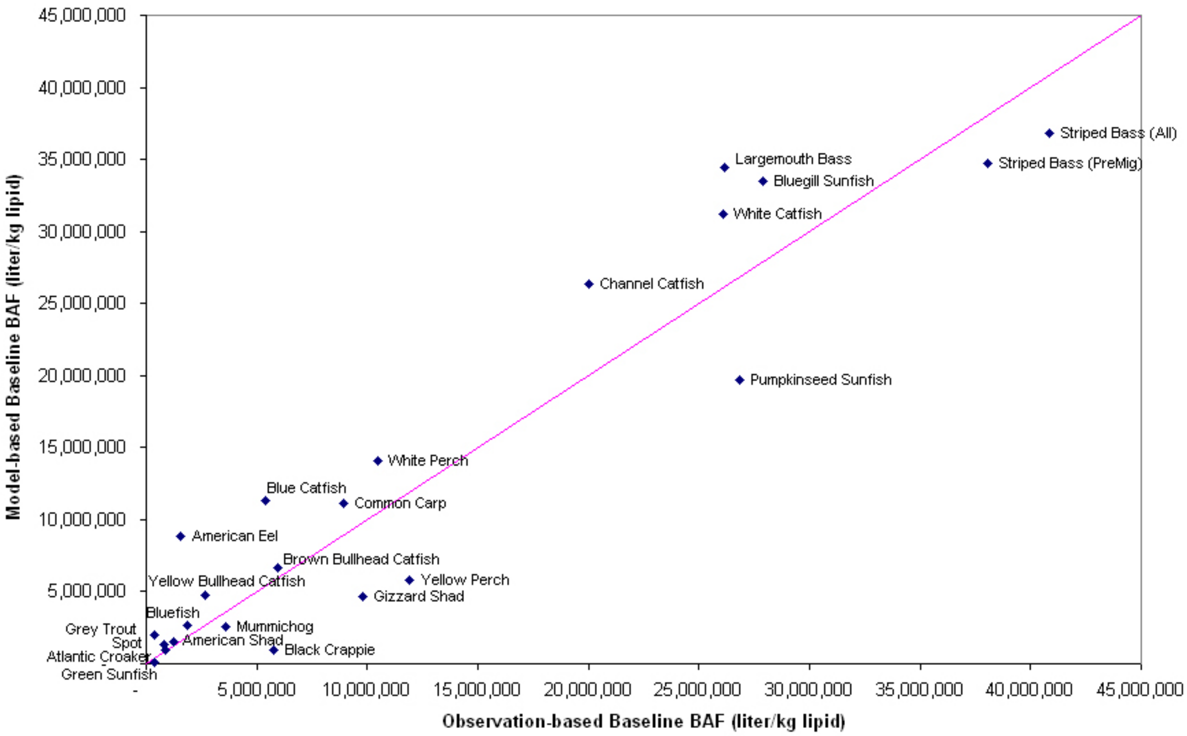
where %fd = fraction of the total PCB concentration in water that is freely-dissolved
%lipid = fraction of tissue that is lipid

The freely-dissolved PCB concentration is a function of dissolved and particulate organic carbon concentrations in the water column. Its derivation and use in the baseline BAF is described below. For individual fish samples, tPCB concentration in the fish tissue was normalized to that sample's measured lipid fraction, and then divided by the average concentration of freely-dissolved tPCB in the species home range centered around the fish sample location (Equation 2).

Species with the highest baseline BAFs, who most readily absorb and maintain tPCBs, are striped bass (all, pre-migratory), largemouth bass, channel and white catfish, and bluegill sunfish and pumpkinseed sunfish (Figure D-3). The two sunfish species, the largemouth bass, and the white catfish have high baseline BAFs but low total BAFs (Table D-2). There are several possible explanations for the differences, including a) bluegill, white catfish, and largemouth bass have low lipid contents in their tissues, and b) some individuals were collected from areas with relatively low, or patchy, water column PCB concentrations over time and space, such as flowing streams.

Overall, baseline BAF_{obs} tend to be very slightly lower than baseline BAF_{mod} (Figure D-3). The differences are the net result of differences in modeled and observed DOC, POC, and tPCBs in the water column. The model supports lower DOC concentrations overall and lower POC concentrations in the lower and middle Potomac mainstem for 2002-2005, as compared to the available observed data for 2002-2005 (downloadable from www.chesapeakebay.net). The model supports higher median concentrations of tPCBs in the lower Potomac and Anacostia rivers, and

Figure D-3. Comparison of observation- and model-based baseline BAFs. Each baseline BAF is the median value of 1 to 40 species-specific samples.



lower median concentrations in embayments to the Potomac mainstem. Model-based concentrations of freely-dissolved tPCBs are thus slightly higher than observed concentrations in the Potomac mainstem embayments, and lower in the Anacostia and upper Potomac mainstems.

1. Freely-Dissolved tPCB Concentration

Freely-dissolved tPCBs are not associated with either dissolved or particulate organic carbon. The concentration of this component of the water column PCB concentration can be calculated with equation 4-6 provided in EPA (2003) on pg 4-7.

$$\%fd = \frac{1}{1 + POC \cdot K_{ow} + DOC \cdot 0.08 \cdot K_{ow}} \qquad (4)$$

where K_{ow} is the PCB partition coefficient, POC is the particulate organic carbon concentration in water, and DOC is the dissolved organic carbon concentration in water.

Partition coefficients of PCB congeners range over four orders of magnitude. To derive a %fd representative of tPCBs, a %fd was calculated for each PCB homolog using a K_{ow} characteristic of the homolog, i.e., the midpoint of the homolog's K_{ow} range:

Homolog	middle log K_{ow}	K_{ow} value
Kow_mono+di	4.675	47,315
Kow_tri	5.425	266,073
Kow_tetra	6.005	1,011,579
Kow_penta	6.525	3,349,654
Kow_hexa	6.730	5,370,318
Kow_hepta	7.235	17,179,084
Kow_octa	7.600	39,810,717
Kow_nona	7.915	82,224,265
Kow_deca	8.180	151,356,125

Homolog %fd's were multiplied by observed homolog concentrations and the products summed to obtain the concentration of all freely-dissolved PCBs a water sample. This sum is divided by the tPCB concentration to obtain a %fd for tPCBs. The %fd is used in the denominator in Equation 2 above.

For modeled data, the calculation is essentially the same except that the median concentrations of the model generated daily DOC, POC, and tPCBs (2002-2005) and the median homolog percentages of the generalized homolog distribution in water (Appendix B, Figure B-7) were used in the calculations.

V. ADJUSTED TOTAL BAFS

A species' baseline BAFs can be standardized to a common condition by normalizing them to that species median lipid content and a single freely-dissolved PCB concentration representative of the ecosystem. This calculation results in adjusted total BAFs for each species with no variability attributable to differences in fish lipid content or freely-dissolved PCB concentrations in the water column:

$$\text{adjusted total BAF} = ((\text{baseline BAF} \cdot \text{median \%lipid}) + 1) \cdot \text{median \%fd} \qquad (5)$$

The jurisdiction's fish tissue screening threshold for tPCBs is then divided by the median adjusted total BAF to derive an estuary-wide water column tPCB target. The fish tissue PCB threshold is presently 20 ng/g in the District of Columbia, 88 ng/g in Maryland, and 54 ng/g in Virginia. A median fraction of freely-dissolved tPCBs, 29.2%, was calculated from water quality samples associated with the fish tissue samples. The median adjusted total BAF for each species and the associated water column tPCB targets for each jurisdiction are shown in Table D-3.

