Basis and Background Document

Revised Human Health Water Quality Criteria for Total PCBs for the Protection of Human Health from Carcinogenic Effects

Delaware River Basin Commission
West Trenton, New Jersey

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Acknowledgments

This report was prepared by the staff of the Delaware River Basin Commission and the Delaware Department of Natural Resources and Environmental Control. Carol R. Collier is the Executive Director of the Commission. Dr. Thomas J. Fikslin and Dr. Richard W. Greene were the principal authors. Dr. Fikslin is the Manager of the Commission's Modeling, Monitoring and Assessment Branch. Dr. Greene is an Environmental Engineer in the Watershed Assessment Section, Division of Watershed Stewardship of the Delaware Department of Natural Resources and Environmental Control.

Significant technical contributions were also made members of the Toxics Criteria Subcommittee of the Commission's Toxics Advisory Committee. Members of the subcommittee included the authors; Dr. Ronald MacGillivray of the Modeling, Monitoring and Assessment Branch; J. Bart Ruiter, DuPont Engineering Research and Technology; Dr. Steven Washburn, Environ Corp.; Lawrence Sandeen, Rohm & Haas Company; Steven Lubow, New Jersey Department of Environmental Protection; Denise Hakowski, U.S. EPA Region III; Wayne Jackson, U.S. EPA Region II; Dr. Roland Hemmett, U.S. EPA Region II; Timothy Kubiak, U.S. Fish and Wildlife Service; Bonita Moore, Pennsylvania Department of Environmental Protection; Carol Young, Pennsylvania Department of Environmental Protection; Dr. Steven Brown, Rohm & Haas Company; and Dr. Robert A. Hoke, Dupont Company.

The Toxics Advisory Committee made the final recommendations to the Commission regarding this water quality criterion. The current membership of the Committee can be found at http://www.nj.gov/drbc/about/advisory/toxics/index.html.

EXECUTIVE SUMMARY

Identification of the governing water quality criteria is an essential step in the TMDL process. For the Delaware Estuary, available water quality criteria for PCBs include human health criteria for carcinogenic and systemic effects, and both freshwater and marine acute and chronic aquatic life criteria. The current DRBC water quality criteria for PCBs in the Delaware Estuary were established in 1996. They pre-date the collection of site-specific bioaccumulation data for the Delaware Estuary and Bay and site-specific fish-consumption data for Zones 2 through 4 that are relevant to the development of human health water quality criteria. They are also inconsistent with current U.S. Environmental Protection Agency (EPA) guidance for the development of such criteria, and they vary by water quality zone. One consequence is that in order to ensure that the water quality criterion of 7.9 picograms per liter in the downstream portion of Zone 5 can be achieved, the allowable PCB loading to Zones 2 and 3, where the current criterion is 44.4 picograms per liter, must be even lower than would be required if the proposed uniform criterion were in place.

Several factors are causing regulatory agencies to update their current human health water quality criteria for PCBs. These factors include: 1) the change in the cancer potency factor for total PCBs reported in EPA's Integrated Risk Information System (IRIS), 2) the availability of an updated default national fish consumption rate, and 3) the issuance of a revised methodology for deriving ambient water quality criteria for the protection of human health (EPA -822-B-00-004) in the fall of 2000. The latter methodology also includes several new recommendations on the use of site-specific fish consumption rates to be used in criteria development, and the use of a bioaccumulation factor (BAF) rather than a bioconcentration factor (BCF).

A subcommittee of the Delaware River Basin Commission's Toxic Advisory Committee was tasked with developing revised human health criteria for five zones of the Delaware Estuary. Existing criteria for the estuary are 44.4 pg/l for Zones 2 and 3 for exposure through drinking water and fish consumption, 44.8 pg/l for Zones 4 and the upper portion of Zone 5 for exposure through fish consumption only, and 7.9 pg/l for the lower portion of Zone 5 for exposure through fish consumption only. The lower criterion in Zone 5 is also due to a higher fish consumption rate being used.

Values for five factors were needed to develop the revised criteria. Three of the factors used EPA-recommended default values. These three factors were 1) risk-specific dose (2.0 mg/kg-day at a risk level of 10^{-6}), 2) body weight (70 KG), and 3) drinking water intake (2 liters/day). Site-specific data were needed to develop appropriate values for the other two factors: fish consumption at each trophic level, and BAF at each trophic level. Site-specific data for fish consumption in Zone 5 and Delaware Bay indicated an average consumption rate for all species of 17.46 grams per day. This value is remarkably close to the national default value of 17.5 grams per day. A second study by Faulds et al, 2004 examined catch and consumption patterns in Zones 2, 3 and 4 of the tidal Delaware River by intercepting and interviewing shore anglers at six sites in urban areas in and around the City of Philadelphia. Consumption data from this study were converted to grams per day, the unit used in the criteria equation, and resulted in consumption rates of 17.9 grams per day for channel catfish and 21.7 grams per day for white perch assuming a meal size of 8 ounces. The

consumption rate selected for use in the criteria equation was 17.5 grams per day. This value is consistent with the national default value and the site-specific data for Zones 2 through 6.

Field studies were conducted to provide PCB congener data on fish tissue concentrations of PCBs in species representative of two trophic levels, channel catfish and white perch. Ambient water concentrations of PCB congeners and organic carbon were also determined using low level sampling and analytical techniques for use in calculating the BAF in the new methodology. Data on the percent lipid of consumed fish were also determined from routine monitoring conducted by state agencies and the Commission since 1990. Data on the proportion of each trophic level consumed was assumed to be 50% based upon data from all zones that indicated roughly equal proportions for the two trophic levels.

Use of these data with the new EPA methodology results in a single criterion value of 15.9 pg/L. A probabilistic approach was also used to assess the impact of the uncertainty of the values used in the methodology. This analysis indicated that the median criterion value of 16.4 pg/L was close to that obtained using the deterministic approach, and that the interquartile range (40^{th} percentile to the 60^{th} percentile) fell between 11.2 pg/L to 24.4 pg/L.

In July 2005, the Commission's Toxics Advisory Committee (TAC) that had guided the development of a new human health water quality criterion for PCBs for the Delaware Estuary and Bay voted to recommend that the Commission adopt a revised human health criterion for the protection from carcinogenic effects of 16 picograms per liter for Zones 2 through 6. This revised criterion will provide a uniform TMDL target throughout the estuary and eliminate the current sharp transition in criteria within the estuary.

As the regulatory agencies agreed on a path forward to adopt the revised PCB criterion and propose a revised long-term implementation strategy for Stage 2 TMDLs, technical staff from the Commission and Delaware DNREC agreed to evaluate the proposed criterion in light of the availability of more recent data on PCB concentrations in ambient waters of the estuary and resident fish tissue. The results of this evaluation affirm the original numerical value of 16 pg/L for the human health criterion for Zones 2 through 6.

INTRODUCTION

An essential step in the TMDL process is the identification of the governing water quality criteria. For the tidal portions of the Delaware River and Bay, applicable criteria include maximum contaminant levels, taste and odor criteria, aquatic life criteria, and human health criteria for protection from carcinogenic and systemic effects (DRBC, 2010). For hydrophobic contaminants like polychlorinated biphenyls or PCBs, the ambient water quality criteria for the protection of human health from carcinogenic effects is the most stringent criteria; on the order of nanograms per liter to picograms per liter due to the high bioaccumulation of these compounds in fish tissue. As a consequence many water bodies are listed as impaired for PCBs including the Delaware River Estuary, resulting in the requirement to develop TMDLs for the water bodies.

