Derivation of New Jersey-Specific Wildlife Values as Surface Water Quality Criteria for:

PCBs
DDT
Mercury

A cooperative effort between the:

U.S. Fish & Wildlife Service
U.S. Environmental Protection Agency
New Jersey Department of Environmental Protection

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EXECUTIVE SUMMARY

This report presents the technical results of a multi-agency effort to develop surface water quality criteria for the protection of wildlife species potentially at risk from environmental contaminants. The three contaminants that are the focus of this effort are: polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT) and its metabolites (expressed as DDTr), and mercury. The committee charged with this task was comprised of representatives from the U.S. Fish & Wildlife Service (Service), the U.S. Environmental Protection Agency (EPA), and the New Jersey Department of Environmental Protection (NJDEP). The goal of the effort was to derive New Jersey-specific numeric surface water quality criteria for the protection of wildlife, using the Great Lakes Water Quality Initiative (GLWQI) methodology developed by the EPA. This report describes the basis for this undertaking and the methods used in arriving at the proposed water quality criteria concentrations.

In December 1993, the NJDEP adopted revised Surface Water Quality Standards (SWQS) (25 NJR 5569) and submitted them to the EPA for the triennial review process. After reviewing the NJDEP's revisions, the EPA proposed approving the SWQS (with the exception of the State's Human Health-based criteria for PCBs) and requested informal consultation with the Service regarding this action, pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.) (ESA). The EPA had determined that the revised SWQS were not likely to adversely affect federally listed threatened and endangered species in New Jersey, and requested Service concurrence with this determination. The Service did not concur with this conclusion and formal consultation was eventually initiated in accordance with Section 7 of the ESA. As a result of formal consultation, the Service prepared a biological opinion regarding EPA's proposed approval of the SWQS and the potential effect of this action on the Bald Eagle (*Haliaeetus leucocephalus*), Peregrine Falcon (*Falco peregrinus*), and Dwarf Wedgemussel (*Alasmidonta heterodon*). At the time the biological opinion was developed, the Bald Eagle was federally listed as threatened and the Peregrine Falcon and Dwarf Wedgemussel were federally listed as endangered.

Numeric water quality criteria for toxic substances are derived to represent the maximum allowable concentrations in surface waters that will generally protect the designated uses of a water body. The NJDEP developed its criteria for various toxicants in order to be protective of aquatic life and/or human health. However, PCBs, DDTr, and mercury are contaminants that persist in the environment, accumulate in biological tissues, and biomagnify in the food chain. Due to these characteristics, concentrations of these contaminants may increase as they are transferred up through various food chain levels. As a result, adverse impacts to non-aquatic, piscivorous (fish eating) organisms may arise from low surface water concentrations.

The GLWQI established numeric limits on specific pollutants in ambient Great Lakes waters to protect human health, aquatic life, and wildlife, as well as the methodologies to derive such criteria for additional pollutants. The EPA developed site-specific wildlife criteria for the Great Lakes using the GLWQI methodology, based on a number of factors, including the toxicity of various pollutants and their tendency to bioaccumulate and biomagnify. In addition, the EPA gathered and applied information about piscivorous wildlife endemic to the Great Lakes region in its derivation of water quality criteria.

That effort resulted in the promulgation of numeric surface water concentrations designed to be protective of all avian and mammalian wildlife using Great Lakes waters.

The mandate of the inter-agency committee assembled for this current effort was to derive water quality criteria for PCBs, DDTr, and mercury that would minimize adverse effects of these pollutants on the Bald Eagle and Peregrine Falcon. Recognizing that the GLWQI criteria were developed using information gathered from the Great Lakes, and may not be appropriate for use in New Jersey for several reasons (see Background section), the inter-agency committee attempted to derive New Jersey-specific criteria. Using all available New Jersey-specific information, this report represents the culmination of that effort and proposes the adoption of numeric wildlife criteria for PCBs, DDTr, and mercury into the NJDEP's Surface Water Quality Standards. These derived maximum allowable surface water concentrations should adequately protect at-risk wildlife species in the State. The proposed New Jersey Wildlife Values are presented in the table below, along with the comparative GLWQI criteria (values are expressed as picograms per liter = parts per quadrillion [ppq]).

	PCBs	DDTr	Mercury
GLWQI Wildlife Criteria	120	11	1300
New Jersey Wildlife Values	72	4	530

Although the information presented in this report concentrated solely on avian species of concern, all proposed New Jersey Wildlife Values are lower than the corresponding GLWQI values, which were derived by considering both avian and mammalian species. The primary factor accounting for this difference in calculated criteria concentrations was the use of the Peregrine Falcon as one of the three representative species. Both the physical characteristics of the peregrine and its ecological niche as an upper trophic level predator combine to increase its susceptibility to toxicants that bioaccumulate and biomagnify in the food chain. As New Jersey is not home to any mammalian wildlife species different from those evaluated during the GLWQI, or that occupy a trophic level comparable to the Peregrine Falcon's (i.e., a large percentage of its prey base comprised of other piscivorous birds or mammals), adopting the proposed New Jersey Wildlife Values should ensure protection for all at-risk species in New Jersey.

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I. INTRODUCTION

This report presents the technical results of a multi-agency effort to develop surface water quality criteria for the protection of wildlife species potentially at risk from environmental contaminants. The three contaminants that are the focus of this effort are: polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT) and its metabolites (expressed as DDTr), and mercury. The committee charged with this task was comprised of representatives from the U.S. Fish & Wildlife Service (Service), the U.S. Environmental Protection Agency (EPA), and the New Jersey Department of Environmental Protection (NJDEP). The goal was to derive New Jersey-specific numeric surface water quality criteria, using the Great Lakes Water Quality Initiative (GLWQI) methodology developed by the EPA (1995a, 1995b, 1995c). This document describes the basis for this undertaking and the methods used in arriving at the proposed water quality criteria concentrations.

A. BACKGROUND

In December 1993, pursuant to Section 303 of the Clean Water Act of 1977 (33 U.S.C. 1251 *et seq*.), the NJDEP adopted revised Surface Water Quality Standards (SWQS) (25 NJR 5569). These SWQS were submitted to the EPA on August 4, 1994 for the EPA's triennial review process. After reviewing the NJDEP's revisions, the EPA proposed approving the SWQS (with the exception of the State's Human Health-based criteria for PCBs) and requested informal consultation with the Service regarding this action, pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.) (ESA). The EPA had determined that the revised SWQS were not likely to adversely affect federally listed threatened and endangered species in New Jersey, and requested Service concurrence with this determination. The Service did not concur with this conclusion and formal consultation was eventually initiated in accordance with Section 7 of the ESA. As a result of formal consultation, the Service prepared a biological opinion regarding EPA's proposed approval of the SWQS and the potential effect of this action on the Bald Eagle (*Haliaeetus leucocephalus*), Peregrine Falcon (*Falco peregrinus*), and Dwarf Wedgemussel (*Alasmidonta heterodon*) (U.S. Fish and Wildlife Service, 1996). At the time the biological opinion was developed, the Bald Eagle was federally listed as threatened and the Peregrine Falcon and Dwarf Wedgemussel were federally listed as endangered.

One of the Service's concerns regarding the revised SWQS was the lack of wildlife criteria for the three bioaccumulative pollutants discussed in this report. Numeric water quality criteria for toxic substances are derived to represent the maximum allowable concentrations in surface waters that will generally protect the designated uses of a water body. The NJDEP developed its criteria for various toxicants to be protective of aquatic life and/or human health. However, as described in the biological opinion, PCBs, DDTr, and mercury are contaminants that persist in the environment, accumulate in biological tissues, and biomagnify in the food chain. Due to these characteristics, concentrations of these contaminants may increase as they are transferred up through various food chain levels. As a result, adverse impacts to non-aquatic, piscivorous (fish eating) organisms may arise from low surface water concentrations. Although the Peregrine Falcon is not a piscivorous species, its prey base can include other piscivorous bird species (U.S. Fish and Wildlife Service, 1991). Pollutants that biomagnify may therefore pose an even greater risk to Peregrine Falcons compared to other piscivorous birds.