VI. SEDBAFS DERIVED FROM SEDIMENT AND FISH

SedBAFs relating surface sediment and fish tissue tPCBs were calculated as follows:

$$\text{SedBAF} = \frac{[\text{tPCB}]_{\text{tissue}}}{[\text{tPCB}]_{\text{sediment}}} \qquad (6)$$

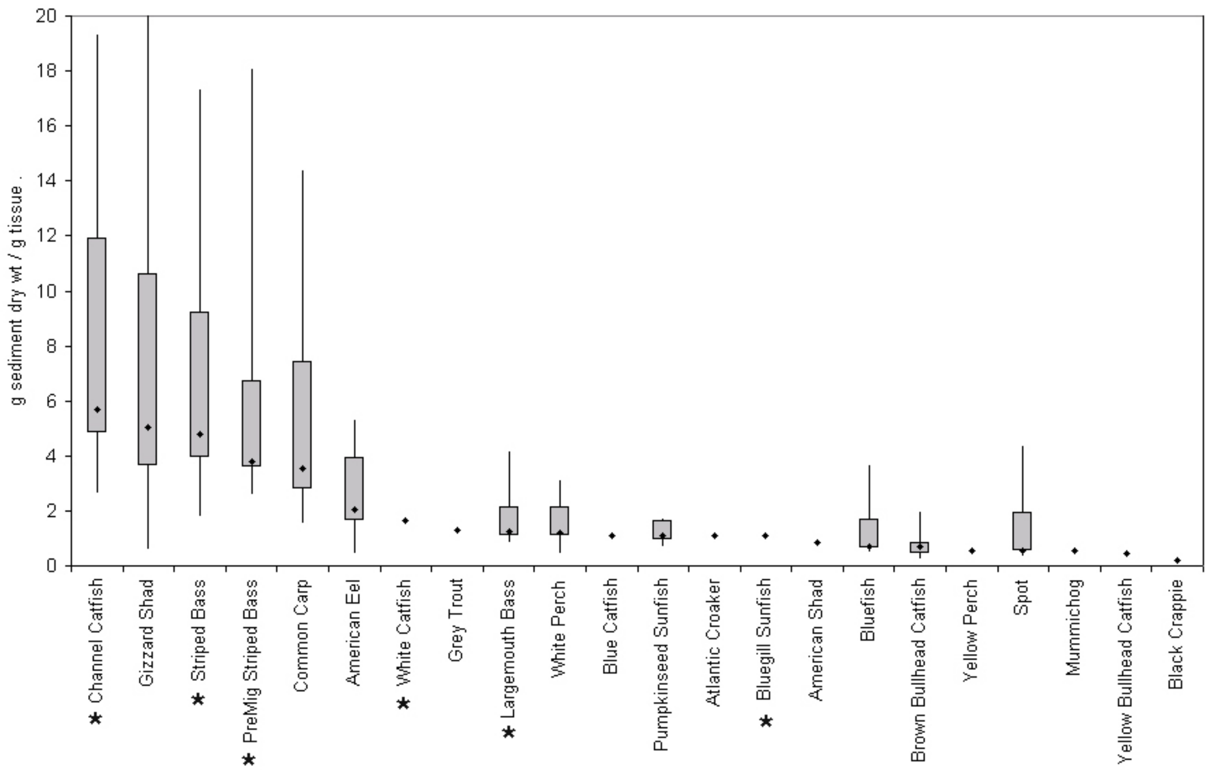
Table D-3. Adjusted total BAFs and associated jurisdiction water column tPCB targets. The adjusted total BAF (Equation 5) is the species' baseline BAFs adjusted to the species' median % lipid and the overall median % freely-dissolved tPCBs determined from water quality samples associated with the fish tissue samples (29.2%, n = 126). Species-specific water column targets are the jurisdictional fish tissue PCB threshold divided by the median adjusted total BAF. The fish tissue PCB threshold is 20 ng/g in the District of Columbia, 88 ng/g in Maryland, and 54 ng/g in Virginia. See text for detail.

Trophic Level	Species	Baseline BAF (median)		% Lipid	Adjusted total BAF (median)	Water Column Target (ng/liter)		
		n	liter/kg lipid	median	liter/kg tissue	DC	MD	VA
planktivore	Gizzard Shad	12	9,790,000	0.296	845,000	0.024	0.10	0.064
predator	Striped Bass (All)	26	40,900,000	0.035	413,000	0.048	0.21	0.13
predator	Striped Bass (Pre-Mig)	13	38,000,000	0.024	268,000	0.075	0.33	0.20
benth/gen	Channel Catfish	37	20,000,000	0.058	341,000	0.059	0.26	0.16
benth/gen	Common Carp	17	8,940,000	0.055	144,000	0.14	0.61	0.38
benth/gen	Pumpkinseed Sunfish	5	26,800,000	0.013	103,000	0.20	0.86	0.53
predator	White Perch	26	10,500,000	0.027	82,000	0.25	1.1	0.66
benth/gen	Yellow Perch	2	11,900,000	0.022	77,700	0.26	1.1	0.70
benth/gen	Mummichog	3	3,600,000	0.062	65,700	0.31	1.3	0.82
predator	Atlantic Croaker	4	843,000	0.266	65,500	0.31	1.3	0.82
predator	Largemouth Bass	19	26,200,000	0.008	61,500	0.33	1.4	0.88
benth/gen	White Catfish	3	26,100,000	0.008	58,700	0.34	1.5	0.92
planktivore	Bluegill Sunfish	3	27,900,000	0.007	57,100	0.35	1.5	0.95
predator	Black Crappie	1	5,750,000	0.032	54,000	0.37	1.6	1.0
predator	American Eel	9	1,540,000	0.090	40,400	0.50	2.2	1.3
predator	Blue Catfish	3	5,400,000	0.025	38,800	0.52	2.3	1.4
benth/gen	Brown Bullhead Catfish	5	5,940,000	0.022	38,500	0.52	2.3	1.4
planktivore	American Shad	3	1,250,000	0.104	38,100	0.53	2.3	1.4
benth/gen	Spot	9	814,000	0.138	32,700	0.61	2.7	1.7
predator	Bluefish	8	1,880,000	0.051	28,100	0.71	3.1	1.9
benth/gen	Green Sunfish	1	380,000	0.190	21,000	0.95	4.2	2.6
predator	Grey Trout (Weakfish)	1	370,000	0.186	20,100	1.00	4.4	2.7
benth/gen	Yellow Bullhead Catfish	2	2,680,000	0.024	18,500	1.1	4.8	2.9

where $[tPCB]_{tissue}$ = concentration of tPCB in fish wet tissue (ng/kg)
$[tPCB]_{sediment}$ = surface sediment tPCB concentration in the fish species home range (ng/g sediment dry wt.)

Species-specific SedBAFs calculated from the observed Potomac estuary fish and surface sediment PCB concentrations are as variable as total BAFs (Figure D-4). Sediment concentrations are less variable over time than water column concentrations, so SedBAF differences are likely related to spatial patchiness in sediment tPCB concentrations. Median SedBAF values range from 0.22 (black crappie) to 7.08 (channel catfish). Species with the highest SedBAFs were channel catfish, gizzard shad, striped bass (pre-migratory, all), common carp, and American eel. Median SedBAF values for each species as well as for the three trophic levels are shown in Table D-4. Trophic SedBAFs were determined by pooling the species samples by trophic level and calculating the geometric means of all the samples, regardless of species.

Figure D-4. Species-specific observed SedBAFs. Median, quartiles, 5th% and 95th% of each species' SedBAFs are shown for sample n $\geq$ 5; only median values are shown for sample n < 5. Median values are given in Table D-4. *, indicates species with high BSAF values, meaning they more readily absorb and maintain PCBs (see Figure D-5).



Model-based SedBAFs ($SedBAF_{mod}$) are higher than observation-based SedBAFs ($SedBAF_{obs}$) overall (Table D-4). The difference is consistent and appears to be due to the fact that for much of the Potomac and Anacostia, the calibrated model produces sediment tPCB concentrations that are somewhat lower than the observed concentrations. The modeled sediment data used to calculate $SedBAF_{mod}$ were for the calibration period 2002-2005. About half of the available observed data were collected in 2000, and these earlier data were used to calculate $SedBAF_{obs}$. Sediment burial rates estimated for the lower Anacostia River, and the Potomac River at Hains Pt. and above Piscataway Creek, indicate sediment tPCB concentrations in 2002-2005 were lower than those in 2000, and estimated burial rates elsewhere averaged -2.6 ng/g sediment dry wt per year. Thus, the $SedBAF_{mod}$, which are based on slightly lower sediment PCB concentrations, can be expected to be higher than the $SedBAF_{obs}$, which contain some older, higher sediment PCB concentrations.

VII. BIOTA-SEDIMENT BIOACCUMULATION FACTORS (BSAFS) AND ADJUSTED SEDBAFS

SedBAFs for PCBs vary depending on the food habits and lipid concentrations each fish species and the sediment fraction of organic carbon. Biota-sediment bioaccumulation factors, or BSAFs,

Table D-4. Species-specific and trophic level SedBAFs. SedBAFs are derived with observed fish tissue tPCB data, in ng PCBs per g wet wt tissue, and observed sediment tPCB data ($SedBAF_{obs}$) or modeled sediment tPCB data ($SedBAF_{mod}$), in ng PCB per g dry wt sediment. Species SedBAFs are the median of all sample-based SedBAFs for that species for individuals collected in tidal waters. Trophic-level SedBAFs are the geometric mean of all sample-based SedBAFs for the trophic level. All values rounded to three significant digits.