As a consequence of the requirement of the 1986 amendments to the Clean Water Act many states were required to adopt water quality criteria for toxic pollutants including PCBs. Water quality criteria developed by EPA in the early 1980s were typically used to establish the states' water quality standards. These criteria were established using a methodology that addressed impacts to aquatic life, and both the carcinogenic and systemic effects of a chemical or, in the case of PCBs, a class of chemical compounds on human health by exposure through ingestion of water and fish (U.S. EPA, 1980a). This methodology included the consideration of six parameters: risk level, cancer potency factor, body weight, drinking water consumption, fish consumption, and the bioconcentration (BCF) of the chemical from water to fish tissue. The risk level is essentially a policy decision of the governmental agency adopting the criteria under their water quality standards regulations. Values for each of the remaining parameters were issued by the U.S. EPA for a group of chemicals referred to as the priority pollutants. While values for the cancer potency factor and BCF were chemical-specific, specified values for body weight, drinking water intake, and fish consumption were used in the methodology for all chemicals. The specified values for these parameters were 70 kilograms, 2 liters per day, and 6.5 grams per day, respectively.

The human health criteria for protection from carcinogenic effects initially recommended by EPA was 79 picograms per liter. This value was derived using a cancer potency factor of 4.3396 (mg/KG)/day (U.S. EPA, 1980b). This factor was subsequently revised in January 1990 to 7.7 (mg/KG)/day. This revision resulted in a recommended criterion value of 44.4 picograms per liter (pg/L). By the mid-1990's, human health criteria had been adopted for the Delaware River Estuary by Delaware, Pennsylvania, the Delaware River Basin Commission (DRBC) and the U.S. EPA. Criteria established by the DRBC varied between areas of the estuary due to differences in the designated use and the use of a different value for fish consumption in the lower portion of Zone 5 (DRBC, 2010). The criteria for the estuary are 44.4 pg/l for Zones 2 and 3, 44.8 pg/l for Zones 4 and the upper portion of Zone 5, and 7.9 pg/l for the lower portion of Zone 5. The lower criterion in Zone 5 is due to a higher fish consumption rate being used while only Zones 2 and 3 are designated as a drinking water source. The water quality regulations of the states of Delaware (Title 7, Section 4.2) and New Jersey (N.J.A.C. 7:9B-1.14(h)) contain provisions that defer to water quality criteria of the Commission for the mainstem of the Delaware River. The Commonwealth of Pennsylvania water quality regulations at Title 25, Chapter 93.2 provide that the more stringent of the water quality standards established under an interstate compact or international agreement or

those adopted by the Commonwealth apply to Zones 2 through 4 of the Delaware River.

Several actions require the criteria originally adopted by the DRBC and most states to be revised. The first is the revision of the cancer slope factor from 7.7 $(mg/KG\text{-}d)^{-1}$ to a range of factors based upon the persistence of the chemical in the environment and the bioaccumulation potential (U.S. EPA, 1999). For hydrophobic chemicals with high bioaccumulation potential like PCBs, the upper bound of the slope factor was recommended by the U.S. EPA. For total PCBs, this slope factor was 2.0 $(mg/KG\text{-}d)^{-1}$. In 2000, the U.S. Environmental Protection Agency issued revised guidance on developing human health criteria (U.S. EPA, 2000). Two significant changes recommended in this guidance were the recommendations to use site-specific values for fish consumption for the water body covered by the criteria, and to use a bioaccumulation factor or BAF rather than a BCF. In lieu of site-specific values on the consumption of fish by recreational fisherman, the guidance also recommended a default value of 17.5 grams per day. In February 2001, the Delaware River Basin Commission's Toxic Advisory Committee (TAC) charged a subcommittee to develop revised criteria for the protection of human health from carcinogenic effects of total PCBs for use in the TMDLs being developed by the Commission for the Delaware River Estuary. The Stage 1 TMDLs established by U.S. EPA Regions 2 and 3 in December 2003 were based upon the criteria adopted in 1996 as the studies to develop a revised criteria were still underway. Delaware, New Jersey and Pennsylvania subsequently revised their criteria to a value of 64 pg/L by incorporating the revised cancer slope factor and incorporating the default nation fish consumption rate of 17.5 grams per day. Adoption of a revised criterion of 16 pg/L by the Commission will establish a uniform criterion for total PCBs in the tidal waters (Zones 2 through 6) of the Delaware River and Bay and incorporated the latest recommendation of the U.S. EPA including the use of a site-specific bioaccumulation factor or BAF.

METHODOLOGY

The TAC subcommittee recommended that the revised criteria be developed using the October 2000 guidance issued by the U.S. EPA. The equation recommended in the guidance is:

$$AWQC = RSD\left[\frac{BW}{DI + \sum_{i=2}^{4}\left(FI_i \bullet BAF_i\right)}\right]$$

where:

AWQC = Ambient Water Quality Criterion (mg/l)

RSD = Risk-specific dose for carcinogens based on a linear low-dose extrapolation (mg/KG-day) such as 10^{-6}. Can also be expressed as

	Risk Level/Cancer Potency Factor.
BW =	Body weight (KG)
DI =	Drinking water intake per day (default = 2 Liters)
FI_i =	Fish intake at trophic level I (where I = 1, 2, 3, 4), KG/day
BAF_i =	Bioaccumulation Factor at trophic level I, L/KG-lipid

Each of the parameters used in the revised criteria methodology was evaluated by the subcommittee. The evaluation approach involved the review of the rationale provided in the EPA guidance document for establishing national values for each of the parameters, and the evaluation of site-specific data for each of the parameters. The site-specific data available for evaluation included data on the consumption of fish by recreational fishermen in the lower estuary, Zones 5 and 6 commissioned by Delaware DNREC (KCA, 1994), and in the more urban portions of the estuary, Zones 2 through 4 (Faulds et al, 2004). DRBC also funded two studies to provide data for use in establishing bioaccumulation factors for PCBs. The first study involved measuring the concentration of PCBs in sediments and various trophic levels of the food chain of selected sport species in the Delaware River Estuary (Ashley et al, 2004). This study examined PCB concentrations in invertebrates, small prey fish, channel catfish and white perch in the fall of 2001 and the spring of 2002 in four zones of the estuary (Zones 2 - 5) that were the focus of TMDL development. The second study involved the measurement of 124 PCB congeners in water samples collected at 15 locations in Zones 2 through 5 (DRBC, 2003). Data from fish tissue surveys conducted in the estuary were also examined to determine the percent lipid of the consumed portion of channel catfish and white perch caught in the estuary (Greene, 2002).

In order to assess the uncertainty in the parameters that are used in the criteria equation, a probabilistic analysis was conducted using @Risk software (Palisade Corporation, 2004). This analysis involves assigning distributions to selected equation parameters and some of their components. Table 1 indicates which of the parameters and their components were assigned a distribution or a fixed value. The distributions used for each parameter and component were determined from the source data or from statistical analysis of the data. POC, DOC, % lipid for channel catfish, and % lipid for white perch were each treated as lognormal distributions. The octanol water partition coefficient (K_{ow}), which is used to calculate the fraction of freely dissolved chemical, was treated as a discrete distribution, with homolog-specific K_{ow} values assigned to different frequencies based upon the possible number of PCB congeners at each homolog level. Fish consumption rate was considered as a triangular distribution with a minimum of zero, a most likely value of 17.46 grams per day, and a maximum value of 53.9 grams per day, based upon the KCA study (1994). The cancer potency slope was treated as a uniform distribution spanning a range from 1 to 2 $(mg/KG\text{-}d)^{-1}$. Finally, baseline BAFs for channel catfish and white perch were specified as Gumbel distributions based upon best fits to the field data.

The distributions described above, in combination with the fixed values for risk level, body weight, and drinking water ingestion, were sampled 10,000 times using the Latin Hypercube procedure to produce a range of possible water quality criterion values for the protection of human health from carcinogenic effects, each with an associated frequency.