The most stringent SWQS criteria adopted in 1993 for the subject contaminants, which were all based on protecting human health, were as follows: PCBs - 244 parts per quadrillion (ppq) for freshwater and 247 ppq for saltwater, DDTr - 588 ppq for freshwater and 591 ppq for saltwater, total recoverable mercury - 144,000 ppq for freshwater and 147,000 ppq for saltwater. The EPA deferred its decision on the State's human health criteria for PCBs, based upon the State's commitment to re-evaluate and possibly revise these criteria using the results of the EPA's PCB-cancer potency reassessment. The result of the EPA deferral is that the NJDEP must use the current National Toxics Rule (NTR) human health criteria for PCBs (170 ppq for both freshwater and saltwater). As part of its December 18, 2000 proposal to revise the New Jersey SWQS, the NJDEP proposed to adopt human health criteria for PCBs consistent with EPA's above current NTR human health criteria for PCBs. The NTR criteria will remain in effect until the State completes its formal adoption of the proposed PCB criteria and these criteria are approved by the EPA. The Service evaluated all of the proposed criteria in comparison with published toxicity data, background concentrations of contaminants in New Jersey Bald Eagle and Peregrine Falcon eggs and prey species, and the wildlife criteria established in the GLWQI.

The GLWQI established numeric limits on specific pollutants in ambient Great Lakes waters to protect human health, aquatic life, and wildlife, as well as the methodologies to derive such criteria for additional pollutants. The EPA developed site-specific wildlife criteria for the Great Lakes using the GLWQI methodology, based on a number of factors, including the toxicity of various contaminants and their tendency to bioaccumulate and biomagnify. In addition, the EPA gathered and applied information about piscivorous wildlife endemic to the Great Lakes region in its derivation of water quality criteria. That effort resulted in the promulgation of numeric surface water concentrations designed to be protective of all avian and mammalian wildlife. The Service believed that a comparison of the proposed SWQS criteria to the established GLWQI criteria would provide a measure of the former's protectiveness to Bald Eagles and Peregrine Falcons.

The GLWQI wildlife criteria values for DDTr and mercury are 11 ppq and 1,300 ppq, respectively. These values are approximately 53 and 110 times lower, respectively, than the criteria values adopted in the 1993 New Jersey SWQS. The GLWQI wildlife criteria value for PCBs as published in 1995 was 74 ppq; however, this was later revised to 120 ppq (62 FR 11724, March 12, 1997). Both of these values are lower than the current NTR human health criteria for PCBs, although by less than one order of magnitude. The Service, basing its biological opinion for PCBs upon review of Ludwig *et al*. (1993) and Service data indicating high levels of PCBs in New Jersey Bald Eagle and Peregrine Falcon populations (U.S. Fish and Wildlife Service, 1995, 1996), felt that neither the proposed SWQS criterion, nor the current NTR human health criteria, nor the established GLWQI wildlife criterion would be protective of these at-risk species.

Based upon these comparisons and other toxicity and background concentration data, the Service concluded that EPA approval of the revised SWQS would not jeopardize the continued existence of the Bald Eagle, Peregrine Falcon, or Dwarf Wedgemussel. However, the biological opinion also concluded that for some water bodies in New Jersey, approval of the proposed criteria could cause an allowable increase of current levels of PCBs, DDTr, and mercury. For this reason, the Service determined that the proposed action was likely to adversely affect those segments of the Bald Eagle and Peregrine Falcon populations consuming prey from surface waters with concentrations of PCBs, DDTr, or mercury allowable under the proposed SWQS criteria.

Sections 4(d) and 9 of the ESA, as amended, prohibit taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct) of federally listed species of fish or wildlife without a special exemption. Incidental take is any take of federally listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant. Under the terms of Section 7(b)(4) and Section 7(o)(2) of the ESA, incidental take resulting from the agency action is not prohibited provided it is in compliance with terms and conditions set forth in an incidental take statement.

The Service (1996) provided such an incidental take statement in its biological opinion and described non-discretionary reasonable and prudent measures to be implemented by the EPA in order to minimize incidental take from the Bald Eagle and Peregrine Falcon populations. One of these measures directed that water quality criteria for PCBs, DDTr, and mercury be derived and adopted by NJDEP to be protective of Bald Eagles and Peregrine Falcons. Due to the bioaccumulative nature of the contaminants of concern and their association with population level impacts, minimizing incidental take required the derivation of criteria using population impairment endpoints.

The Service originally suggested adopting the established GLWQI wildlife criteria for these pollutants, until such time as New Jersey-specific wildlife criteria could be developed, as the goal of the GLWQI was to develop criteria that were protective of populations rather than individual animals (U.S. Environmental Protection Agency, 1995c). To achieve that goal, the EPA determined that measurement endpoints used to derive the methodology’s test dose parameter should be those that could reasonably be expected to have implications at the population level (i.e., reproductive or developmental success, organismal viability or growth, or any endpoint which is, or is directly related to, a parameter that influences population dynamics).

However, recognizing that the GLWQI criteria were developed using information gathered from the Great Lakes, and may not be appropriate for use in New Jersey for several reasons, the Service, EPA, and the NJDEP agreed to form an inter-agency taskforce that would attempt to derive New Jersey-specific criteria. This report represents the culmination of that effort and proposes the adoption of numeric wildlife criteria for PCBs, DDTr, and mercury into the NJDEP’s Surface Water Quality Standards. Adoption of these criteria will help protect wildlife species at risk from exposure to these environmental contaminants.

B. DEFINITIONS

Acceptable Endpoint: Subchronic and chronic endpoints that affect reproduction or developmental success, organismal viability or growth, or any other endpoint that is, or is directly related to, parameters that influence population dynamics.

Allometry: The study of relationships between the growth and size of a particular body part to the growth and size of the whole organism.

Bioaccumulation: The increase of the concentration of a substance within the tissues of an organism, to levels in excess of that substance's ambient environmental concentration, directly from the water or through the ingestion of food (usually other organisms).

Bioaccumulation Factor (BAF): The ratio (in L/kg) of the concentration of a substance in tissue of an aquatic organism to the concentration in the ambient water, in situations where both the organism and its food are exposed and the ratio does not change substantially over time.

Biomagnification: The increase in tissue concentration of poorly depurated materials in organisms along a series of predator-prey associations, primarily through the mechanism of dietary accumulation.

Biomagnification Factor (BMF): The ratio of the concentration of a substance in the tissue of an animal that consumes aquatic organisms to the concentration in the aquatic organisms consumed (unitless).

Chronic Effect: An adverse effect that is measured by assessing an acceptable endpoint and results from continual exposure over several generations, or at least over a significant part of the test species' projected life span or life stage.

Depuration: The loss of a substance from an organism as a result of any active or passive process.

Lowest-Observed-Adverse-Effect-Level (LOAEL): The lowest tested dose or concentration of a substance that resulted in an observed adverse effect in exposed test organisms, when all higher doses or concentrations resulted in the same or more severe effects.

No-Observed-Adverse-Effect-Level (NOAEL): The highest tested dose or concentration of a substance that resulted in no observed adverse effect in exposed test organisms, where higher doses or concentrations resulted in an adverse effect.

Population: An aggregate of individuals of a species within a specified location in space and time.

Representative Species: Wildlife species representative of resident New Jersey avifauna that are likely to experience the highest exposures to bioaccumulative contaminants through the aquatic food web.

Subchronic Effect: An adverse effect, measured by assessing an acceptable endpoint, resulting from continual exposure for a period of time less than that deemed necessary for a chronic test.