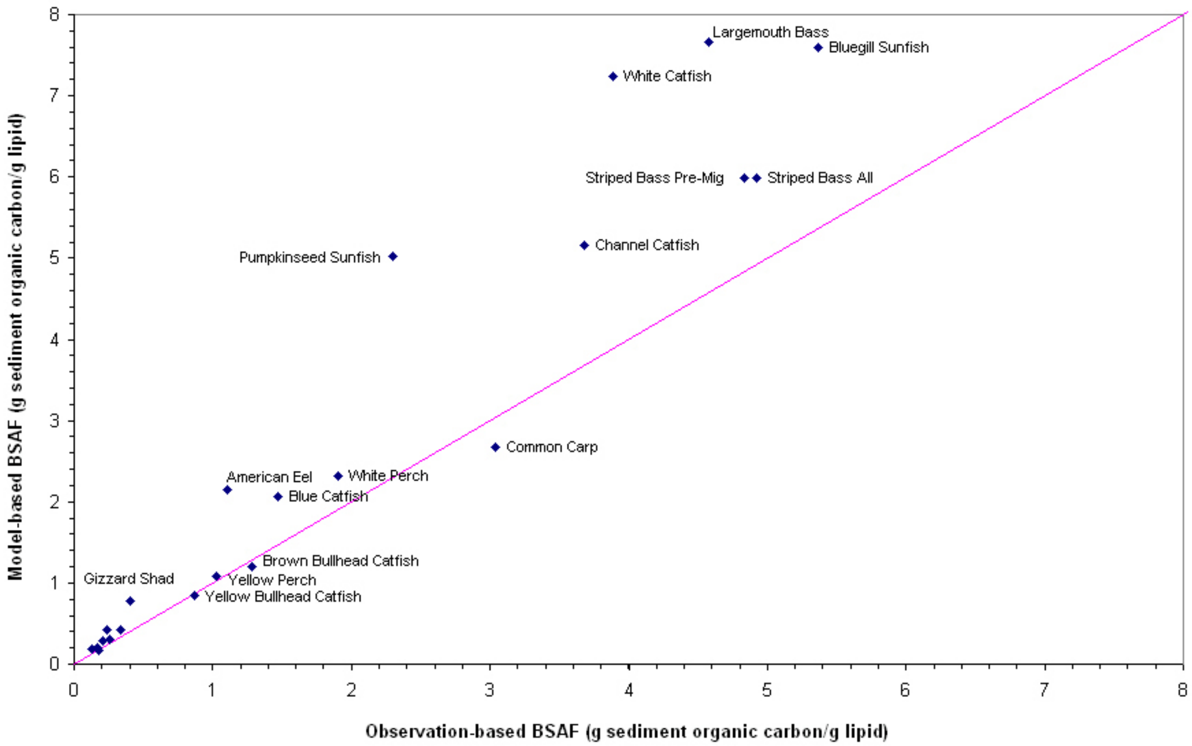
Trophic Level	Species	$SedBAF_{obs}$ (median)		$SedBAF_{mod}$ (median)	
		g sed./g tissue	n	g sed./g tissue	n
benth/gen	Channel Catfish	7.08	39	9.22	40
planktivore	Gizzard Shad	6.27	12	9.50	12
predator	Striped Bass (All)	5.97	26	7.42	26
predator	Striped Bass (Pre-Mig)	4.77	13	5.89	13
benth/gen	Common Carp	4.44	17	3.85	17
predator	American Eel	2.57	9	4.28	9
predator	White Catfish	2.09	3	2.93	3
predator	Grey Trout (Weakfish)	1.64	1	2.20	1
predator	Largemouth Bass	1.59	19	2.21	19
predator	White Perch	1.47	26	1.86	26
predator	Blue Catfish	1.37	3	1.85	3
benth/gen	Pumpkinseed Sunfish	1.37	5	1.86	5
predator	Atlantic Croaker	1.36	4	1.87	4
planktivore	Bluegill Sunfish	1.34	3	1.42	3
planktivore	American Shad	1.07	3	1.30	3
predator	Bluefish	0.869	8	1.13	8
benth/gen	Brown Bullhead Catfish	0.846	5	1.18	6
benth/gen	Yellow Perch	0.683	2	0.780	2
benth/gen	Spot	0.675	9	0.850	9
benth/gen	Mummichog	0.655	3	1.010	3
benth/gen	Yellow Bullhead Catfish	0.560	2	0.570	3
predator	Black Crappie	0.222	1	0.200	1
predator	Rainbow Trout		0	0.520	1
benth/gen	Green Sunfish		0	0.060	1
	Planktivores	2.94	18	3.36	18
	Benthivore-Generalists	3.20	89	3.94	92
	Predators	2.14	93	2.72	94

are SedBAFs normalized to the home range's average sediment organic carbon fraction and the lipid content of the fish tissue sample (Equation 2-14 in EPA 2003):

$$BSAF = \left[\frac{tPCB_{tissue} / \%lipid}{tPCB_{sediment} / \%organic\ carbon} \right] \qquad (7)$$

BSAFs were calculated to facilitate species comparisons and identify those species most susceptible to absorbing PCBs through sediment pathways. Both the model-based and observation-based BSAFs are in agreement on which species are most susceptible to PCB accumulation: bluegill sunfish, striped bass (all, pre-migratory), largemouth bass, and white and channel catfish. Model-based BSAF values are typically larger than observation-based BSAF

Figure D-5. Comparison of observation- and model-based BSAFs. Each BSAF is the median value of 1 to 40 species-specific samples.



values, especially for the most susceptible species (Figure D-5). This is a consequence of the differences in model and observation SedBAF discussed above.

Each species' BSAFs can be standardized to a common condition by normalizing them to the median lipid content of the species and a sediment organic carbon fraction representative of the ecosystem. This calculation results in adjusted SedBAFs for each species with no variability attributable to regional differences in fish lipid content or sediment organic carbon concentrations:

$$\text{adjusted SedBAF} = \text{BSAF} \cdot \frac{\text{median \%lipid}}{\text{median \%sed.carbon}} \qquad (8)$$

A median %sediment organic carbon of 2.85% was calculated from all sediment samples associated with Potomac estuary fish tissue samples. The median adjusted SedBAFs for each species and the associated sediment tPCB targets for each jurisdiction are shown in Table D-5.

VIII. WATER AND SEDIMENT PCB TARGETS

Species-specific total BAFs, adjusted total BAFs, SedBAFs, and adjusted SedBAFs were used to calculate water column and surface sediment targets that equate tPCB concentrations in the

Table D-5. Adjusted SedBAFs and associated jurisdiction surface sediment tPCB targets. The adjusted SedBAF (Equation 8) is the species' BSAF adjusted to the species' median % lipid and the overall median sediment organic carbon (SOC) fraction determined from sediment samples associated with the fish tissue samples (2.85%, n = 75). Species-specific sediment targets are the jurisdictional fish tissue PCB threshold divided by the median adjusted SedBAFs. The fish tissue PCB threshold, in ng PCB per g wet wt tissue, is 20 in the District of Columbia, 88 in Maryland, and 54 in Virginia. See text for detail.

Trophic Level	Species	n	BSAF (median)	% Lipid	Adjusted SedBAF (median)	Sediment Target (ng tPCB / g sed dry wt)		
			g SOC/ g lipid		g sed dry wt / g tissue	DC	MD	VA
benth/gen	Channel Catfish	39	3.68	0.058	7.52	2.66	11.7	7.18
predator	Striped Bass (All)	26	4.92	0.035	5.97	3.35	14.7	9.04
benth/gen	Common Carp	13	3.04	0.055	5.87	3.41	15.0	9.20
predator	Striped Bass (Pre-Mig)	13	4.84	0.032	5.40	3.70	16.3	10.0
planktivore	Gizzard Shad	9	0.404	0.296	4.19	4.77	21.0	12.9
predator	American Eel	9	1.10	0.090	3.46	5.78	25.4	15.6
predator	White Perch	26	1.91	0.027	1.79	11.2	49.2	30.2
predator	Grey Trout (Weakfish)	1	0.254	0.186	1.66	12.1	53.1	32.6
planktivore	Bluegill Sunfish	2	5.36	0.007	1.32	15.2	66.8	41.0
predator	Largemouth Bass	17	4.57	0.008	1.29	15.5	68.2	41.9
predator	Blue Catfish	3	1.47	0.025	1.27	15.8	69.4	42.6
predator	Atlantic Croaker	4	0.124	0.266	1.16	17.3	76.0	46.6
benth/gen	Pumpkinseed Sunfish	5	2.30	0.013	1.06	18.9	83.2	51.1
predator	White Catfish	3	3.88	0.008	1.05	19.1	83.9	51.5
benth/gen	Brown Bullhead Catfish	4	1.28	0.022	1.00	20.1	88.3	54.2
benth/gen	Spot	9	0.172	0.138	0.830	24.1	106	65.0
benth/gen	Yellow Perch	2	1.02	0.022	0.801	25.0	110	67.4
planktivore	American Shad	3	0.204	0.104	0.747	26.8	118	72.3
benth/gen	Yellow Bullhead Catfish	2	0.864	0.024	0.716	27.9	123	75.5
predator	Bluefish	8	0.333	0.051	0.597	33.5	147	90.4
benth/gen	Mummichog	2	0.237	0.062	0.519	38.5	170	104
predator	Black Crappie	1	0.180	0.032	0.203	98.5	433	266

natural environment to fish tissue criteria or screening thresholds. Fish tissue thresholds for total PCBs are currently 20 ng/g in the District of Columbia, 88 ng/g in Maryland, and 54 ng/g in Virginia (Table D-6). Each water or sediment target is a jurisdiction's fish tissue threshold divided by a species-specific bioaccumulation factor. Water and sediment concentrations below these targets are not expected to result in fish consumption advisories for PCBs. The targets must be protective of species most susceptible to PCB bioaccumulation, as these will be protective of less susceptible species. The water targets must also be less than or equal to jurisdiction-specific water quality standards for PCBs. The PotPCB model can run scenarios to identify PCB load reductions that meet these water column and surface sediment PCB targets.