Table 1: Summary of Parameters and Data Used in Calculating Human Health Criteria for Carcinogens

Parameter	Policy	Fixed Value	Distribution Used
Risk Level of 10^{-6}	X		
Body weight - 70 kilograms		X	
Drinking water intake per day - 2 liters per day		X	
Cancer potency factor			Uniform
Fish intake at each trophic level			
Total consumption rate			Triangular
Proportion of each trophic level species		X	
Bioaccumulation factor at each trophic level (BAF_i)			
Octanol-water partition coefficient (K_{ow})			Discrete
Particulate organic carbon (POC)			Lognormal
Dissolved organic carbon (DOC)			Lognormal
% lipid of consumed portion			Lognormal
Intermediate Parameters			
Fraction of PCB freely-dissolved in water			Calculated
Baseline BAF for channel catfish			Gumbel
Baseline BAF for white perch			Gumbel
Trophic level BAF for channel catfish			Calculated
Trophic level BAF for white perch			Calculated

The distributions were then sampled 10,000 times using the Latin Hypercube procedure and summarized in frequency distributions.

RESULTS

The value(s) selected for each parameter in the revised criteria equation are discussed below:

Cancer potency factor

The value selected for use is the upper bound factor for total PCBs published in the U.S. EPA's Integrated Risk Information System (U.S. EPA, 2013). This factor was first published in 1997 along with central estimate and upper bound factors for high risk and persistence, low risk and persistence, and lowest risk and persistence as a result of a reevaluation of the data on the carcinogenicity of PCB Aroclors. The upper bound slope factor is recommended for use where there is exposure through the food chain; dioxin-like, tumor-promoting, or persistent congeners are present; or early life exposure is expected. The subcommittee recommended the use of the upper bound estimate of 2.0 $(mg/KG\text{-}d)^{-1}$.

Body weight

The value selected for use is the average weight of male and female adults of 70 kilograms. This value is recommended by the U.S. EPA for establishing ambient water quality criteria (U.S. EPA, 2000). It is slightly lower, however, than that reported in the U.S. EPA analysis of the 1999 - 2006 National Health and Nutrition Examination Surveys or NHANES (U.S. EPA, 2011). The mean body weight of adults of both sexes observed in this survey was 80.0 kilograms. The median body weights ranged from 67.4 to 81.4 kilograms. U.S. EPA recommends continued use of 70 kilograms for consistency since this value is used in the Integrated Risk Information System for deriving cancer slope factors and unit risks for drinking water.

Risk level

The risk level used in establishing ambient water quality criteria is a risk management policy decision. It is defined as the number of cases of disease such as cancer in a population exposed to a chemical or chemicals. While the U.S. EPA believes that a risk level of either 10^{-5} or 10^{-6} may be acceptable as a *de minimus* risk for the general population, it uses a level of 10^{-6} for criteria actions under Sections 304(a) and 303(c) of the Clean Water Act. The agency believes that this risk level reflects an appropriate risk for the general population, and is consistent with the policies and regulations of the agency as a whole (U.S. EPA, 2000). The recommendation of a range of risk levels does provide flexibility to government entities in establishing water quality standards.

A risk level of 1 additional cancer case in 1 million exposed individuals or 10^{-6} was selected for use in the equation. This risk level is used by the Commission, the states of Delaware and New Jersey, and the Commonwealth of Pennsylvania in establishing their water quality standards. In March 2003, the Commission adopted Resolution 2003-11 following discussion of the recommendations of the Commission's Toxics Advisory Committee on revised human health criteria and wildlife criteria for total PCBs. This resolution directed the Commission staff to solicit comment on the revised human health criteria for PCBs including the appropriate cancer risk level.

Drinking water intake rate

A value of 2.0 liters/day was selected for this parameter. This value was used in the development of the 1980 national water quality criteria, and continues to be recommended by the U.S. EPA in the 2000 guidance (U.S. EPA, 2000). This recommendation was based upon a more recent survey of food intake by individuals conducted by the U.S. Department of Agriculture entitled "1994-96 Continuing Survey of Food Intake by Individuals" (U.S.D.A., 1998). This survey reported a mean and 90th percentile drinking water consumption for adults 20 years of age and older of 1.1 and 2.2 liters/day, respectively. The U.S. EPA believes that new studies continue to support the use of 2.0 liters/day as a reasonable and protective consumption rate for the general population (U.S. EPA, 2000).

Fish consumption rate

In the 2000 guidance, the U.S. EPA recommends that a hierarchy of preference be used in the selection of a fish consumption rate for use in the criteria equation (U.S. EPA, 2000). This hierarchy is: 1) the use of local data on fish consumption patterns, 2) use of data reflecting similar geography or population groups for the water body of concern, 3) use of data from national surveys, and 4) use of the U.S. EPA default consumption rates. The default rate recommended by the U.S. EPA for both recreational fisherman and the general population is 17.5 grams per day. Ths rate is based upon the 1994-96 Continuing Survey of Food Intake by Individuals (U.S.D.A., 1998)

Two sources of data were available on the fish consumption patterns of recreational fisherman in the Delaware River Estuary. A study commissioned by the State of Delaware examined catch and consumption patterns in Zones 5 and 6, the lower portion of the tidal Delaware River and Delaware Bay (KCA, 1994). The study involved dockside intercepts and follow-up phone interviews of over 800 participants. The northern part of Zone 5 adjoins the urban area of Wilmington, and the surrounding suburban area of New Castle County in Delaware. The second study by Faulds et al, (2004) examined catch and consumption patterns in Zones 2, 3 and 4 of the tidal Delaware River by intercepting and interviewing shore anglers at six sites in Pennsylvania. These zones include the urban areas in and around the City of Philadelphia.

The average consumption of all species in Zones 5 and 6 was 17.46 grams per day, and the maximum fish consumption by any particular demographic group was 53.9 grams per day (KCA, 1994). Channel catfish and white perch were consumed at approximately equal rates. Faulds et al (2004) reported that channel catfish, striped bass and white perch were the most frequently consumed species in Zones 2 through 4. Ethnic groups reporting the highest consumption were Cambodian, Vietnamese and Afro-American. Faulds et al (2004) reported the number of meals of the species consumed by shore anglers. This data was converted to grams per day, the unit used in the criteria equation, and resulted in consumption rates of 17.9 grams per day for channel catfish and 21.7 grams per day for white perch assuming a meal size of 8 ounces.

The consumption rate selected for use in the criteria equation was 17.5 grams per day. This value is consistent with the national default value and the site-specific data for Zones 2 through 6. The

consumption data reported by Faulds et al (2004) on urban fisherman in Zones 2 - 4 was not substantially higher than the rate observed in the lower estuary, and did not support the use of a different consumption rate for zones in the Philadelphia area, especially in light of the management benefits associated with a consistent, estuary-wide criterion.

Bioaccumulation factor

Bioconcentration factors, or BCFs, represent the accumulation of a chemical in an aquatic species due to uptake from the water only. In contrast, bioaccumulation factors, or BAFs, represent the accumulation due to all routes of exposure, including exposure through the water and through the consumption of contaminated prey and sediment. Use of a bioaccumulation factor rather than a bioconcentration factor was endorsed by the Commission's Toxics Advisory Committee at their meeting in February 2001 and directed by the Commission in Resolution 2000-13 in March 2003. The 2000 guidance calls for the use of a separate factor for each of the trophic levels represented in the species consumed in the water body for which the criteria will apply. In the case of the Delaware Estuary, two trophic levels were used. Trophic level 3 represents species whose diet consists of consumers of primary producers and detritus, principally invertebrates such as amphipods of the genus *Gammarus*. The species selected to represent this trophic level was the channel catfish. Trophic level 4 represents species whose diet includes more fish. The species selected to represent this trophic level was the white perch. The use of a single value for the BAF for these two trophic levels was unanimously endorsed by the Commission's Toxics Advisory Committee in February 2003.