Trophic Level: A functional classification of taxa within a community that is based on feeding relationships (*e.g.*, aquatic green plants are the first trophic level and herbivores the second).

Uncertainty Factor, Species-Specific (UF_A): The factor for extrapolating toxicity data across species (unitless). A species-specific uncertainty factor shall be selected for each representative species.

Uncertainty Factor, Subchronic to Chronic (UF_S): The factor for extrapolation from subchronic to chronic exposures (unitless).

Uncertainty Factor, LOAEL to NOAEL (UF_L): The factor for LOAEL to NOAEL extrapolations (unitless).

Uptake: The acquisition by an organism of a substance from the environment as a result of any active or passive process.

Wildlife Value, Species Specific: The value derived from applying the equation using exposure parameters for a representative species.

II. CALCULATION OF NEW JERSEY-SPECIFIC WILDLIFE VALUES

A. DETERMINATION OF APPROPRIATE DERIVATION METHODOLOGY

In developing the GLWQI, the EPA's goal was to derive chemical-specific water quality criteria to protect wildlife species. For the purposes of that effort, wildlife was defined as non-domesticated species in the taxonomic classes Aves and Mammalia (birds and mammals).

Wildlife Values were calculated using the following equation and input parameters:

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + 3(F_{TLi} \times BAF_{TLi})}$$

Where: WV = Wildlife Value in milligrams of substance per liter (mg/L).

TD = Test Dose (TD) in milligrams of substance per kilograms per day (mg/kg-d) for the test species. This should be either a NOAEL or a LOAEL.

UF_A = Uncertainty Factor (UF) for extrapolating toxicity data across species (unitless). A species- specific UF should be selected and applied to each representative species, consistent with the equation.

UF_S = UF for extrapolating from subchronic to chronic exposures (unitless).

UF_L = UF for LOAEL to NOAEL extrapolations (unitless).

Wt = Average weight in kilograms (kg) for the representative species.

W = Average daily volume of water consumed in liters per day (L/d) by the representative species.

F_{TLi} = Average daily amount of food consumed from trophic level 'i' in kilograms per day (kg/d) by the representative species.

BAF_{TLi} = Bioaccumulation factor (BAF) for wildlife food in trophic level 'i' in liters per kilogram (L/kg). For consumption of piscivorous birds by other birds (*e.g.*, herring gull by eagles), the BAF is derived by multiplying the trophic level 3 BAF for fish by a biomagnification factor (BMF) to account for the biomagnification from fish to the consumed birds.

The EPA (1995c) Technical Support Document (TSD) describing the wildlife criteria methodology provides two types of chemical-specific criteria numbers that can be derived: Tier I Wildlife Criteria and Tier II Wildlife Values. In deriving Tier I Criteria, taxonomic class-specific numbers are generated. The avian WV is the geometric mean of the WVs calculated for the three representative avian species. The mammalian WV is the geometric mean of the WVs calculated for the two representative mammalian species. Where both mammalian and avian values can be derived, the lower of the two geometric means is selected as the wildlife criterion. The Tier II methodology calculates species-specific numbers from only one taxon. According to the TSD, Tier II values can be derived with as much scientific validity as Tier I values, but must provide assurance that the taxonomic class not considered in the derivation would also be protected.

The committee to develop New Jersey-specific criteria determined and agreed that the Tier II wildlife value methodology was suitable for the current effort. This decision was arrived at based on several factors: (1) the Service's biological opinion (1996) regarding the impact of bioaccumulative contaminants, which was the basis for this effort, focused on two avian species, (2) one of the two species of concern, the Peregrine Falcon, may be exposed to higher concentrations of bioaccumulative pollutants through its diet of piscivorous birds, and (3) for two of the three contaminants examined (DDTr & mercury), the avian values derived in the GLWQI were lower than the corresponding mammalian values. The GLWQI's PCB value is based on a mammalian WV lower than its avian WV, and no comparative analysis was performed during this effort; however, for the reasons cited above, the committee concluded that the use of the Tier II methodology is appropriate and the values proposed in this report will sufficiently protect wildlife species at risk from the three bioaccumulative contaminants of concern.

As detailed in the sections below, the majority of the input and exposure parameters used to derive the New Jersey Wildlife Values for PCBs, DDTr and mercury in this report came from the work conducted under the GLWQI. The BAFs and BMFs were also based on this original effort; however, BAFs were revised for use in this report's final calculations, based on work subsequent to the GLWQI and the use of New Jersey-specific values for dissolved and particulate organic carbon.

B. DETERMINATION OF REPRESENTATIVE SPECIES

Based on the Service's biological opinion, both Bald Eagle and Peregrine Falcon were included in the current effort as organisms for calculation of wildlife values because both species are present in New Jersey and require protection from exposure to PCBs, DDTr, and mercury. In addition, the Bald Eagle and Peregrine Falcon are classified as endangered species on New Jersey's Endangered and Threatened Wildlife list. The Osprey (*Pandion haliaetus*) was included in the analysis due to its fish diet, presence in areas with evidence of contamination, its State listing as a threatened species, and its recent range expansion within the State. Adverse effects from exposure to the three bioaccumulative contaminants are possible due to the Osprey's exclusive diet of fish.

The Dwarf Wedgemussel was not included in the calculation of water quality criteria for the protection of wildlife. While the single known viable population of Dwarf Wedgemussels extant in the State may potentially be exposed to the contaminants of concern, the danger of contaminant biomagnification should be less than with higher trophic level organisms. In the case of the Dwarf Wedgemussel, the State's aquatic life-based criteria are intended to provide the necessary level of protection. However, as a result of the above-referenced biological opinion, the NJDEP has included proposed revisions to its State mixing zone and antidegradation policies to ensure the protection of the Dwarf Wedgemussel in the State's December 18, 2000 proposal to revise the New Jersey SWQS.

The three species used in the calculations are upper trophic level organisms that represent resident New Jersey avifauna likely to experience the highest exposures to contaminants through the aquatic food web. The criteria developed should be protective of all other wildlife species at risk.

C. DETERMINATION OF TEST DOSE

For the GLWQI, the EPA (1995b) conducted literature searches to determine the appropriate test doses (TD) for calculating chemical-specific criteria. Numerous studies were evaluated, with several restrictions regarding acceptability (*e.g.*, study duration, endpoints, dose-response correlation). Once acceptable studies were chosen, the EPA used the TDs to develop the necessary Uncertainty Factors for the wildlife values.

An extensive literature search was conducted for this report in an effort to find any additional studies conducted since the completion of the GLWQI. These searches revealed almost no new experimental investigations into dose-response effects. Of the few additional studies, none met the acceptability requirements as defined in the GLWQI (U.S. Environmental Protection Agency, 1995c). Therefore, the same studies used in the GLWQI for avian wildlife were used in the calculations of New Jersey Wildlife Values.

1. PCBs

Much of the recent emphasis on PCBs has shifted from the study of Aroclors to the study of PCB congeners. A number of papers were reviewed and a summary of recent studies examining toxic effects of PCBs is presented in Appendix A. Most of these studies did not meet the EPA (1995c) criteria for an acceptable endpoint, due to the endpoint chosen or the study duration. In addition, some of the most sensitive endpoints involved the examination of cytochrome P450 associated monooxygenase activity (*e.g.*, ethoxyresorufin-O-dealkylase [EROD] activity) as a biomarker:

> "The biological consequences of monooxygenase induction can include enhanced detoxification and elimination of xenobiotics, alterations of endogenous steroid metabolism, and generation of reactive metabolites causing toxic injury. Such biochemical effects may foreshadow other subtle and adverse consequences of contaminants at higher levels of biological organization." (Rattner *et al.*, 1997)

The induction of these enzymes indicates a response by the organism to the contaminants that can possibly lead to harmful effects. However, the induction itself does not indicate an adverse impact at that dose. Therefore, these studies did not meet acceptability criteria. Alternatively, the use of congeners in calculating a wildlife value, as opposed to Aroclors, may be a more sensitive and accurate method of protecting piscivorous species. However, there are inadequate data at this time to determine wildlife values based on congeners.