State agency representatives of Maryland, Virginia, and the District of Columbia reviewed a technical memo dated 29 May, 2007 (Haywood and Buchanan 2007), which describes alternative methods and results for the calculation of bioaccumulation factors and equivalent water and sediment targets. After reviewing that memo, the steering committee selected the species specific

Table D-6. Comparison of jurisdiction PCB criteria for water, fish tissue screening thresholds, and BAF-based targets. Calculations used to derive total PCB criteria for water quality standards and the targets for water column and surface sediment concentrations in the District of Columbia (DC), Maryland (MD), and Virginia (VA) are shown. Key: *, based on EPA's 1980 ambient water quality criteria (AWQC) methodology; RL, acceptable risk level (EPA default 10^{-5}-10^{-6}); BW, average adult body weight (EPA default 70 kg); CSF, cancer slope factor for PCBs (EPA default 2 mg/kg/day); FI, fish consumption rate; BCF, bioconcentration factor (EPA default 31,200 liters/kg tissue).

Total PCBs	Water Quality Standard Criteria*	Fish Tissue Threshold	Water Column Target	Surface Sediment Target
Formula (carcin-ogen)	$\frac{RL * BW * 1,000,000}{CSF * (FI * BCF)}$ = allowable water column concentration, in ng/liter	Various Methods	$\frac{\text{Fish Threshold}}{\text{Adjusted Total } BAF_{species}}$ = allowable water column concentration, in ng/liter	$\frac{\text{Fish Threshold}}{\text{Adjusted } BSAF_{species}}$ = allowable sediment concentration, in ng/g sediment dry wt
DC	$\frac{0.000001 * 70 * 1,000,000}{2 * (0.0175 * 31,200)}$ **= 0.064 ng/liter**	20 ng PCB per g wet wt tissue	$\frac{20}{341,000_{\text{channel catfish}}}$ **= 0.059 ng/liter**	$\frac{20}{7.52_{\text{channel catfish}}}$ **= 2.7 ng/g sediment**
MD	$\frac{0.00001 * 70 * 1,000,000}{2 * (0.0175 * 31,200)}$ **= 0.64 ng/liter**	88 ng PCB per g wet wt tissue	$\frac{88}{341,000_{\text{channel catfish}}}$ **= 0.26 ng/liter**	$\frac{88}{7.52_{\text{channel catfish}}}$ **= 12 ng/g sediment**
VA	$\frac{0.00001 * 70 * 1,000,000}{2 * (0.0065 * 31,200)}$ **= 1.7 ng/liter**	54 ng PCB per g wet wt tissue	$\frac{54}{845,000_{\text{gizzard shad}}}$ **= 0.064 ng/liter**	$\frac{54}{7.52_{\text{channel catfish}}}$ **= 7.2 ng/g sediment**

"median observed baseline BAF re-adjusted" (May 29 memo Table 2) and species specific "median observed BSAF re-adjusted" (May 29 memo Table 5) as the preferred calculation methods. These are the "adjust total BAF (median)" in Table D-3 and "adjusted SedBAF (median)" in Table D-5. The decision was based on a preference for calculations based on observed data rather than model simulations since sufficient data were available for the species of interest.

Each jurisdiction selected from the tables target species that have the highest bioaccumulation factors (excluding striped bass which, because they are migratory, may not be representative of PCB conditions in the Potomac). Although gizzard shad have the highest water BAF, there are no samples collected in MD or DC so those two jurisdictions selected channel catfish. Channel catfish have the highest sediment BAF so all three jurisdictions selected that species for calculating the sediment PCB target.

The final water column and sediment target concentrations for total PCBs are compared to the jurisdictions' existing criteria for their water quality standards for PCBs in Table D-6. In all three jurisdictions, the BAF-based water target is lower than the water quality standard so, for the purpose of calculating a TMDL, the BAF-based water target takes precedence over the water quality standard. The water column targets, in ng PCBs per liter, are 0.059 (DC), 0.26 (MD), and 0.064 (VA). The sediment targets, in ng PCBs per g sediment dry weight, are 2.7 (DC), 12 (MD), and 7.2 (VA).

IX. REFERENCES

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APPENDIX E

SEMI-PERMEABLE MEMBRANE DEVICES (SPMD)

This appendix presents the SPMD data collected in 2005-2006 and some general conclusions about its use as a PCB screening tool.

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Appendix E

Semi-Permeable Membrane Devices (SPMDs)

Semi-permeable membrane devices (SPMDs) provide an effective means to screen a waterbody for low level dissolved contaminants like PCBs in the water column. SPMDs, otherwise known as "fatbags," consist of three long, tubular bags filled with a highly purified fat. These devices are exposed at predetermined areas in the environment for a lengthy period of time (around 30 days). Since contaminants like PCBs are lipophilic (fat loving) and hydrophobic (water fearing), dissolved PCBs will readily transfer across the membrane upon coming into contact with the fatbag. This is one of the main pathways of contaminant exposure to fish in the environment. Once the PCBs are "captured" in the "fatbag", the SPMDs are taken to the laboratory where the PCBs are then separated from the fat and then analyzed for PCB congeners. The SPMD PCB congener concentrations expressed as ng/SPMD are then converted to an estimated water concentration (ng/L) using a model developed by the USGS and summed to yield total PCB.

SPMDs were utilized in the development of the Potomac River TMDL as a mechanism to target potential sources of PCBs. Twenty-eight SPMDs were deployed in the Potomac River and Virginia tributaries, recovered, and analyzed in 2006 (USGS memo, Tables E-1, E-2, E-3). Water column congener concentrations (ng/liter) derived from the measured PCB contents of the SPMDs (ng/SPMD) were censored as follows:

1) Values less than the method detection limits (MDL) are not included in the Quantification Total.
2) Values greater than the MDL but less than the method quantitation limits (MQL) are included in the Quantification Total.
3) Values with known interference (congeners 87 and 136) were excluded.

Originally, the idea was to use these devices to help establish loads from the many tributaries to the Potomac River as well as to provide a means to measure water column concentrations. It has been demonstrated that SPMDs provide an estimation of ambient time-weighted average dissolved or vapor phase concentrations (Huckins et al, 2006). As such, these devices could underestimate PCB loadings to the system as they have a great affinity for the adsorption to the carbon content of total suspended solids (TSS), which significantly increases during storm events. It became evident during this study that SPMDs may not fully account for high flow "events" which is very important when calculating PCB loads. Estimates of daily watershed PCB3+ loads derived with the Chesapeake Bay Program (CBP) Watershed Model version 5 (WM5) and summed over the deployment periods of the bags correlated very weakly ($r^2 = 0.15$, $p = 0.07$) with SPMD PCB3+ concentrations (Figure E-1). Water column PCB3+ concentrations did not correlate with PCB3+ water concentrations estimated from the SPMDs (Figure E-2). However, it should be noted that temporal and spatial considerations were excluded from this analysis. On the other hand, the SPMD estimated water results did show a declining trend in PCB3+ with distance from Washington, DC (Figures E-3, E-4), which is consistent with the declining trends observed in water, sediment, and fish. SPMDs appear to be a useful method to bracket potential sources of PCBs and to detect hotspots.

Huckins, J.N., J.D. Petty, and K. Booij. 2006. Monitors of Organic Chemicals in the Environment - Semipermeable Membrane Devices. Springer, New York.