The 2000 guidance recommends two possible procedures for deriving BAFs for nonionic organic chemicals (U.S. EPA, 2000). Procedure #1 is recommended for nonionic organic chemicals with log K_{ow} values equal to or greater than 4.0 where metabolism is expected to be sufficiently low. PCB homologs have log K_{ow} values that range from 4.69 for monochlorobiphenyls to 8.18 for decachlorobiphenyls. The guidance specifically mentions PCBs as a group of chemicals for which Procedure #1 is deemed appropriate. Procedure #1 contains four methods for calculating the BAFs. The first method uses field measurements to derive the BAFs. The 2000 guidance recommends this method over the other three methods which utilize predictive approaches for establishing BAFs (U.S. EPA, 2000).

The first step in using measured data to derive the BAFs is to calculate Baseline BAFs. Baseline BAFs are defined as a BAF in units of Liters/kilogram-lipid that is based upon the concentration of freely dissolved chemical in the ambient water and the lipid-normalized concentration in the fish tissue (U.S. EPA, 2000). Baseline BAFs are calculated using the formula:

$$Baseline\ BAF_{l}^{fd} = \left[\frac{Measured\ BAF_{T}^{t}}{f_{fd}} - 1 \right] \left[\frac{1}{f_{l}} \right]$$

where:

Baseline BAF^{fd}_{l} =	BAF based upon the total concentration of the chemical in tissue and ambient water
f_l =	The fraction of tissue that is lipid
f_{fd} =	The fraction of the total chemical that is freely-dissolved in water
Measured BAF^{t}_{T} =	BAF based upon the total concentration of the chemical in tissue and ambient water and calculated using the formula:

$$Measured\ BAF_T^t = \frac{C_t}{C_w}$$

where:

C_t =	Total concentration of the chemical in the specified wet tissue
C_w =	Total concentration of the chemical in water

Zone-specific data on PCB concentrations in fish tissue and ambient water were obtained from two studies: a bioaccumulation study conducted by the University of Maryland and the Academy of Natural Sciences in the fall of 2001 and spring of 2002 (Ashley et al, 2004), and ambient water measurements of PCBs conducted by the Delaware River Basin Commission in late 2001 and early 2002 (DRBC, 2003). Each of these studies measured a common set of 124 congeners which were summed to derive total PCB concentrations. The fraction of the total chemical that is freely-dissolved in water is determined using the octanol water partition coefficient, and the concentration of particulate organic carbon and dissolved organic carbon in the ambient waters determined in surveys conducted by DRBC in the fall 2001 and spring 2002. The formula is:

$$f_{fd} = \frac{1}{\left[1+\left(POC \bullet K_{ow}\right)+\left(DOC \bullet 0.08 \bullet K_{ow}\right)\right]}$$

where:

POC =	Particulate organic carbon concentration in ambient water in Kilograms/liter
K_{ow} =	octanol water partition coefficient for the chemical
DOC =	Dissolved organic carbon concentration in ambient water in Kilograms/liter
f_{fd} =	The fraction of the total chemical that is freely-dissolved in water

Table 2 contains the ambient water, tissue concentration, organic carbon concentrations and fraction lipid that were used in the derivation of the Baseline BAFs.

Table 2: Data used in the derivation of the Baseline BAFs.

Study Period	Tissue Concentration (ng/g)	Ambient Water Concentration (pg/L)	POC (mg/L)	DOC (mg/L)	fraction lipid
Fall 2001		3194.4	1.51	6.44	
Channel catfish	1230.4				0.0892
White perch	1013.4				0.0734
Spring 2002		4691.8	1.84	10.74	
Channel catfish	1621				0.0817
White perch	1127.6				0.0684

Baseline BAFs are then converted to trophic level BAFs using the following formula:

$$BAF_{(TLn)} = \left[Baseline\ BAF_{l}^{fd} \bullet (f_l)_{TLn} + 1 \right] \bullet (f_{fd})$$

where

$BAF_{(TL\,n)}$ = Final trophic level baseline BAF expressed on a freely-dissolved and lipid-normalized basis for trophic level n

Baseline BAF_{l}^{fd} = BAF based upon the total concentration of the chemical in tissue and ambient water

f_l = The fraction of tissue that is lipid for trophic level n

f_{fd} = The fraction of the total chemical that is freely-dissolved in water

Table 3 lists the Baseline BAFs, fraction lipid of consumed tissue, fraction of chemical freely-dissolved and the final trophic level BAFs.

Prior to calculating the water quality criterion, the proportion of fish intake from each trophic level must be determined. Faulds et al (2004) reported that 42.6% of the fish consumed by shore anglers in Zones 2 through 4 were channel catfish while 42% of the fish consumed were white perch. Since these data indicated similar proportions for both trophic levels 3 and 4, equal proportions of each trophic level were assumed in calculating the revised ambient water quality criteria.

Table 3: Values used in the calculation of final trophic level baseline BAFs.

Trophic Level	Baseline BAF (L/KG-lipid)	fraction lipid of consumed tissue	fraction freely-dissolved	Trophic Level BAF (L/KG-lipid)
Level 3 - Channel catfish				
Fall 2001	35,288,611	0.0387	0.122	167,200
Spring 2002	44,088,605	0.0387	0.095	162,465
Level 4 - White perch				
Fall 2001	22,458,380	0.0248	0.122	68,190
Spring 2002	35,267,280	0.0248	0.095	83,281

Criterion calculation

Values for each of the parameters in the criteria equation presented in the 2000 guidance and the resulting ambient water quality criterion for the protection of human health from the carcinogenic effects of PCBs for Zones 2 through 5 is presented in Table 4.

Table 4: Parameter values used in the equation for calculating the human health criterion for the protection from carcinogenic effects for PCBs.

Parameter	Value
Risk Level	1×10^{-6}
Cancer potency factor	2.0 $(mg/KG\text{-}d)^{-1}$
Risk Specific Dose	5.0×10^{-7} mg/KG-d
Body Weight	70 KG
Drinking Water Intake	2.0 liters/day
Fish Intake	17.5 grams per day
Proportion of fish intake at each trophic level	Trophic level 3 - 0.5 Trophic level 4 - 0.5
BAF at each trophic level (L/KG-lipid)	Trophic level 3 - 164,832 Trophic level 4 - 75,736
Ambient Water Quality Criterion	**15.9 picograms/liter**

This ambient water quality criterion applies where exposure is from drinking water and fish consumption or only from fish consumption.

Probabilistic analysis

The results of the probabilistic analysis from exposure through drinking water and fish consumption, and through fish consumption only are presented in Table 5 and Figure 1. The 50th percentile of the criterion was 16.4 pg/liter for both exposure scenarios.

Table 5: Results of probabilistic analysis using @Risk.