Based on the GLWQI review, a TD of 1.8 mg/kg-d was used from reproduction studies conducted on pheasant (Dahlgren *et al.*, 1972). Pheasant were orally administered Aroclor 1254 once per week for 16 weeks. Egg production, egg fertility, egg hatchability, survivability, and growth of chicks through 6 weeks of age (post-hatch) were measured. Female pheasants fed 12.5 mg per week or 50 mg per week of Aroclor 1254 exhibited significant reductions in egg hatchability. Egg production and chick survivability were significantly reduced in females fed 50 mg Aroclor 1254. This equated to a NOAEL of 1.8 mg/kg-day for egg production and chick survivability, and a LOAEL of 1.8 mg/kg-day for egg hatchability. This is the TD used in this report for the calculation of New Jersey Wildlife Values for PCBs.

2. DDTr

For DDTr, the EPA selected two studies by Anderson *et al.* (1975, as cited by the U.S. Environmental Protection Agency, 1995b) that examined the reproductive success of Brown Pelicans (*Pelecanus occidentalis*) for their TD. In these studies, DDTr was measured in eggs from a Brown Pelican colony and in the anchovies that comprised the majority of the Pelican diet. These levels were compared with fledging rates, which revealed a significant decline over the course of the studies' 5 years. From these data, the EPA was able to derive a LOAEL of 0.027 mg/kg-day for reproductive success. This is the TD used in this report for the calculation of New Jersey Wildlife Values for DDTr.

3. Mercury

In the GLWQI, the studies on the effects of methylmercury dicyandiamide on the Mallard duck, *Anas platyrhynchos*, by Heinz (1974, 1975, 1976a, 1976b, and 1979) were considered to be the most appropriate. These studies showed a toxic reproductive effect on a three-generation study of Mallard ducks at a LOAEL concentration of 0.078 mg/kg-day. This is the TD used in this report for the calculation of New Jersey Wildlife Values for mercury.

D. DETERMINATION OF UNCERTAINTY FACTORS

The Interspecies Uncertainty Factor, UF_A, is a value ranging from 1 to 10 used to adjust the TD for uncertainty due to differences in toxicological sensitivity between species.

The Subchronic-to-Chronic Uncertainty Factor, UF_S, is a value ranging from 1 to 10 used to adjust the TD for uncertainty when extrapolating subchronic to chronic toxicity.

The LOAEL-to-NOAEL Uncertainty Factor, UF_L, is a value ranging from 1 to 10 used to adjust the TD for uncertainty when extrapolating from LOAEL to NOAEL toxicity levels.

The Uncertainty Factors for PCBs and DDTr presented in this report are the same as those used in the development of the GLWQI wildlife criteria. It was determined that the representative species selected for this effort were sufficiently similar to those used in the GLWQI, so that different UF_A's were not necessary. Considering that the TDs chosen for the New Jersey Wildlife Value derivations were taken from the same studies used in the GLWQI, both the UF_S's and the UF_L's could also remain unchanged.

In determining the Uncertainty Factors for mercury, the taskforce also reviewed the EPA's Mercury Study Report to Congress (MSRC) (1997a, 1997b). Section 112(n)(1)(B) of the Clean Air Act, amended in 1990, directed the EPA to submit to Congress a comprehensive study on mercury air emissions. Included in Volume VI of the MSRC was an ecological risk assessment for anthropogenic mercury emissions, which served as an update to the methods for the calculation of the wildlife criterion value for mercury from the GLWQI. The Uncertainty Factors presented in the MSRC were evaluated regarding their suitability for use in this effort. For a more detailed explanation of the function and determination of Uncertainty Factors, see Abt Associates Inc. (1995).

1. PCBs

An UF_A of 3 for PCBs was selected as an intermediate value between 1, which was considered not sensitive enough since the 3 species may be more sensitive than Gallinaceous birds, and 10, which was considered overly conservative (U.S. Environmental Protection Agency, 1995b).

An UF_S of 1 for PCBs was selected because the LOAEL derived from the test dose study was based on a reproductive and sensitive life stage study using a 112-day exposure period. Therefore, the LOAEL did not need to be adjusted to cover longer exposure periods (U.S. Environmental Protection Agency, 1995b).

An UF_L of 3 for PCBs was selected because a LOAEL, but not a NOAEL, was established in the Dahlgren *et al.* (1972) study for egg hatchability in pheasants exposed to PCBs. The LOAEL of 12.5 ppm was deemed to be relatively close to a threshold for effects. Therefore, the full factor of 10 was not needed to extrapolate to a NOAEL (U.S. Environmental Protection Agency, 1995b).

2. DDTr

An UF_A of 1 for DDTr was selected because the organism used in the EPA's (1995b) TD determination for the GLWQI was a piscivorous bird, as are two of the current representative species. The third representative species, Peregrine Falcon, is not piscivorous; however, it is also a raptor. This species is sufficiently similar to the Bald Eagle and Osprey to warrant the same UF_A.

An UF_S of 1 for DDTr was selected because the TD study used for the GLWQI (U.S. Environmental Protection Agency, 1995b) was of sufficient duration to examine chronic toxicity.

An UF_L of 3 for DDTr was selected because a LOAEL, but not a NOAEL, was established in the Anderson *et al*. study (1975, as cited by U.S. Environmental Protection Agency, 1995b) from the number of young fledged per nest. This number serves as an intermediate value between 1 and 10.

3. Mercury

For wildlife value calculations based on the GLWQI methodology, an UF_A of 3 for mercury was selected because the birds used in the test study, Mallards (*Anas platyrhyncos*), are in a different taxonomic order from all three of the representative species used in this effort. This value was selected as an intermediate value between 1, which was considered not sensitive enough, and 10, which was considered overly sensitive, as determined in the GLWQI (U.S. Environmental Protection Agency, 1995b).

An UF_A of 1 for mercury was used in this derivation of New Jersey-specific wildlife values based on the MSRC. As discussed on pp. 5.11 - 5.12 of the MSRC Volume VI (1997b), it was decided that a UF_A greater than 1 was unnecessary because "a review of the literature suggests that piscivorous birds possess a greater capability to detoxify methylmercury than do non-piscivorous birds (see Section 4 of this volume). Adjusting the TD for Mallards even lower is, therefore, unjustified."

An UF_S of 1 for mercury was selected for both the GLWQI and MSRC methods because Heinz's studies (1975, 1976a, 1976b, 1979, as cited by the U.S. Environmental Protection Agency, 1995b) were for an exposure duration of three generations.

For wildlife value calculations based on the GLWQI methodology, an UF_L of 2 for mercury was selected because the LOAEL in Heinz's studies appeared to be at the threshold for mercury toxicity to Mallards (U.S. Environmental Protection Agency, 1995b).

An UF_L of 3 for mercury was used in this derivation of New Jersey-specific wildlife values based on the MSRC. On page 5-23 of the MSRC Volume VI (1997b), the inconsistency in the numeric value of UF_L is defended in this statement, "(g)iven the substantial uncertainties in all the values used to calculate the (wildlife criteria) for mercury exposure, neither two nor three can be considered to be the only correct value."

E. DETERMINATION OF EXPOSURE PARAMETER VALUES

i. Chemical-specific Bioaccumulation Factors

As stated in Section IIA of this document, the BAFs for the three contaminants examined in this effort were initially developed using the GLWQI methodology, but were revised based on subsequent EPA re-evaluations of that methodology and the use of New Jersey-specific DOC and POC data for the organic contaminants (*i.e.*, PCBs and DDTr). For mercury BAFs, the taskforce used the methodology found in the MSRC, which does not use DOC and POC data to calculate BAF values. Although there is evidence that DOC plays some role in the bioavailability of methylmercury and researchers have developed some bioaccumulation models (Hudson *et al*., 1994; Driscoll *et al*., 1995), these models tend to be very site-specific and the conventional methods for determining bioavailability of organic chemicals are generally not applicable for inorganics and organometallics (U.S. Environmental Protection Agency, 2000a).