United States Department of the Interior

U. S. GEOLOGICAL SURVEY

Columbia Environmental Research Center
4200 New Haven Road
Columbia, Missouri 65201

November 21, 2006

To: Roger Stewart, Virginia Department of Environmental Quality (VA DEQ)

From: David Alvarez, USGS Columbia Environmental Research Center (CERC)

Subject: Data report for the Potomac River PCB TMDL study

Attached in this email are the reviewed data tables containing PCB residues in the field deployed SPMDs (reported as ng/SPMD) and the estimated water concentrations (pg/L) for these residues. This memo is intended to provide a brief summary of the processing and analysis, data manipulation, and data evaluation. As discussed during our phone call of November 16, 2006, the preparation of a full project report or the co-authored publication of results including VA DEQ's TMDL determinations in a peer-reviewed scientific journal will be determined at a later date.

Method Notes -
Procedures for the preparation, shipping, storage, processing, and analysis of SPMDs for congener PCB (c-PCB) residues have been previously described in detail (1-4). At each site, four SPMDs were deployed, each spiked with PCB congeners 14, 29, and 50 to be used as performance reference compounds (PRCs). Three of the four deployed SPMDs were combined into a single sample to enhance the amount of chemical sampled and the fourth SPMD was archived prior to processing. Sample processing involved dialysis, size exclusion chromatography, Florisil® and Silica Gel fractionation techniques optimized for PCBs. Congener-specific analysis was performed using a dual-column capillary gas chromatography-electron capture detection (GC-ECD) method. A total of 147 congeners were determined with 40 congeners confirmed by quantification on both columns. The chromatographic separation was achieved using 60m DB-5 and 60m DB-17HT columns. Quantitation was performed by comparison of target responses to a multi-point calibration curve ranging from 0.03 to 100 ng/mL of each congener.

The estimation of ambient water concentrations for the PCB congeners was performed using the latest uptake models as described by Huckins et al. (1). In general, SPMD-water partitioning is driven by hydrophobic interactions and a strong correlation exists between the SPMD-water partition coefficient (K_{sw}) and the chemical's octanol-water partition coefficient (K_{ow}). Using an empirical uptake rate model, based on a third-order polynomial derived from published calibration studies, site-specific sampling rates (R_s) can be determined from the chemical's K_{ow} and PRC loss data. This approach increased the overall accuracy of the water concentration estimates by using a single expression to describe the entire sampling process (i.e., linear, curvilinear, and equilibrium sampling) instead of using separate equations for each phase of sampling. A multi-PRC approach was also used to provide an average adjustment to the target chemical's R_s over a larger range of K_{ow}s.

Observations –
The c-PCB and total PCB values are reported in the attached Excel spreadsheets as both ng sequestered (ng/SPMD) and estimated water concentrations (pg/L). PRC data was available for all sites with the exception of the sample from Four Mile Run @ Rt. 120 (1AFOU001.92). In this sample, the PRC numbers were elevated, indicating a possible interference. To estimate water concentrations for this sample, the PRC data from Four Mile Run (1AFOU002.02) was used. The two sites were 0.1 mile apart and flow data showed similar average flows (38 and 28 ft^3/s) during the two deployment periods. Differences in temperature between the May 2005 deployment (1AFOU002.02) and the December 2005 deployment (1AFOU001.92) should only have had a modest effect on the R_s as a 10-20 ºC temperature change has shown to cause an increase in R_s by a factor of about 1.7 (1).

While reviewing the data, note that there exists a possible p,p'-DDE interference with congeners 87 and 136. The silica gel fractionation used in this study results in about a 50:50 split of p,p'-DDE between the PCB and pesticide fractions. The presence of p,p'-DDE was not confirmed in this study. The silica gel fractionation also results in lower recovery of the lower chlorinated PCBs in the PCB fraction. This generally accounts for less than 5% of the total PCB loading.

For most sites, there did not appear to be any major problems arising from the identification and quantitation of the c-PCBs. The one exception was the SPMD composite sample from Noman Cole STP (1APOH004.79). This site contained an extremely complex early third of the chromatogram making quantification of most of the c-PCBs impossible (Figure 1). As a result of this unknown contamination, determination of c-PCBs were not possible and any values provided are for informational purposes only. This sample was screened by GC-mass spectrometry in a effort to identify some of the interfering compounds. Although no definitive identifications could be made, most of the major components in the chromatograph appeared to be brominated compounds which possibly may have been created during the waste treatment process at the STP. Additional knowledge of the types of treatment used at the STP and work to isolate these compounds would be necessary to make any conclusions on this sample.

Per the request of Roger Stewart of the VA DEQ, none of the data was censored for method detection limits (MDL) or method quantitation limits (MQL) prior to entering it into the attached tables. Values shown in Bold are reportable values >MQL. Values in normal type are detectable but not quantifiable (>MDL but <MQL). Values in italics are below the defined detection limit (<MDL). The MDL was operationally defined as the mean of field blanks plus three standard deviations (5). The MQL was operationally defined as the mean of field blanks plus ten standard deviations (5). For individual congeners having no coincident chromatographic peak, an assumed value equal to the low sample reject for the instrumental method (operationally defined as 20% of the concentration of the lowest standard concentration used for the calibration curve) was used to calculate the mean. In the cases where the calculated values of the MQLs were below the level of the calibration curve employed in the analysis, the MQLs were set at

the value of the lowest level of the calibration curve employed in quantifying concentrations of an analyte. MDL and MQL values shown in the "Estimated water concentration table" are presented for informational purposes only. These were calculated using average PRC values and days deployed for the whole study. These average MDL and MQL values were not used to determine the limits for each site. The censor tags shown in the table are based on the MDL and MQL values determined from the SPMD residue data.

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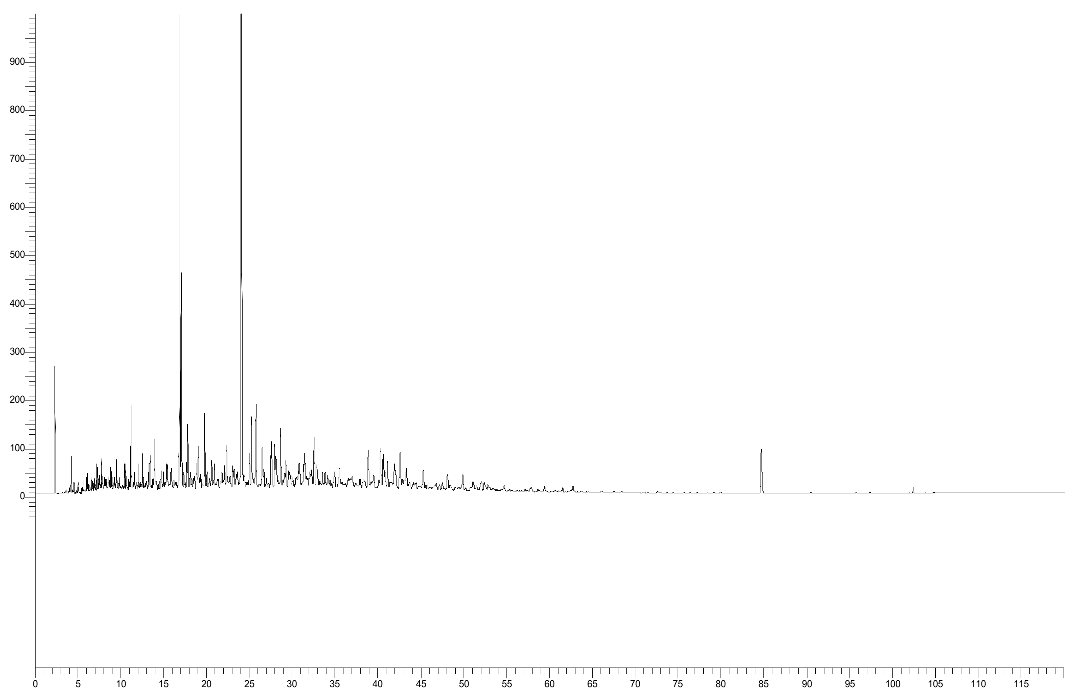


Figure 1 of USGS November 21, 2006 memo to Roger Stewart (VADEQ). GC-ECD chromatogram (DB-5 column) of SPMD composite sample from Noman Cole STP (1APOH004.79). The large unknown peaks in this sample appeared to be brominated compounds as determined by GC-mass spectrometry.

Table E-1. SPMD deployment locations and time periods.