Percentile	**Ambient Water Quality Criterion**	
	Fish and Water Consumption	**Fish Consumption Only**
10%	3.0	3.0
25%	6.2	6.2
50%	**16.4**	**16.4**
75%	49.6	49.7
90%	144.5	145.4

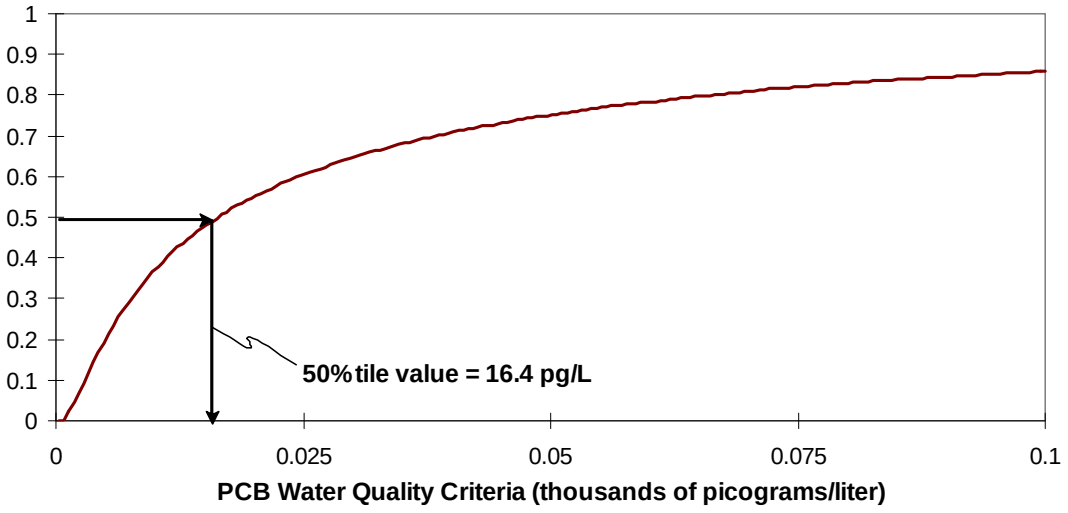

Figure 1: Distribution of ambient water quality criterion for PCBs

DISCUSSION

The keystone of any TMDL is the water quality criterion upon which it is based. In developing TMDLs for PCBs for the Delaware Estuary, several factors influence the selection of the governing criterion. These factors include: 1) a change in the cancer potency factor for total PCBs reported in EPA's Integrated Risk Information System, 2) the possible future adoption of wildlife criteria for PCBs, and 3) the issuance of a revised methodology for deriving ambient water quality criteria for the protection of human health in the fall of 2000. The latter methodology also includes several new recommendations on the fish consumption rate to be used in criteria development, and the use of a bioaccumulation factor (BAF) rather than a bioconcentration factor (BCF).

Another confounding factor that influences the development of TMDLs for hydrophobic contaminants like PCBs in interstate waters is the existence of different human health criteria adopted by bordering states. Furthermore, the requirement under the Clean Water Act that states update their criteria every three years can result in changing criteria over time, thus making the basis of the TMDLs difficult to establish. An example of the impact of these factors is the human health criteria for Zones 2 through 6 of the Delaware Estuary. In 1996, the Delaware River Basin Commission, the states of Delaware and New Jersey, and the Commonwealth of Pennsylvania all had the same criteria for water and fish consumption for PCBs, 44.4 picograms/liter. With the issuance of a revised slope factor and revised methodology for deriving human health criteria by the U.S. EPA, the adoption of different criteria by each of the three states during their triennial review was possible depending on the extent to which the new data and methodology were implemented. In 2004, both Delaware and New Jersey proposed revised human health criteria for PCBs. Delaware developed its revised criterion using the new cancer slope factor and site-specific fish consumption data, and derived a value of 64 picograms per liter. New Jersey developed its revised criterion using only the new cancer slope factor, deriving a value of 170 picograms per liter. In September 2006, New Jersey adopted a criterion of 64 picograms per liter using both the new cancer slope factor and the national default fish consumption value of 17.5 grams per day. The Commission still retains the criterion value of 44.4 picograms per liter adopted in 1996.

Adoption of the revised human health criterion for protection from carcinogenic effects for PCBs presented by the Commission will result in a uniform standard that fully implements the October 2000 guidance issued by the U.S. EPA. Even if the three states bordering the estuary have different criteria for PCBs depending on the extent to which they have implemented the new guidance, provisions in the standards of New Jersey and Delaware deferring to standards adopted by the Commission will make the revised criteria the governing criteria. Pennsylvania water quality standards do not have language deferring to the Commission's standard, but do have regulations stating that the more stringent of state, interstate or international criteria will apply in interstate or international bodies of water.

Wildlife criteria could theoretically be more stringent than human health criterion for carcinogenic effects. Factors affecting the relative stringency of each criteria include the numerical values of both the wildlife and human health criteria, and the exposure duration used in applying the criteria. The exposure duration for human health criteria for protection from carcinogenic effects is 70 years. The exposure duration for wildlife criteria is 90 days. Figure 2 compares the assimilative capacity (a

close analog of a TMDL) of Zones 2 - 5 of the Delaware Estuary based upon existing human health criteria, proposed wildlife criteria, and revised human health criteria implementing one or more recommendations of the October 2000 guidance. This graph indicates that existing criteria are not the most controlling, and that only by fully implementing the recommendations of the October 2000 guidance with respect to the cancer slope factor, fish consumption rates and the use of BAFs will the revised human health criteria be controlling.

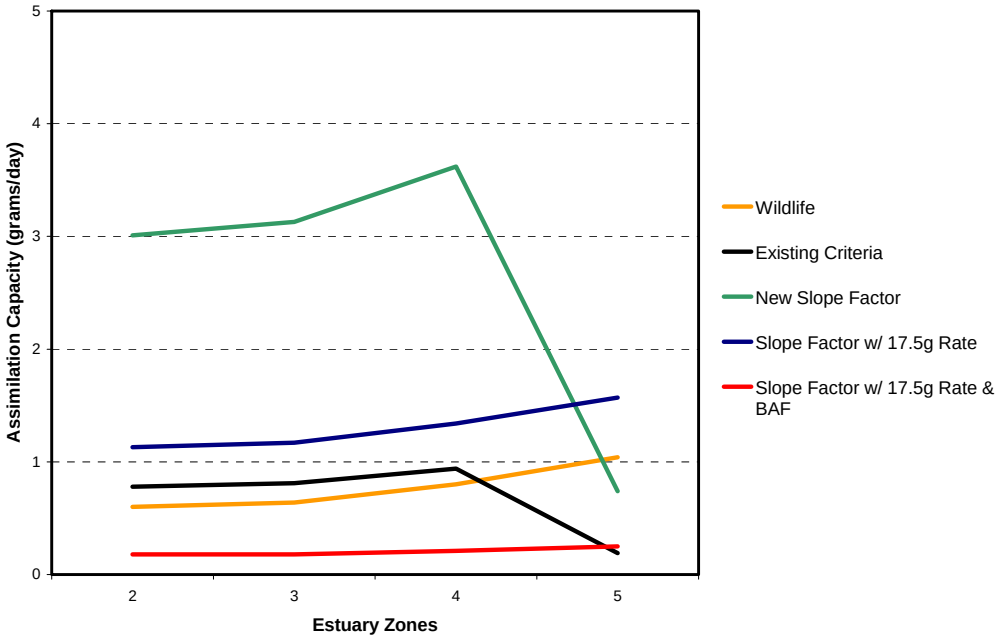

Figure 2: Comparison of assimilative capacity at different criteria values.

CONCLUSION

Revised human health criteria for the protection of human health from carcinogenic effects were developed using the updated cancer potency factor of 2.0 $(mg/KG\text{-}d)^{-1}$ and the October 2000 guidance issued by the U.S. EPA. Two significant changes recommended in this guidance were to use site-specific values for fish consumption for the water body covered by the criteria, and to use a bioaccumulation factor or BAF rather than a BCF. A value of 17.5 grams/day was selected for use in the criteria formula. This value is similar to site-specific values of 17.5 and 19.8 grams per day observed in two studies conducted in the Delaware Estuary, and is also the recommended national default value. Site-specific BAFs were developed for two trophic levels in the estuary using fish tissue data collected during the fall 2001 and spring 2002, and data on concentrations of PCB congeners in water samples collected during the same time period. Trophic level BAFs of 164,832 L/KG-lipid for trophic level 3 and 75,736 L/KG-lipid for trophic level 4 were determined using these data.