1. PCBs

The PCB BAF revisions resulted in part from the EPA's 1997 re-evaluations of the methodology used to develop PCB water quality criteria for the GLWQI (62 FR 11724, March 12, 1997). These re-evaluations involved calculating composite baseline BAFs for PCBs, using a revised method for calculating composite octanol-water partition coefficients (K_{ow}) for PCBs. Using the new baseline BAF and K_{ow} values from the 1997 methodology, trophic level-specific wildlife BAFs could then be calculated using the methodology presented in Appendix B to Part 132 of the Code of Federal Regulations (40 CFR 132 - Water Quality Guidance for the Great Lakes System). However, this methodology requires determining the fraction of the chemical freely dissolved (f_{fd}) in the ambient water, which in turn requires input of DOC and POC concentrations. Once the f_{fd} is determined, wildlife BAFs can be calculated and used to derive numeric wildlife values.

The Appendix B equation used to calculate f_{fd} is:

$$f_{fd} = \frac{1}{1 + \frac{(DOC \times K_{ow})}{10} + (POC \times K_{ow})}$$

Instead of using the GLWQI f_{fd} calculated with Great Lakes DOC and POC data, the taskforce obtained New Jersey-specific DOC and POC concentrations and calculated a new f_{fd} value. The DOC and POC data available included statewide averages, Pinelands region averages, and North/Central region averages. The taskforce decided that the lowest of these averages (i.e., the North/Central region) should be used for calculating f_{fd}, as this would result in wildlife values protective for the entire state. These lowest average DOC and POC values are still greater than those used for the Great Lakes, and result in a lower f_{fd} than what was used for the GLWQI.

North/Central Region DOC Average: 3.8 mg/L	GLWQI DOC: 2 mg/L
North/Central Region POC Average: 0.7 mg/L	GLWQI POC: 0.04 mg/L

However, the f_{fd} was further revised by the taskforce, based on a subsequent EPA change in the equation used to calculate this value. The original equation to determine f_{fd} presented in Appendix B to 40 CFR 132 calculates one term in the denominator by multiplying the DOC and K_{ow} values, and then dividing the result by 10. However, in the more recent EPA document, Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000) (U.S. Environmental Protection Agency, 2000a), this term is calculated by dividing by 12.5.

$$f_{fd} = \frac{1}{1 + \frac{(DOC \times K_{ow})}{12.5} + (POC \times K_{ow})}$$

The taskforce agreed that the most recent methodology should be used for this effort and calculated a new f_{fd} using the updated equation. The result was an f_{fd} value slightly greater than the one calculated using the Appendix B methodology, but still substantially lower than the f_{fd} used for the GLWQI. The trophic level-specific BAFs for PCBs resulting from the methodology revisions and the use of New Jersey DOC and POC data are presented in Table 2.

New Jersey-specific PCB f_{fd} (Trophic Level 3 & 4):	0.3210
GLWQI PCB f_{fd} (Trophic level 3 & 4):	0.6642

2. DDTr

Literature searches revealed no new data or re-evaluations recommending revisions for the DDTr BAFs or BMFs. As with PCBs however, the DDTr BAF methodology from the GLWQI also requires the use of DOC and POC values to determine the fraction of the chemical freely dissolved in ambient water. Using the New Jersey-specific DOC and POC values and the updated EPA equation for determining f_{fd} described in the preceding section, the taskforce calculated new DDTr f_{fd} values for trophic levels 3 and 4. The resulting f_{fd} values were also substantially lower than those used in the GLWQI, causing a subsequent decrease in the trophic level-specific BAFs for DDTr. These BAFs are presented in Table 3.

New Jersey-specific DDTr f_{fd} (Trophic Level 3):	0.1756
New Jersey-specific DDTr f_{fd} (Trophic Level 4):	0.1626
GLWQI DDTr f_{fd} (Trophic Level 3):	0.4695
GLWQI DDTr f_{fd} (Trophic Level 4):	0.4462

3. Mercury

The BAFs recommended in the MSRC are estimated directly from methylmercury measurements in field studies, and are based on the ratio of methylmercury concentration in fish flesh divided by the concentration of dissolved methylmercury in the water column. Methylmercury has a higher potential for bioaccumulation and biomagnification and has been shown to be more toxic to avian species than total inorganic mercury. The wildlife values generated by the dissolved methylmercury BAFs are then adjusted to represent the concentration of total mercury in unfiltered water.

Several field studies were used in the MSRC to determine methylmercury concentrations, and these were averaged to represent a worldwide methylmercury percentage from which BAFs were calculated. Because no information was readily available to the taskforce giving New Jersey-specific dissolved methylmercury concentrations in ambient water, and because it cannot be determined whether the MSRC worldwide methylmercury average would be any more or less appropriate than any individual site-specific values in the scientific literature, the taskforce opted to use the MSRC recommended

BAFs to calculate the wildlife values. This resulted in slightly more conservative New Jersey Wildlife Values than those derived using the GLWQI methodology. Both sets of BAFs (MSRC and GLWQI) are presented in Table 4.

ii. Species-specific Exposure Parameters

In order to perform the Wildlife Value calculation, various parameters must be defined for each representative species. These include adult body weights, and drinking water and food ingestion rates. In addition, food ingestion rates must be defined for each trophic level prey type consumed. As empirical data on these parameters for free-living wildlife species may be minimal or nonexistent, these values may have to be estimated (U.S. Environmental Protection Agency, 1993).

Allometric equations used to calculate the drinking water and food ingestion rates are dependent on the estimated adult body weights. Allometry is defined as the study of relationships between the growth and size of a particular body part to the growth and size of the whole organism (U.S. Environmental Protection Agency, 1993). These relationships also exist between body size and other parameters such as metabolic rate. For this effort, average adult body weights of the three representative species were taken from Dunning (1993).

Food ingestion rate (F) is the amount of food eaten each day by a species. To estimate F, an allometric equation is first used to estimate the species' free-living metabolic rate (FMR) (U.S. Environmental Protection Agency, 1993). The FMR establishes the metabolizable energy (ME) needs of a species in the wild. Metabolizable energy equates to the gross energy (GE) in the diet multiplied by the assimilation efficiency (AE) for the species of that diet (U.S. Environmental Protection Agency, 1995c).

FMR (kcal/day) = $2.601 \times Wt^{0.640}$ (g) [this equation is for all bird types]

ME (kcal/g diet) = GE (kcal/g diet) x AE

GE: The GE for each species of prey was taken from EPA (1993). A value of 1.2 kcal/g was used for fish prey and 1.9 kcal/g for bird prey.

AE: The AE for prey items was taken from EPA (1993). An AE value of 79% was used for fish prey and a value of 78% was used for bird prey.

ME: Metabolizable energy was calculated based on the GE and AE values resulting in ME values of 0.948 kcal/g for fish (as prey) and 1.482 kcal/g for birds (as prey).

Once the FMR and ME have been determined, F can be calculated using the equation:

$$F = FMR \div ME$$

Using the methodology from the GLWQI TSD (1995c), food ingestion rates can be delineated into the amount of food per day consumed from each trophic level. All of the above values are presented in Table 1. The following sections describe the representative species and the rationale behind the determination of exposure parameters used in this report.