STATION ID	COMMENT	DATE DEPLOYED	DATE RETRIEVED	Days Deployed
1AMAW001.28	Mattawoman Creek Near mouth suspended	06/16/2005	07/18/2005	32
1AQUA002.38	Quantico Creek Upper embayment, ½ mile upstream from Power Lines	05/17/2005	06/16/2005	30
1ACHO001.57	Chopawamsic Creek Upper embayment	05/19/2005	06/16/2005	28
1ADOU001.40	Dogue Creek Embayment Upper embayment, just upstream from Ft. Belvoir Marina suspended	06/30/2005	08/04/2005	35
1APOH002.32	Pohick Bay (Gunston Cove) Embayment Upper embayment, move to ambient station due to SAVs suspended	06/30/2005	08/04/2005	35
1AFOU002.02	Four Mile Run ~200 yds upstream from S. Glebe Rd	05/10/2005	06/14/2005	35
1AACO002.50	Accotink Creek ~20 yds upstream from Rt. 1 Bridge	05/09/2005	06/14/2005	36
1APOT080.29	Potomac River at Quantico Bite - between Island and wetland	05/19/2005	06/16/2005	28
1AOCC003.82	Occoquan River (Belmont Bay) Near the mounth of Massey Creek (Close to the #7 marker for the channel)	05/10/2005	06/16/2005	37
1AHUT001.54	Hunting Creek ~300 yds downstream from Telegraph Rd	05/10/2005	06/14/2005	35
1AMRC002.81	CAGE ON SW SIDE OF BRIDGE TIED TO TREE Monroe Creek (assoc field blank site 5)	05/16/2005	06/15/2005	30
1APOT119.82	Potomac River at Chain Bridge ~50 yds upstream from Chain Bridge Blank Can # Extra Site	06/15/2005	07/21/2005	36
1APRE001.58	Presley Creek	05/17/2005	06/16/2005	30
1AMON002.60	N38.25009,W076.97084, MOVED BECAUSE SITE WAS MUDFLAT AT LOW TIDE Monroe Bay	05/16/2005	06/15/2005	30
1ACON000.96	UNDER SOUTH SIDE OF HYWAY BRIDGE Coan Mill	05/17/2005	06/16/2005	30
1APOT000.00	EXACTLY ON STATION COORDINATES Mouth	05/26/2005	06/28/2005	33
1ACOA004.14	N37.95840, W076.48138, MOVED TO AVOID HIGH BOAT TRAFFIC LANE NEAR DOCK Coan River	05/17/2005	06/16/2005	30
1ANOM011.37	Assoc. AIR BLANK CAN #1, NOMINI CREEK	05/16/2005	06/15/2005	30
1ANOM007.79	N38.07749,W76.71854 Nomini Creek	06/27/2005	07/27/2005	30
1ALIF001.09	Little Hunting Creek Upper embayment	05/17/2005	06/13/2005	27
1APOW003.03	Powells Creek ~ 100 yds downstream from Rt. 1 Bridge	07/26/2005	08/26/2005	31
1ANEA002.74	Neabsco Creek ~200 yds downstream from Rt. 1 Bridge	07/26/2005	08/26/2005	31
1ABUL006.32	Bull Run Downstream from old hydro dam site	07/29/2005	08/29/2005	31
1AAUA003.71	Aquia Creek	09/01/2005	10/03/2005	32
1AWLL00.94	Williams Creek	09/01/2005	10/03/2005	32
1AUMC002.30	Upper Machodoc Creek	09/01/2005	10/03/2005	32
1AFOU001.92	Four Mile Run @ Rt. 120	12/14/2005	01/11/2006	28
1APOH004.79	Pohick Creek	12/14/2005	01/11/2006	28

Table E-2. PCB concentrations in SPMD bags (ng/SPMD bag). Data has not been censored for method detection limits (MDL) or method quantitation limits "MQL" per request by the VA DEQ. Data has not been adjusted for significant figures, however, two significant figures would be appropriate. PCB3+ refers to the sum of PCB homologs 3-10. Mono-, di-, etc. refer to the PCB homologs 1 – 10.

Station	Site Description	Total PCB	PCB3+	MONO	DI	TRI	TETRA	PENTA	HEXA	HEPTA	OCTA	NONA	DECA
1AMAW001.28	Mattawoman Creek	212.64	188.77	2.64	21.23	17.34	59.36	65.64	35.36	9.17	1.45	0.17	0.28
1AQUA002.38	Quantico Creek	83.14	81.45	0.61	1.09	9.37	21.88	23.56	19.29	6.07	0.91	0.12	0.25
1ACHO001.57	Chopawamsic Creek	79.52	78.22	0.95	0.36	3.33	13.18	21.68	28.65	9.89	1.15	0.10	0.23
1ADOU001.40	Dogue Creek	151.53	146.78	1.84	2.90	22.58	50.45	38.94	26.40	6.98	1.06	0.12	0.25
1APOH002.32	Pohick Bay (Gunston Cove)	138.48	136.14	1.07	1.27	15.49	40.32	39.49	29.91	8.93	1.44	0.22	0.33
1AFOU002.02	Four Mile Run	303.74	282.45	18.44	2.85	11.65	41.21	64.35	101.45	54.73	8.39	0.38	0.28
1AACO002.50	Accotink Creek	99.98	90.96	3.44	5.58	22.28	29.91	17.01	15.63	5.01	0.79	0.10	0.23
1APOT080.29	Potomac River at Quantico Bite	305.28	290.23	13.51	1.55	16.18	56.70	108.75	75.63	28.83	3.64	0.24	0.26
1AOCC003.82	Occoquan River	153.76	148.57	4.96	0.24	13.50	32.27	35.05	45.95	18.60	2.70	0.21	0.28
1AHUT001.54	Hunting Creek	207.28	144.39	4.70	58.19	23.57	47.76	51.22	16.42	4.37	0.70	0.11	0.24
1AMRC002.81	Monroe Creek	51.56	26.41	6.01	19.14	1.26	3.78	16.71	3.45	0.69	0.18	0.10	0.25
1APOT119.82	Potomac River at Chain Bridge	119.07	111.42	3.79	3.86	7.68	27.06	34.10	29.17	11.12	1.82	0.18	0.30
1APRE001.58	Presley Creek	59.86	32.25	13.24	14.37	12.90	2.51	13.56	2.33	0.52	0.13	0.07	0.23
1AMON002.60	Monroe Bay	95.29	91.59	2.17	1.53	12.91	21.88	29.65	20.41	5.22	1.00	0.21	0.31
1ACON000.96	Coan Mill	40.52	31.90	2.46	6.16	12.29	5.04	10.54	3.18	0.41	0.13	0.06	0.24
1APOT000.00	Mouth	51.14	30.95	8.01	12.18	4.53	5.21	15.11	4.02	1.32	0.38	0.14	0.23
1ACOA004.14	Coan River	73.27	56.79	1.17	15.31	23.65	8.14	18.60	4.96	0.91	0.20	0.09	0.25
1ANOM011.37	Nomini Creek	22.98	22.30	0.06	0.62	10.93	3.64	4.81	2.15	0.39	0.10	0.07	0.21
1ANOM007.79	Nomini Creek	90.50	86.82	0.91	2.77	38.36	11.90	25.76	8.46	1.69	0.31	0.10	0.23
1ALIF001.09	Little Hunting Creek	219.26	213.39	2.31	3.56	36.39	56.39	78.63	31.33	8.89	1.38	0.14	0.23
1APOW003.03	Powells Creek	74.51	59.31	5.36	9.84	27.38	14.51	12.22	3.70	1.00	0.21	0.06	0.23
1ANEA002.74	Neabsco Creek	44.24	41.60	0.11	2.52	9.67	13.57	10.13	5.75	1.87	0.32	0.07	0.23
1ABUL006.32	Bull Run	80.33	59.28	20.07	0.99	10.38	19.59	16.72	9.74	2.10	0.42	0.08	0.25
1AAUA003.71	Aquia Creek	129.23	92.98	2.20	34.06	8.58	16.67	47.54	14.89	4.28	0.68	0.10	0.22
1AWLL00.94	Williams Creek	242.45	136.61	0.14	105.70	10.04	19.99	86.37	15.41	3.86	0.58	0.12	0.24
1AUMC002.30	Upper Machodoc Creek	130.41	128.26	0.00	2.15	19.89	11.53	82.32	11.06	2.76	0.40	0.09	0.22
1AFOU001.92	Four Mile Run @ Rt. 120	174.38	131.93	34.94	7.51	15.65	54.08	35.52	19.09	5.95	1.26	0.13	0.25
1APOH004.79	Pohick Creek	59.74	30.18	23.76	5.80	6.24	9.78	9.09	3.63	0.95	0.19	0.07	0.24

Table E-3. Water concentration of PCBs (ng/liter) derived from SPMD bags. Data has been censored (see text for details).