Values for other parameters in the criteria equation were a risk level of 10^{-6}, body weight of 70 kilograms, drinking water intake of 2.0 liters/day. The revised ambient water quality criterion for the protection of human health from carcinogenic effects of exposure through drinking water and fish consumption using these parameter values is 15.9 picograms/L. The results of a probabilistic analysis of selected equation parameters and some of their components indicated a 50^{th} percentile value of 16.4 picograms/L for the revised water quality criterion. This value is close to that obtained with the deterministic approach. A water quality criterion for the protection of human health from carcinogenic effects of 16 picograms per liter is therefore proposed for Water Quality Management Zones 2 through 6 from the head of the tide at Trenton, NJ to the mouth of Delaware Bay.

The values obtained using the revised criteria equation are approximately 2.5 more stringent than the criteria in Zones 2 - 4 and in the upper portion of Zone 5, and 2.2 times less stringent than the current criterion in the lower portion of Zone 5 and in Zone 6. Criteria of this magnitude would be more stringent than the wildlife criterion proposed for the State of New Jersey. Use of a revised water quality criterion for the development of TMDLs for PCBs in the Delaware Estuary will ensure consistency and stability in the value of the TMDLs.

In July 2005, the Commission's Toxics Advisory Committee (TAC) that had guided the development of a new human health water quality criterion for PCBs for the Delaware Estuary and Bay voted with no objections to recommend that the Commission adopt a revised criterion of 16 picograms per liter for Zones 2 through 6.

As the regulatory agencies agreed on a path forward to adopt the revised PCB criterion and propose a revised long-term implementation strategy for Stage 2 TMDLs, technical staff from the Commission and Delaware DNREC agreed to evaluate the proposed criterion in light of the availability of more recent data on PCB concentrations in ambient waters of the estuary and resident fish tissue. Review of the available data for this evaluation indicated that ambient water data for PCBs and carbon was available from a September 2007 survey, and that fish tissue data was available for 2007 for Zones 2 - 4. Results for the fish sample from Zone 5 were not available so data for a 2006 sample collected in Zone 5 was used. A point estimate for the criterion was calculated using the most recent U.S. EPA methodology (U.S. EPA, 2000), while a probabilistic analysis of the data was performed to develop distributions of the criterion using @Risk software. Details of the evaluation are contained in Appendix F. This analysis indicated that both the point estimate and median criterion value were the same (13.4 pg/L), with the 25th and 75th percentile values of 7.2 pg/L and 25.2 pg/L, respectively. These results compare well with the distribution of the criterion in the original analyses where the 25th and 75th percentile values were 6.2 pg/L and 49.6 pg/L, respectively. The results of this evaluation affirm the original numerical value of 16 pg/L for the human health criterion for Zones 2 through 6.

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Appendix A

Comparison of Current and Revised Criteria for Total PCBs for the Protection of Human Health from Carcinogenic Effects in Zones 2 through 6 of the Delaware River

Revised Water Quality Criteria for Total PCBs
Delaware River Basin Commission

Parameter	Cancer Potency Factor	BCF/BAF	% Lipid of Consumed Fish	Consumption Rate (Grams/day)	Basis for Consumption Rate	Freshwater Criteria (picograms/L)		Marine Criteria (picograms/L)
						Fish & Water Ingestion (Zones 2 & 3)	Fish Ingestion Only (Zones 4 & 5)	Fish Ingestion Only (Zones 5 & 6)
Total PCBs	7.70e+00	31,200[a]	3.0	6.5	Old default value	44.4	44.8	-
Total PCBs	7.70e+00	31,200[a]	3.0	37.0	Current DRBC value	-	-	7.9
Total PCBs	2.00e+00	164,832[b] 75,736[c]	3.9[b] 2.5[c]	17.5 (50% - Level 3 and 4)	National default and Estuary-Specific Data	**16.0**	**16.0**	**16.0**

a - BCF from 1980 Ambient Water Quality Criteria document.
b - BAF for trophic level 3 (mean of Fall 2001 and Spring 2002).
c - BAF for trophic level 4 (mean of Fall 2001 and Spring 2002).

Notes:Values were developed using percent lipid values from estuary data base of fillet samples, and a consumption rate of 17.5 grams per day.

Appendix B

Site-Specific BAFs
Fall 2001

Revised Water Quality Criteria for Total PCBs for the Protection of Human Health from Carcinogenic Effects in Zones 2 through 6 of the Delaware River

BAF Calculations

Freely-Dissolved Fraction:

			Freely-Dissolved Fraction										**Median**	**Minimum**	**Maximum**
	POC	DOC	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca			
Zone 2	1.06	5.68	0.931	0.849	0.629	0.376	0.214	0.099	0.044	0.017	0.012	0.004	0.156	0.004	0.931
Zone 3	1.54	6.25	0.909	0.807	0.558	0.309	0.168	0.075	0.033	0.012	0.009	0.003	0.122	0.003	0.909
Zone 4	1.19	9.56	0.913	0.814	0.569	0.319	0.174	0.078	0.035	0.013	0.009	0.003	0.126	0.003	0.913
Zone 5	2.48	5.99	0.874	0.742	0.465	0.236	0.122	0.053	0.023	0.009	0.006	0.002	0.088	0.002	0.874
All Zones	1.51	6.44	0.910	0.808	0.559	0.311	0.169	0.076	0.033	0.013	0.009	0.003	0.122	0.003	0.910

	Kow
Mono	4.69
Di	5.07
Tri	5.59
Tetra	6.04
Penta	6.39
Hexa	6.78
Hepta	7.16
Octa	7.59
Nona	7.74
Deca	8.18

Note: POC, DOC and Kow are all median values.

Fall 2001

White Perch
Concentration in Tissue (Ct)
ng/g

Zone 2	681.60
Zone 3	1345.10
Zone 4	1441.02
Zone 5	334.51
All Zones (median)	1013.35

Zone	Sample ID	Wet Weight (ng/g)	(ng/g lipid)
2	2CORE WF	681.60	11485
3	3CORE WF	1345.10	17586
4	4CORE WF	1441.02	19776
5	5CORE WF	334.51	3246

Channel catfish
Concentration in Tissue (Ct)
ng/g

Zone 2	1151.09
Zone 3	2191.38
Zone 4	1309.65
Zone 5	664.36
All Zones (median)	1230.37

Zone	Sample ID	Wet Weight (ng/g)	(ng/g lipid)
2	2CORE WF	1151.09	12485
3	3CORE WF	2191.38	21740
4	4CORE WF	1309.65	15211
5	5CORE WF	664.36	11222

Baseline BAF Calculation - using Sept 2001 DRBC water data

Channel catfish - Fall 2001
Whole Body Conc.

	Concentration in Tissue (Ct) ng/g	Total Water Concentration (Cw) pg/l	Measured BAF	Log BAF	% lipid	Fraction fd	Baseline BAF
Zone 2	1151.09	2729.36	421,744	5.63	9.22	0.156	29,258,732
Zone 3	2191.38	8739.41	250,747	5.40	10.08	0.122	20,449,300
Zone 4	1309.65	2529.14	517,824	5.71	8.61	0.126	47,558,891
Zone 5	664.36	3659.44	181,547	5.26	5.92	0.088	34,926,342
All Zones (median)	1230.37	3194.40	385,165	5.59	8.92	0.122	35,288,611

Note: Tissue concentration is converted to ng/kg and water concentration is converted to ng/l in the formula.

White Perch - Fall 2001
Whole Body Conc.