1. Bald Eagle

The Bald Eagle (*Haliaeetus leucocephalus*) suffered serious declines in New Jersey due to the use of DDTr, with only one nest remaining in the state in 1970 (Paturzo *et al.*, 1998). The banning of DDTr in conjunction with restoration efforts by NJDEP's Endangered and Nongame Species Program have increased the number of Bald Eagle pairs to 17 in 1998 and the number of active nesting pairs to 14. There were 21 nesting pairs in 1999 and 25 nesting pairs in 2000. Bald Eagle nests are primarily located in the Delaware Bay region with additional pairs near or along the Delaware River, and Atlantic Coast. Two nests are located in northern New Jersey, one at Round Valley Reservoir and one at Merrill Creek Reservoir. In addition to nesting pairs, 176 Bald Eagles were counted in 1997, 121 in 1998, and 115 in 2000 during winter surveys (Paturzo *et al.*, 1998; New Jersey Department of Environmental Protection, 2000). These migrating eagles spend their winters primarily in southern New Jersey with most nesting out of state.

Bald Eagle eggs were collected between 1993 and 1997 from three sites in New Jersey to determine the cause of nest failures (Clark *et al*., 1998). Concentrations of PCBs in Racoon Creek eggs averaged 43 ppm, and one egg from Stow Creek contained 20 ppm. Concentrations of the DDTr metabolite DDE in Raccoon Creek eggs averaged 15 ppm, while the Stow Creek egg contained 6 ppm (Clark *et al*., 1998).

During 1998, fourteen Bald Eagle pairs had active nests, with nine of the nests successful in hatching, rearing and fledging 16 young. Four nests failed and one nest received a foster chick (Paturzo *et al*., 1998). Contamination continues to be suspected as a cause of failure at three nests. Eggshell measurements were 13.8% thin at Raccoon Creek, 16.8% thin at Horne Run, and 21.9% thin at Rancocas Creek (Paturzo *et al*., 1998). Reproductive impairment has been associated with eggshell thinning greater than 15-18%. The NJDEP continues to monitor the population, most recently evaluating contaminant analyses (e.g., DDTr, PCBs, and metals) of eaglet egg and blood samples collected in 1998-1999.

Two methods were followed in developing the exposure parameters and calculations for the Wildlife Value for the Bald Eagle, as no data specific to New Jersey were found from the NJDEP or a literature search. The GLWQI developed Bald Eagle exposure parameters using adult body weights, observed food ingestion rates, and estimated metabolizable energy taken from a few specific references (U.S. Environmental Protection Agency, 1995c). These parameters are presented in Table 1.

Exposure parameters were also developed for this effort using adult body weights from Dunning (1993), while the FMR was derived using the allometric method. The allometric method is a more conservative procedure for the Bald Eagle since it results in a larger FMR and food ingestion rate. Although both sets of exposure parameters are presented in Table 1, the allometric-derived parameters were used in calculating a New Jersey Wildlife Value for the Bald Eagle. This was done for consistency, because Wildlife Values for the other two species (i.e., Osprey and Peregrine Falcon) were also calculated using the allometric method, and because the calculated Wildlife Values did not differ significantly between the two parameter sets.

Currently there are no comprehensive data on Bald Eagle diet in New Jersey (Clark, pers. comm., 1999). Data on prey selection for New Jersey Bald Eagles are limited to incidental qualitative observations during nest surveys and other observations. In general, Bald Eagles in New Jersey feed primarily on fish in the summer and on available food items in the winter [*e.g.*, muskrat (*Ondatra zibethicus*), carrion] (Clark, pers. comm., 1999). Bald Eagles generally feed on the most abundant fish species available, and have been observed to feed on shad (*Alosa* spp.) and catfish (*Ictalurus* spp.) in the Delaware estuary (Clark, pers. comm., 1999). Other food items include turtles, birds, gulls, and waterfowl. In 1999, the NJDEP collected fish samples from waters where the Bald Eagle and Osprey feed. A total of 16 samples representing seven species of fish were collected. An evaluation of these prey species indicated that the range of trophic levels overlapped the levels used in the GLWQI. Since no distinction could be made between the New Jersey and the GLWQI prey data, the prey items from the GLWQI were used. A prey selection of 73.6% trophic level 3 fish, 18.4% tropic level 4 fish, and 8% birds was used based on GLWQI. The bird prey items were further separated into piscivorous birds (70%) and non-piscivorous birds (30%).

2. Peregrine Falcon

The Peregrine Falcon (*Falco peregrinus*) is a medium sized raptor that preys on a wide variety of avifauna, including passerines, gulls, terns, shorebirds, wading birds, and waterfowl (Steidl *et al.*, 1995). Being a top food chain predator, this species historically has been impacted by exposure to bioaccumulative contaminants picked up by its prey base. Breeding stock of New Jersey Peregrine Falcons was depleted from this exposure by the mid-1960's (U.S. Fish and Wildlife Service, 1991). Recovery efforts over the last two decades, coupled with the banning of DDTr and reductions of other harmful pollutants, have succeeded in allowing reintroduced falcons to once again establish breeding populations in New Jersey (U.S. Fish and Wildlife Service, 1996). According to the NJDEP's Endangered & Nongame Species Program, 15 pairs of Peregrine Falcons nested successfully in the State in 1999.

In August 1999, the Peregrine Falcon was removed from the federal endangered species list (64 FR 46541, August 25, 1999), a result of the nationwide population's continued recovery. However, the NJDEP plans to keep the species on the State endangered species list for the foreseeable future, in part because of the threat of exposure to environmental contaminants. Ongoing studies by the Service and the NJDEP will monitor New Jersey's Peregrine Falcon population for signs of contaminant-related adverse impacts.

The adult body weight for this species used in the calculations was taken from Dunning (1993). Average male and female weights were combined to derive the mean of 0.7815 kg. The drinking waters rate (0.05 L/day) and FMR (184.76 kcal/day) were then calculated by the allometric method, using the derived body weight. This in turn provided the information necessary to determine the food ingestion rates. As stated, Peregrine Falcons prey on other birds, some of which may be piscivorous themselves, depending on the geographic location. While no definitive data could be found indicating what percent of all New Jersey Peregrine Falcons diet is composed of piscivorous birds, Steidl *et al*. (1995) collected prey remains from around three southern New Jersey falcon nests. Identification assessment of these remains yielded a composition of approximately 35% piscivorous prey and 65% non-piscivorous prey. These percentages are not static and may not be appropriate for all falcon territories; however, they represent a scientifically valid scenario in which Peregrine Falcons may be exposed to contaminants that have biomagnified through the food chain. For this reason, this diet composition was used in the calculations of New Jersey Wildlife Values.

3. Osprey

The Osprey (*Pandion haliaetus*) is a large fish-eating bird of prey with a worldwide distribution. Like the Bald Eagle and Peregrine Falcon, Osprey populations have been affected by exposure to DDTr, PCBs, and mercury. In a Salem County, New Jersey study, Steidl *et al*. (1991) reported a 10.4% thinning in osprey eggshells compared to the years preceding DDTr use. Nationally, approximately 20% of Osprey range overlaps areas of high mercury deposition (> 10 mg/m^2). These overlapped areas are located mostly in the eastern region of the United States and include all Osprey in New Jersey (U.S. Environmental Protection Agency, 1997b).

Recent surveys have indicated, however, that New Jersey Osprey populations may be on the rise (Clark, 1995). In the 1999 biennial survey, 331 pairs of Osprey were observed in the State. These coastal birds are primarily found along the Atlantic coast of New Jersey from Sandy Hook to Cape May. A few pairs live in Raritan Bay. Approximately 50 pairs of Osprey can be found in Delaware Bay, with most in the Maurice River drainage area. A small colony is located near the Salem nuclear power plant, and there are scattered pairs between the power plant and Maurice River. One pair was also found on the Delaware River in the Hunterdon County area. Individuals tend to return to the same nesting site each year (Clark, pers. comm., 1999).