Station	Site Description	Total PCB	PCB3+	MONO	DI	TRI	TETRA	PENTA	HEXA	HEPTA	OCTA	NONA	DECA
1AMAW001.28	Mattawoman Creek	0.393	0.390		0.004	0.031	0.122	0.106	0.094	0.031	0.006		
1AQUA002.38	Quantico Creek	0.749	0.749			0.047	0.169	0.199	0.229	0.091	0.014		
1ACHO001.57	Chopawamsic Creek	0.676	0.675		0.000	0.013	0.085	0.150	0.281	0.127	0.019		
1ADOU001.40	Dogue Creek	0.602	0.593		0.009	0.059	0.184	0.163	0.133	0.045	0.008		
1APOH002.32	Pohick Bay (Gunston Cove)	0.368	0.364		0.003	0.031	0.099	0.091	0.094	0.037	0.008	0.001	0.003
1AFOU002.02	Four Mile Run	0.812	0.808		0.004	0.024	0.093	0.147	0.291	0.211	0.040	0.002	
1AACO002.50	Accotink Creek	1.053	1.035		0.019	0.128	0.334	0.204	0.249	0.101	0.019		
1APOT080.29	Potomac River at Quantico Bite	2.473	2.465		0.008	0.100	0.459	0.507	0.885	0.439	0.071	0.004	
1AOCC003.82	Occoquan River	0.931	0.931		0.000	0.055	0.164	0.178	0.329	0.171	0.031	0.002	
1AHUT001.54	Hunting Creek	0.797	0.716	0.026	0.054	0.120	0.262	0.158	0.127	0.042	0.007		
1AMRC002.81	Monroe Creek	0.032	0.027		0.005	0.003	0.022		0.000	0.001	0.000		
1APOT119.82	Potomac River at Chain Bridge	0.380	0.378		0.002	0.019	0.080	0.091	0.118	0.058	0.012		
1APRE001.58	Presley Creek	0.010	0.006		0.004	0.001		0.001	0.000	0.003			
1AMON002.60	Monroe Bay	1.391	1.386		0.005	0.052	0.306	0.428	0.414	0.137	0.032		0.017
1ACON000.96	Coan Mill	0.361	0.183		0.177	0.021	0.144	0.008	0.009	0.002			
1ACOA004.14	Coan River	0.102	0.083		0.019	0.030	0.035	0.016	0.002		0.000		
1APOT000.00	Potomac River Mouth	0.030	0.029		0.001	0.002	0.014	0.001	0.006	0.006			
1ANOM011.37	Nomini Creek	0.011	0.011				0.007		0.000	0.003			
1ANOM007.79	Nomini Creek	0.270	0.244		0.025	0.028	0.099	0.032	0.063	0.022	0.000		
1ALIF001.09	Little Hunting Creek	1.015	0.992	0.008	0.014	0.167	0.276	0.240	0.215	0.079	0.015		
1APOW003.03	Powells Creek	0.434	0.350		0.084	0.099	0.241	0.004	0.004	0.002	0.001		
1ANEA002.74	Neabsco Creek	0.225	0.207		0.018	0.040	0.131	0.001	0.003	0.032	0.001		
1ABUL006.32	Bull Run	0.215	0.215			0.031	0.105	0.010	0.049	0.019	0.001		
1AAUA003.71	Aquia Creek	0.338	0.334		0.004	0.027	0.083	0.070	0.108	0.039	0.007		
1AWLL000.94	Williams Creek	0.685	0.674		0.011	0.076	0.176	0.179	0.176	0.058	0.009		
1AUMC002.30	Upper Machodoc Creek	0.243	0.236		0.006	0.088	0.046	0.025	0.055	0.021	0.001		
1AFOU001.92	Four Mile Run @ Rt. 120	0.348	0.329		0.020	0.036	0.121	0.088	0.056	0.022	0.006		
1APOH004.79	Pohick Creek	0.809	0.740		0.068	0.246	0.456	0.033		0.005			
VA0025364-001	Noman Cole STP	0.437	0.391		0.046	0.157	0.157	0.050	0.025	0.002	0.000		

Figure E-1. PCB3+ content of SPMD bag versus the corresponding CBP WM5 watershed PCB3+ load estimated for the SPMD deployment period. The exponential relationship is very weak ($r^2 = 0.15$, $p = 0.07$), but PCB3+ content of the SPMD bags generally increases as the corresponding watershed load increases.

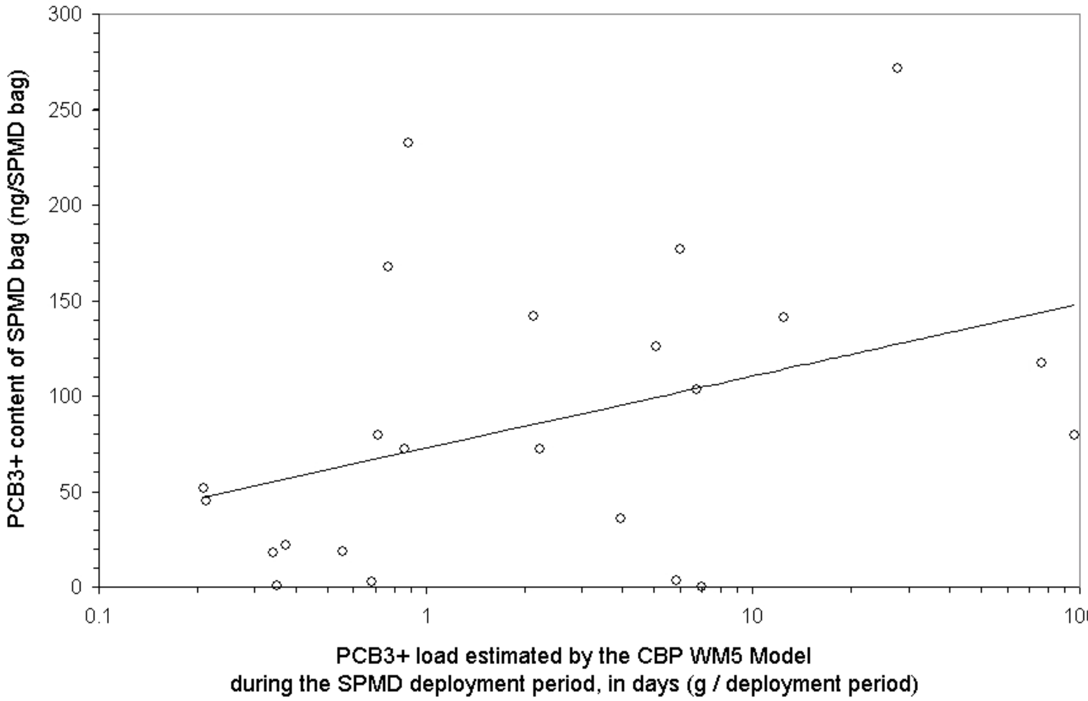


Figure E-2. Water column PCB3+ concentrations estimated from SPMD bags versus observed water column PCB3+ concentrations in grab samples collected in roughly the same time period and location as the SPMD deployments. The correlation is not significant ($p<0.05$).

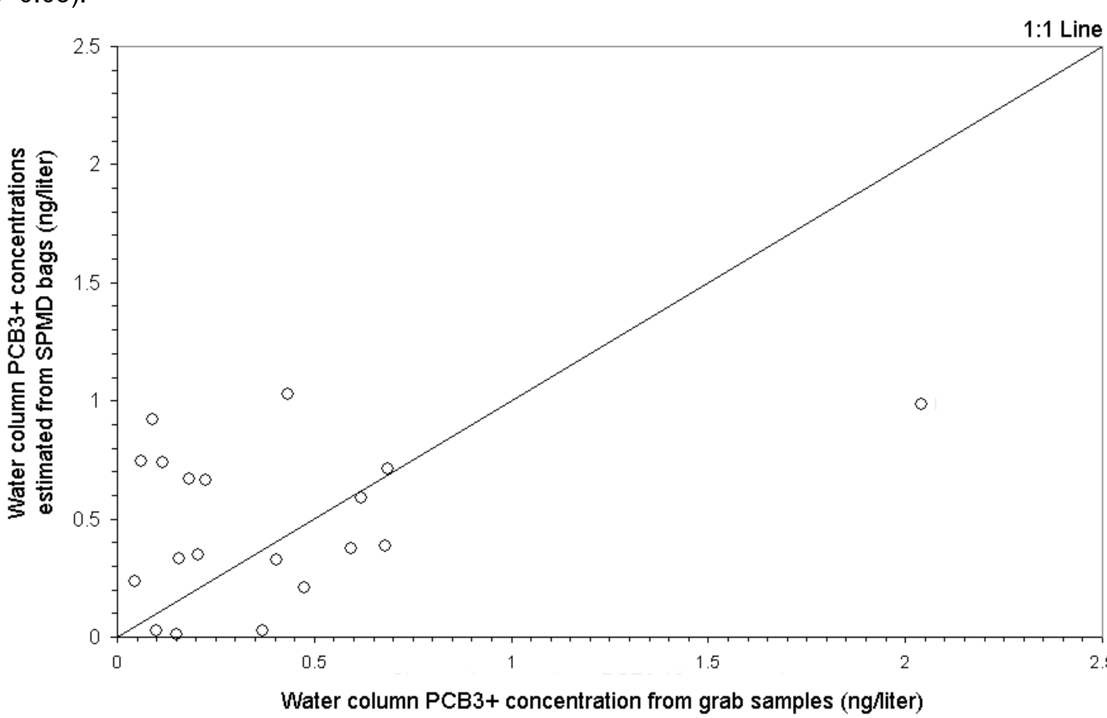


Figure E-3. PCB3+ content of SPMD bags versus distance from the Potomac River estuary mouth. The exponential relationship is significant (r^2 = 0.56, p<0.01).