	Concentration in Tissue (Ct) ng/g	Total Water Concentration (Cw) pg/l	Measured BAF	Log BAF	% lipid	Fraction fd	Baseline BAF
Zone 2	681.60	2729.36	249,729	5.40	5.96	0.156	26,801,577
Zone 3	1345.10	8739.41	153,912	5.19	7.67	0.122	16,496,065
Zone 4	1441.02	2529.14	569,767	5.76	7.01	0.126	64,273,452
Zone 5	334.51	3659.44	91,410	4.96	10.58	0.088	9,839,988
All Zones (median)	1013.35	3194.40	201,820	5.30	7.34	0.122	22,458,380

Final Trophic Level BAF Calculation

Trophic Level 3

	Baseline BAF	Fraction lipid	Fraction fd	Trophic Level BAF
Zone 2	29,258,732	0.092	0.156	421,744
Zone 3	20,449,300	0.101	0.122	250,747
Zone 4	47,558,891	0.086	0.126	517,824
Zone 5	34,926,342	0.059	0.088	181,547
All Zones	35,288,611	**0.0387**	0.122	167,200

Trophic Level 4

	Baseline BAF	Fraction lipid	Fraction fd	
Zone 2	26,801,577	0.060	0.156	249,729
Zone 3	16,496,065	0.077	0.122	153,912
Zone 4	64,273,452	0.070	0.126	569,767
Zone 5	9,839,988	0.106	0.088	91,410
All Zones	22,458,380	**0.0248**	0.122	68,190

Note: All Zones fraction lipid is derived from the estuary-wide data compilation and UMd-CBL/ANSP data.

Final BAF Calculation - Fall 2001

ALL ZONES

Trophic Level	Trophic Level BAF	Proportion of Fish Intake*	Trophic Level Fish Intake (g/day)	BAF& Fish Intake Term
3	167,200	0.5	8.95	1,496
4	68,190	0.5	10.85	740
Total			19.8	
	Final BAF& Fish Intake Term (All Zones Combined) -		**2,236**	

* This proportion based upon data from the PSU study that indicated that 42.6% of fish consumed was channel catfish or carp while 42.0% of fish consumed was white perch or striped bass. Therefore, equal proportions from each trophic level was used in the calculation.

Appendix C

Site-Specific BAFs
Spring 2002

Revised Water Quality Criteria for Total PCBs for the Protection of Human Health from Carcinogenic Effects in Zones 2 through 6 of the Delaware River

BAF Calculations

Freely-Dissolved Fraction:

			Freely-Dissolved Fraction										**Median**	**Minimum**	**Maximum**
	POC	DOC	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca			
Zone 2	0.87	4.18	0.944	0.876	0.681	0.430	0.255	0.121	0.055	0.021	0.015	0.005	0.188	0.005	0.944
Zone 3	1.85	9.58	0.886	0.765	0.496	0.259	0.136	0.060	0.026	0.010	0.007	0.003	0.098	0.003	0.886
Zone 4	2.17	9.78	0.874	0.743	0.466	0.236	0.123	0.053	0.023	0.009	0.006	0.002	0.088	0.002	0.874
Zone 5	2.47	19.43	0.835	0.679	0.390	0.185	0.093	0.040	0.017	0.006	0.005	0.002	0.066	0.002	0.835
All Zones	1.84	10.74	0.883	0.759	0.488	0.253	0.132	0.058	0.025	0.009	0.007	0.002	0.095	0.002	0.883

	Kow
Mono	4.69
Di	5.07
Tri	5.59
Tetra	6.04
Penta	6.39
Hexa	6.78
Hepta	7.16
Octa	7.59
Nona	7.74
Deca	8.18

Carbon data is from March 15 and April 11, 2002 DRBC surveys.

Note: POC, DOC and Kow are all median values.

Spring 2002

	White Perch Concentration in Tissue (Ct) ng/g	Channel catfish Concentration in Tissue (Ct) ng/g
Zone 2	659.88	510.88
Zone 3	1127.98	1659.77
Zone 4	1202.04	1815.17
Zone 5	1127.26	1582.18
All Zones (median)	1127.62	1620.98

Zone	Sample ID	Wet Weight (ng/g)	(ng/g lipid)
2	2CORE WF	659.88	10965
3	3CORE WF	1127.98	15983
4	4CORE WF	1202.04	17037
5	5CORE WF	1127.26	26479

Zone	Sample ID	Wet Weight (ng/g)	(ng/g lipid)
2	2CORE WF	510.88	10577
3	3CORE WF	1659.77	22582
4	4CORE WF	1815.17	20213
5	5CORE WF	1582.18	15681

Baseline BAF Calculation

Channel catfish - Spring 2002
Whole Body Conc.

	Concentration in Tissue (Ct) ng/g	Total Water Concentration (Cw) pg/l	Measured BAF	Log BAF	% lipid	Fraction fd	Baseline BAF
Zone 2	510.88	2220.76	230,047	5.36	4.83	0.188	25,367,088
Zone 3	1659.77	5591.81	296,822	5.47	7.35	0.098	41,261,386
Zone 4	1815.17	5233.22	346,855	5.54	8.98	0.088	43,897,648
Zone 5	1582.18	4224.84	374,495	5.57	10.09	0.066	56,008,956
All Zones (median)	1620.98	4729.03	342,771	5.54	8.17	0.095	44,088,605

Note: Tissue concentration is converted to ng/kg and water concentration is converted to ng/l in the formula.

White Perch - Spring 2002
Whole Body Conc.

	Concentration in Tissue (Ct) ng/g	Total Water Concentration (Cw) pg/l	Measured BAF	Log BAF	% lipid	Fraction fd	Baseline BAF
Zone 2	659.88	2220.76				0.188	
Zone 3	1127.98	5591.81	201,720	5.30	7.33	0.098	28,117,752
Zone 4	1202.04	5233.22	229,694	5.36	6.84	0.088	38,164,805
Zone 5	1127.26	4224.84	266,817	5.43	4.26	0.066	94,516,411
All Zones (median)	1127.62	4729.03	229,694	5.36	6.84	0.095	35,267,280

Final Trophic Level BAF Calculation

Trophic Level 3

	Baseline BAF	Fraction lipid	Fraction fd	Trophic Level BAF
Zone 2	25,367,088	0.048	0.188	230,047
Zone 3	41,261,386	0.074	0.098	296,822
Zone 4	43,897,648	0.090	0.088	346,855
Zone 5	56,008,956	0.101	0.066	374,495
All Zones	44,088,605	**0.0387**	0.095	162,465

Trophic Level 4

	Baseline BAF	Fraction lipid	Fraction fd	
Zone 2		0.000	0.188	
Zone 3	28,117,752	0.073	0.098	201,720
Zone 4	38,164,805	0.068	0.088	229,694
Zone 5	94,516,411	0.043	0.066	266,817
All Zones	35,267,280	**0.0248**	0.095	83,281

Note: All Zones fraction lipid is derived from the estuary-wide data compilation and UMd-CBL/ANSP data.

Final BAF Calculation - Spring 2002

ALL ZONES

Trophic Level	Trophic Level BAF	Proportion of Fish Intake*	Trophic Level Fish Intake (g/day)	BAF& Fish Intake Term
3	162,465	0.5	8.75	1,422
4	83,281	0.5	8.75	729
Total			17.5	
	Final BAF& Fish Intake Term (All Zones Combined) -		**2,150**	

* - This proportion based upon data from the PSU study that indicated that 42.6% of fish consumedhas been assumed to be 50% for each trophic level.
was channel catfish or carp while 42.0% of fish consumed was white perch or striped bass. Therefore, equal proportions from each trophic level was used in the calculation.