As stated above, Ospreys are almost completely piscivorous. Their prey selection tends to follow the most abundant species present seasonally and Ospreys are most successful catching fish that feed in shallow waters or swim near the water surface. Ospreys have a tendency to consume the entire fish except for large bones (U.S. Environmental Protection Agency, 1993). In the Delaware Bay region, Ospreys consume predominantly menhaden (*Brevoortia tyrannus*), channel catfish (*Ictalurus* *punctatus*), and white perch (*Morone americana*) (Clark, 1995).

To calculate a wildlife value for Osprey, a prey selection of 90% trophic level 3 fish and 10% tropic level 4 fish was used. In EPA's Trophic Level and Exposure Analysis, Volume I (1995d), the trophic level of Osprey prey selection was determined to be 100% trophic level 3. However, there are many small, shallow water bodies in New Jersey which enable the Osprey to catch higher trophic level prey in greater amounts than in the Great Lakes. Osprey are commonly observed catching largemouth bass (*Micropterus salmoides*) and chain pickerel (*Esox niger*) from New Jersey's inland lakes and ponds. Volume III of EPA's Trophic Level and Exposure Analysis, Appendix B, (1995e) lists estimated trophic levels for largemouth bass ranging from 3.5 - 3.8 and a level of 4 for chain pickerel. The taskforce assigned a conservative estimate of 10% trophic level 4 fish for the Osprey diet in determining wildlife values in New Jersey, based on physical geography, EPA's estimated prey trophic levels (1995e), and observations by Service personnel of Osprey predation patterns. Due to a lack of New Jersey-specific Osprey weights, a combined average of male and female adults weights was used for the purpose of developing wildlife values in order to protect both sexes. This value, 1.4855 kg, was calculated from Dunning (1993). The FMR, the food ingestion rate (F) and the drinking water rate (W) used in the Osprey calculations were derived using the allometric equations described in the GLWQI TSD.

F. CALCULATIONS

The calculations to derive the New Jersey Wildlife Values are presented in the following pages, as are tables delineating the various parameters used in the equations. Exposure parameters for the various representative species are shown in Table 1. This is followed by the contaminant-specific input parameters (Tables 2, 3, & 4) and calculations.

Table 1. Exposure Parameter Values for the Representative Species

Parameter	Bald Eagle (GLWQI)	Bald Eagle (Allometric)	Osprey	Peregrine Falcon
Adult Body Weight Wt (kg)	4.6	4.74	1.4855	0.7815
Water Ingestion Rate W (L/day)	0.16	0.167	0.077	0.05
Gross Energy GE (kcal/g)	1.2 - bony fishes 1.9 - birds	1.2 - bony fishes 1.9 - birds	1.2	1.9
Assimilation Energy AE (%)	79 - fish 78 - birds	79 - fish 78 - birds	79	78
Metabolizable Energy ME (kcal/g)	0.948 - fish 1.482 - birds	0.948 - fish 1.482 - birds	0.948	1.482
Free-living Metabolic Rate FMR (kcal/kg-day)	500	585.65	278.70	184.76
Fish Prey Trophic Level 3 TL3 (% of ***total*** diet)	73.6	73.6	90	0
Fish Prey Trophic Level 4 TL4 (% of ***total*** diet)	18.4	18.4	10	0
Bird Prey Piscivorous PB (% of ***total*** diet)	5.6	5.6	0	35.1
Bird Prey Non-Piscivorous NPB (% of ***total*** diet)	2.4	2.4	0	64.9
Food Ingestion Rate F (kg/day)	F_{TL3} - 0.371 kg F_{TL4} - 0.093 kg F_{PB} - 0.028 kg F_{NPB} - 0.012 kg	F_{TL3} - 0.435 kg F_{TL4} - 0.109 kg F_{PB} - 0.033 kg F_{NPB} - 0.014 kg	F_{TL3} - 0.265 kg F_{TL4} - 0.029 kg	F_{PB} - 0.044 kg F_{NPB} - 0.081 kg

Table 2. Input Parameters for Calculating Wildlife Values - PCBs

Parameter	Value
Test Dose	1.8 mg/kg - day
Interspecies Uncertainty Factors	
$UF_{A\ Eagle}$	3
$UF_{A\ Osprey}$	3
$UF_{A\ Peregrine}$	3
Sub-chronic to Chronic Uncertainty Factor UF_S	1
LOAEL to NOAEL Uncertainty Factor UF_L	3
Bioaccumulation Factor Trophic Level 3 Fish **BAF_3** (L/kg body weight)	550,600
Bioaccumulation Factor Trophic Level 4 Fish **BAF_4** (L/kg body weight)	1,744,800 (1.7448×10^6)
Bioaccumulation Factor Other Prey (terrestrial) **BAF_{other}** (L/kg body weight)	0
Biomagnification Factor Piscivorous Bird Prey **BMF**	90

Calculation of Wildlife Values - PCBs

Bald Eagle ~ (*Haliaeetus leucocephalus*)

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + [(F_{TL3} \times BAF_3) + (F_{TL4} \times BAF_4) + (F_{PB} \times BAF_3 \times BMF) + (F_{NPB} \times BAF_{other})]}$$

$$WV = \frac{1.8 \text{ mg/kg-day} \times [1/(3\times1\times3)] \times 4.74 \text{ kg}}{0.167 \text{ L/day} + [(0.435 \text{ kg/day} \times 550{,}600) + (0.109 \text{ kg/day} \times [1.7448 \times 10^6]) + (0.033 \text{ kg/day} \times 550{,}600 \times 90) + (0.014 \text{ kg/day} \times 0)]}$$

$$WV = \frac{0.948 \text{ mg}}{2{,}064{,}976.367 \text{ L}}$$

WV = 0.000000459 mg/L **WV = 459 pg/L PCBs**

Osprey ~ (*Pandion haliaetus*)

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + [(F_{TL3} \times BAF_3) + (F_{TL4} \times BAF_4)]}$$

$$WV = \frac{1.8 \text{ mg/kg-day} \times [1/(3\times1\times3)] \times 1.4855 \text{ kg}}{0.077 \text{ L/day} + [(0.265 \text{ kg/day} \times 550{,}600) + (0.029 \text{ kg/day} \times [1.7448 \times 10^6])]}$$

$$WV = \frac{0.2971 \text{ mg}}{196{,}508.277 \text{ L}}$$

WV = 0.000001512 mg/L **WV = 1,512 pg/L PCBs**

Peregrine Falcon ~ (*Falco peregrinus*)

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + [(F_{PB} \times BAF_3 \times BMF) + (F_{NPB} \times BAF_{other})]}$$

$$WV = \frac{1.8 \text{ mg/kg-day} \times [1/(3\times1\times3)] \times 0.7815 \text{ kg}}{0.05 \text{ L/day} + [(0.044 \text{ kg/day} \times 550{,}600 \times 90) + (0.081 \text{ kg/day} \times 0)]}$$

$$WV = \frac{0.1563 \text{ mg}}{2{,}180{,}376.05 \text{ L}}$$

WV = 0.000000072 mg/L **WV = 72 pg/L PCBs**

Table 3. Input Parameters for Calculating Wildlife Values - DDTr

Parameter	Value
Test Dose	0.027 mg/kg - day
Interspecies Uncertainty Factors $UF_{A\ Eagle}$ $UF_{A\ Osprey}$ $UF_{A\ Peregrine}$	 1 1 1
Sub-chronic to Chronic Uncertainty Factor UF_S	 1
LOAEL to NOAEL Uncertainty Factor UF_L	 3
Bioaccumulation Factor Trophic Level 3 Fish $\mathbf{BAF_3}$ (L/kg body weight)	631,100
Bioaccumulation Factor Trophic Level 4 Fish $\mathbf{BAF_4}$ (L/kg body weight)	3,409,900 (3.4099×10^6)
Bioaccumulation Factor Other Prey (terrestrial) $\mathbf{BAF_{other}}$ (L/kg body weight)	0
Biomagnification Factor Piscivorous Bird Prey **BMF**	63