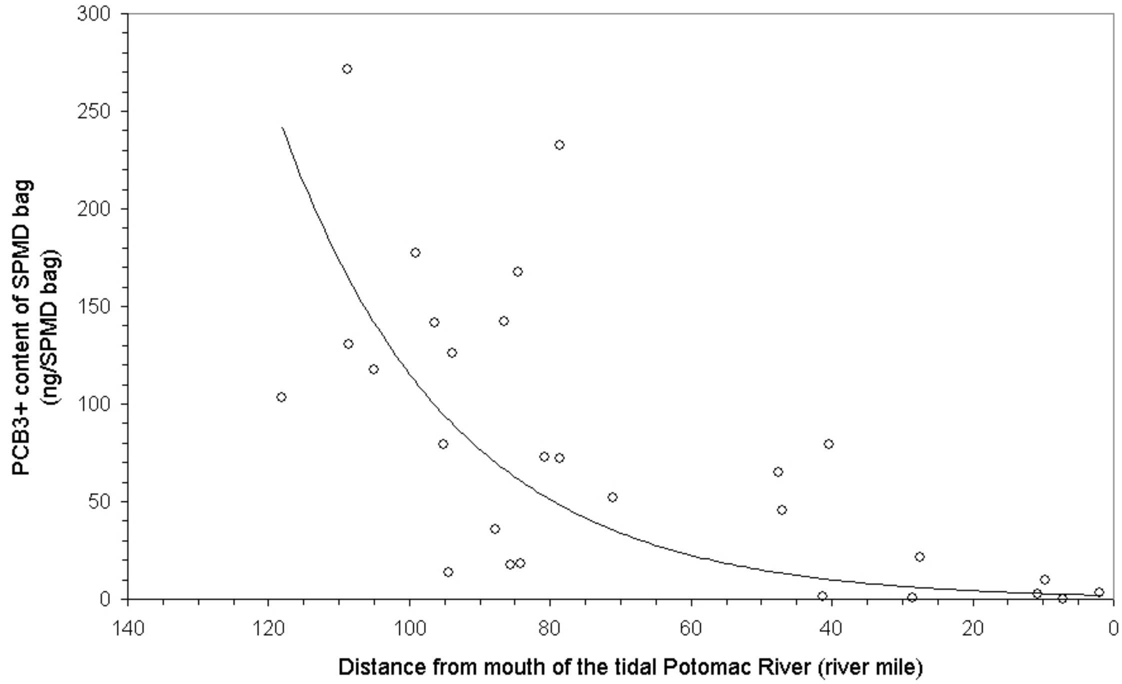
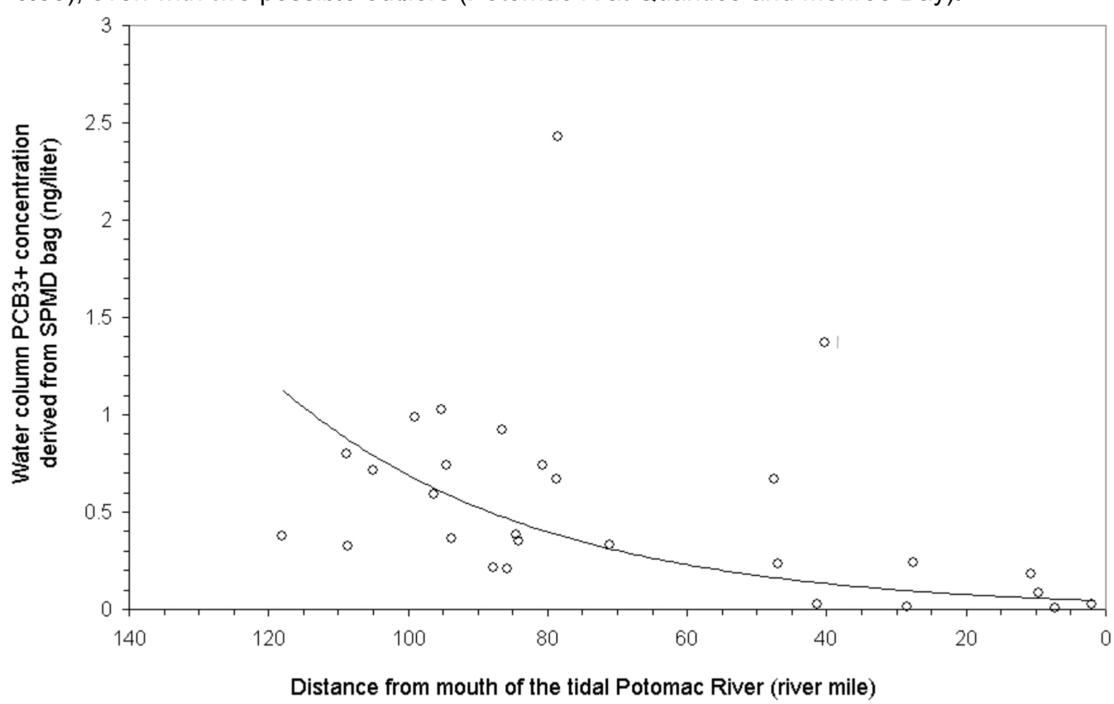


Figure E-4. Water column PCB3+ concentrations derived from SPMD bags versus distance from the Potomac River estuary mouth. The exponential relationship is weakly significant (r^2 = 0.17, p = 0.03), even with two possible outliers (Potomac R at Quantico and Monroe Bay).



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APPENDIX F

CALCULATION OF WLAs FOR THE DC AND ALEXANDRIA CSO SYSTEM

This appendix explains how the separate WLA allocations for the DC and Alexandria CSO systems were calculated.

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Appendix F

Calculation of WLAs for the DC and Alexandria CSO systems

This Appendix provides additional detail on the CSO wasteload allocations because the TMDL tables in the report do not separately identify the DC and Alexandria CSO systems. These two load sources discharge to multiple impairments and both systems discharge to the DC Lower Potomac impairment. Section V(1) of this report provides an overview of the process that was followed to arrive at TMDL load allocations. In the POTPCB model run that became the TMDL scenario, Alexandria CSO loads were reduced by 0% and DC CSO loads by 95%. These reductions, combined with reductions in other sources, were just sufficient to meet the PCB water target concentrations in the Anacostia and DC Potomac impaired waterbodies. After the model run a 5% explicit Margin of Safety (MOS) was applied to the CSO loads (the explicit MOS was applied to all sources but WWTPs).

Thus, (all numbers g/year tPCB)

CSO system	**Baseline**	**TMDL**
Alexandria	26.8	25.46
DC	2,993	32.68
TOTAL	3,020	58.14

The % reduction for CSO shown in Table 13 of the TMDL report is 98%. The reason this number is higher than the 0% and 95% reductions applied to Base loads in the TMDL model runs is that the Baseline referred to in the TMDL report is based on 2005 flows and 2005 concentrations, while the TMDL model runs applied reductions to the Base Scenario. The Base Scenario assumed that CSO Long Term Control Plans (LTCP) had already been implemented. The DC LTCP, which has not been implemented, includes a considerable reduction in flow, resulting in Base Scenario PCB loads of 688 g/yr PCB. So the 95% reduction applied in the TMDL scenario model run results in a DC CSO load of 34.4 g/year PCB (688 * (1-0.95)) which, with a 5% MOS applied, becomes 32.68 g/year (34.4 * (1-0.05)).

A qualitative summary of the PCB load reductions required from the DC CSO system is that implementing the LTCP by itself will achieve most of the needed reductions through reduced flow, but additional reductions in PCB concentrations still will be required to meet the TMDL allocation.

The Alexandria LTCP already is implemented and no additional changes to its CSO system are anticipated, so its Baseline and Base Scenario loads are the same. The modest reduction in TMDL allocation due to the 5% MOS may be addressed in the adaptive management phase with additional monitoring to better define loads in this area and with some expectation that reduction in atmospheric deposition to the land surface will accomplish the 5% reduction.