Appendix D

Final BAF Calculation

Revised Water Quality Criteria for Total PCBs for the Protection of Human Health from Carcinogenic Effects in Zones 2 through 6 of the Delaware River

Final BAF Calculation Using Fall 2001 & Spring 2002 Data

BAF & Fish Intake Term

Trophic Level 3	1,459
Trophic Level 4	734
Mrean of Fall & Spring*	**2,193**

* - Using %lipid values of 3.87% for trophic level 3 and 2.48% for trophic level 4 and 17.5 grams per day for consumed fish

Appendix E

Lipid Analysis

Revised Water Quality Criteria for Total PCBs for the Protection of Human Health from Carcinogenic Effects in Zones 2 through 6 of the Delaware River

Lipid Analysis for PCB Water Quality Criteria

12-Mar-03

	Channel Catfish					White Perch				
Year	Crosswicks	Tacony-Palmyra	Paulsboro	Deepwater	C&D Canal	Crosswicks	Tacony-Palmyra	Paulsboro	Deepwater	C&D Canal
2001	4.6	3.7	1.7	4.1	5.9	1.8	2.0	1.6	2.3	2.4
1998	13.4	9.6	15.7		9.1	3.0	2.4	7.1		8.8
1996	3.6	3.5	7.4	7.0	7.6	1.1	1.8	3.7	3.2	1.5
1994	3.6	6.9	1.8	3.3	0.9	1.0	2.0	1.2	1.4	3.8
1993	6.2	2.3	1.9	1.8	7.1	13.0	1.7	5.4	2.3	1.7
1992		3.3	3.9	1.8	2.5		2.4	3.5	1.4	0.9
1991	1.5	5.3	1.2	0.7	1.3	2.6	2.1	2.9	1.2	1.7
1990	11.1	3.6	7.3	9.0		1.9	3.8	2.7	3.5	
Median	4.6	3.6	2.9	3.3	5.9	1.9	2.1	3.2	2.3	1.7
Mean	6.3	4.8	5.1	4.0	4.9	3.5	2.3	3.5	2.2	3.0
STDev	4.4	2.4	5.0	3.0	3.3	4.3	0.7	1.9	0.9	2.7
90% C.L.	13.5	8.7	13.3	8.9	10.3	10.5	3.4	6.7	3.7	7.5
10% C.L.	-0.9	0.8	-3.0	-1.0	-0.5	-3.5	1.2	0.3	0.7	-1.5

Notes: 1990 data on samples collected at Raccoon Creek (assigned to Paulsboro), Petty Island (assigned to Tacony-Palmyra Bridge), and Yardley (assigned to Crosswicks Cr.).

	Zone 2	Zone 3	Zone 4	Zone 5	Zone 2	Zone 3	Zone 4	Zone 5
Median	4.6	3.6	2.9	3.7	1.9	2.1	3.2	2.0
Mean	6.3	4.8	5.1	4.4	3.5	2.3	3.5	2.6
STDev	4.4	2.4	5.0	3.1	4.3	0.7	1.9	2.0
90% C.L.	13.5	8.7	13.3	9.5	10.5	3.4	6.7	5.9
10% C.L.	-0.9	0.8	-3.0	-0.6	-3.5	1.2	0.3	-0.7

Estuary-wide Percent Lipid

			R. Greene's Estuary Data Base		ANSP/Baker Study	
	Channel Catfish	White Perch	Channel Catfish	White Perch	Channel Catfish	White Perch
Median	3.7	2.3	**3.87**	**2.48**	3.87	5.09
Mean	5.0	2.9	4.67	3.32	3.84	4.97
STDev	3.6	2.4				
90% C.L.	10.9	6.8				
10% C.L.	-0.9	-1.0				

Appendix F

Reanalysis of the Water Quality Criterion for Total PCBs for the Protection of Human Health from Carcinogenic Effects Using Recent Data

Reanalysis of Human Health Criterion for PCBs using Recent Data

Background

On August 14, 2009, the DRBC issued a public notice requesting comment on proposed rulemaking to adopt a revised human health criterion for PCBs for Zones 2 - 6 of the Delaware River. This rulemaking did not proceed pending agreement among co-regulators on the long-term implementation strategy to achieve Stage 2 TMDLs that would be based on this revised criterion. At a meeting of the co-regulators on September 27, 2012 where concurrence was reached on a path forward to adopt the revised criterion and establish the Stage 2 TMDLs, a question was raised about the impact on the criterion if more recent data was used. Technical staff from DRBC and Delaware DNREC agreed to reanalyze the criterion based upon more recent data to affirm the numerical value of 16 picograms/Liter for the criterion. The purpose of this document is to report on the results of this analysis.

Procedure

The original criterion recommendation was developed by Thomas Fikslin of the DRBC staff and Richard Greene of the DNREC staff in 2003 using data that was collected in the Fall 2001 and Spring 2002 as part of a bioaccumulation study (Ashley et al, 2004). Dr. Fikslin established the point estimate for the criterion using the most recent U.S. EPA methodology (U.S. EPA, 2000). Dr. Greene performed a probabilistic analysis of the data to develop distributions of the criterion using @Risk software. Review of the available data for reanalyzing the criterion indicated that ambient water data for PCBs and carbon was available from September 2007, and that fish tissue data was available for 2007 for Zones 2 - 4. Results for the fish sample from Zone 5 were not available so data for a 2006 sample collected in Zone 5 was used.

Results

Point Estimate - Values for five factors are needed to calculate the criterion using the U.S. EPA methodology. Three of the factors used EPA-recommended default values. These three factors were 1) risk-specific dose (2.0 mg/kg-day at a risk level of 10^{-6}), 2) body weight (70 KG), and 3) drinking water intake (2 liters/day). Site-specific data were utilized to develop appropriate values for the other two factors: fish consumption at each trophic level, and BAF at each trophic level. Site-specific data for fish consumption in Zones 2 to 5 and Delaware Bay indicated an average consumption rate for all species that was close to the national default value of 17.5 grams per day. This consumption rate was selected for use in the criteria equation.

The reanalysis focused on the bioaccumulation factors (BAFs) for trophic level 3 (channel catfish) and trophic level 4 (white perch) fish species as was done in the original calculation. The data on the percent lipid of consumed fish that was used in the original calculation were also used in the reanalysis. Data on the proportion of each trophic level consumed was assumed to be 50% based upon site-specific data from all zones that indicated roughly equal proportions for the two trophic levels.

Use of the 2007 data with the 2000 EPA methodology results in a single criterion value of 13.4 pg/L for Zones 2 through 5.

Probabilistic Analysis - A probabilistic approach was also used to assess the impact of the uncertainty of the values used in the methodology. This approach involves assigning distributions to variables used either directly or indirectly in the 2000 EPA Methodology. POC, DOC, % lipid for channel catfish, % lipid for white perch, total PCB in water, and total PCB in Channel catfish and white perch were each treated as normal distributions based upon the underlying data. The octanol-water partition coefficient, which is used to calculate the fraction of freely dissolved chemical, was treated as a normal distribution based upon the homolog pattern in the September 2007 ambient water data. Fish consumption rate was considered as a triangular distribution with a minimum of zero, a most likely value of 17.46 grams per day, and a maximum value of 53.9 grams per day, based upon the KCA study (KCA Research Div., 1994). The cancer potency slope was treated as a uniform distribution spanning a range from 1 to 2 (mg/KG-d)-1.Fixed values for risk level, body weight, and drinking water ingestion were used as was done in the original analysis.

This analysis indicated that the median criterion value (13.4 pg/L) was similar to that obtained using the point estimate approach, with the 40^{th} and 60^{th} percentile values of 10.7 pg/L and 16.9 pg/L, respectively.

Recommendation

The results of the reanalysis of the PCB criterion using more recent data affirm the original numerical value of 16 picograms/Liter for the criterion for all Zones of the Delaware Estuary.

References

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