Calculation of Wildlife Values - DDTr

Bald Eagle ~ (*Haliaeetus leucocephalus*)

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + [(F_{TL3} \times BAF_3) + (F_{TL4} \times BAF_4) + (F_{PB} \times BAF_3 \times BMF) + (F_{NPB} \times BAF_{other})]}$$

$$WV = \frac{0.027 \text{ mg/kg-day} \times [1/(1\times1\times3)] \times 4.74 \text{ kg}}{0.16 \text{ L/day} + [(0.435 \text{ kg/day} \times 631{,}100) + (0.109 \text{ kg/day} \times [3.4099 \times 10^6]) + (0.033 \text{ kg/day} \times 631{,}100 \times 63) + (0.014 \text{ kg/day} \times 0)]}$$

$$WV = \frac{0.04266 \text{ mg}}{1{,}958{,}263.519 \text{ L}}$$ WV = 0.000000022 mg/L **WV = 22 pg/L DDTr**

Osprey ~ (*Pandion haliaetus*)

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + [(F_{TL3} \times BAF_3) + (F_{TL4} \times BAF_4)]}$$

$$WV = \frac{0.027 \text{ mg/kg-day} \times [1/(1\times1\times3)] \times 1.4855 \text{ kg}}{0.077 \text{ L/day} + [(0.265 \text{ kg/day} \times 631{,}100) + (0.029 \text{ kg/day} \times [3.4099 \times 10^6])]}$$

$$WV = \frac{0.0133695 \text{ mg}}{266{,}128.416 \text{ L}}$$ WV = 0.000000050 mg/L **WV = 50 pg/L DDTr**

Peregrine Falcon ~ (*Falco peregrinus*)

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + [(F_{PB} \times BAF_3 \times BMF) + (F_{NPB} \times BAF_{other})]}$$

$$WV = \frac{0.027 \text{ mg/kg-day} \times [1/(1\times1\times3)] \times 0.7815 \text{ kg}}{0.05 \text{ L/day} + [(0.044 \text{ kg/day} \times 631{,}100 \times 63) + (0.081 \text{ kg/day} \times 0)]}$$

$$WV = \frac{0.0070335 \text{ mg}}{1{,}749{,}409.25 \text{ L}}$$ WV = 0.000000004 mg/L **WV = 4 pg/L DDTr**

Table 4. Input Parameters for Calculating Wildlife Values - Mercury

Parameter	GLWQI Value (Total mercury)	MSRC Value (Dissolved methylmercury)
Test Dose	0.078 mg/kg - day	0.078 mg/kg - day
Interspecies Uncertainty Factors		
$UF_{A\ Eagle}$	3	1
$UF_{A\ Osprey}$	3	1
$UF_{A\ Peregrine}$	3	1
Sub-chronic to Chronic Uncertainty Factor UF_S	1	1
LOAEL to NOAEL Uncertainty Factor UF_L	2	3
Bioaccumulation Factor Trophic Level 3 Fish $\mathbf{BAF_3}$ (L/kg body weight)	27,900	1,600,000 (1.6×10^6)
Bioaccumulation Factor Trophic Level 4 Fish $\mathbf{BAF_4}$ (L/kg body weight)	140,000	6,800,000 (6.8×10^6)
Bioaccumulation Factor Other Prey (terrestrial) $\mathbf{BAF_{other}}$ (L/kg body weight)	0	0
Biomagnification Factor Piscivorous Bird Prey **BMF**	10	10

Calculation of Wildlife Values - Mercury (MSRC)

Bald Eagle ~ (*Haliaeetus leucocephalus*)

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + [(F_{TL3} \times BAF_3) + (F_{TL4} \times BAF_4) + (F_{PB} \times BAF_3 \times BMF) + (F_{NPB} \times BAF_{other})]}$$

$$WV = \frac{0.078 \text{ mg/kg-day} \times [1/(1\times1\times3)] \times 4.74 \text{ kg}}{0.167 \text{ L/day} + [(0.435 \text{ kg/day} \times [1.6 \times 10^6]) + (0.109 \text{ kg/day} \times [6.8 \times 10^6]) + (0.033 \text{ kg/day} \times [1.6 \times 10^6 \times 10]) + (0.014 \text{ kg/day} \times 0)]}$$

$$WV = \frac{0.12324 \text{ mg}}{1965200.167 \text{ L}} \qquad WV = 0.00000006271 \text{ mg/L} \qquad WV = 62.71 \text{ pg/L dissolved methylmercury}$$

Current best estimate of methylmercury as a proportion of total is 0.078 (USEPA, 1997a). Therefore:

WV = 62.71 pg/L ÷ 0.078 = 803.97 pg/L total dissolved mercury

On average, total dissolved mercury comprises ~ 70% of total in unfiltered water (USEPA, 1997b). Therefore:

WV = 803.97 pg/L ÷ 0.70 = **1148.53 pg/L total mercury, unfiltered**

Calculation of Wildlife Values - Mercury (MSRC)

Osprey ~ (*Pandion haliaetus*)

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + [(F_{TL3} \times BAF_3) + (F_{TL4} \times BAF_4)]}$$

$$WV = \frac{0.078 \text{ mg/kg-day} \times [1/(1\times1\times3)] \times 1.4855 \text{ kg}}{0.077 \text{ L/day} + [(0.265 \text{ kg/day} \times [1.6 \times 10^6]) + (0.029 \text{ kg/day} \times [6.8 \times 10^6])]}$$

$$WV = \frac{0.038623 \text{ mg}}{621200.077 \text{ L}}$$ WV = 0.00000006217 mg/L WV = 62.17 pg/L dissolved methylmercury

Current best estimate of methylmercury as a proportion of total is 0.078 (USEPA, 1997a). Therefore:

WV = 62.17 pg/L ÷ 0.078 = 797.05 pg/L total dissolved mercury

On average, total dissolved mercury comprises ~ 70% of total in unfiltered water (USEPA, 1997b). Therefore:

WV = 797.05 pg/L ÷ 0.70 = **1138.64 pg/L total mercury, unfiltered**

Calculation of Wildlife Values - Mercury (MSRC)

Peregrine Falcon ~ (*Falco peregrinus*)

$$WV = \frac{TD \times [1/(UF_A \times UF_S \times UF_L)] \times Wt}{W + [(F_{PB} \times BAF_3 \times BMF) + (F_{NPB} \times BAF_{other})]}$$

$$WV = \frac{0.078 \text{ mg/kg-day} \times [1/(1\times1\times3)] \times 0.7815 \text{ kg}}{0.05 \text{ L/day} + [(0.044 \text{ kg/day} \times [1.6 \times 10^6] \times 10) + (0.081 \text{ kg/day} \times 0)]}$$

$$WV = \frac{0.020319 \text{ mg}}{704000.05 \text{ L}}$$ WV = 0.00000002886 mg/L WV = 28.86 pg/L dissolved methylmercury

Current best estimate of methylmercury as a proportion of total is 0.078 (USEPA, 1997a). Therefore:

WV = 28.86 pg/L ÷ 0.078 = 370 pg/L total dissolved mercury

On average, total dissolved mercury comprises ~ 70% of total in unfiltered water (USEPA, 1997b). Therefore:

WV = 370 pg/L ÷ 0.70 = **528.57 pg/L total mercury, unfiltered**

III. SUMMARY

The Great Lakes Water Quality Initiative included an effort to determine values that would be protective for all wildlife. These values were determined by deriving wildlife values for representative species of the Aves and Mammalia taxonomic classes, calculating the taxonomic-specific geometric mean, and adopting the lower of the two values as the water quality criteria for each target contaminant. The geometric mean for each class was derived using the equation:

$$WV_{(TAXONOMIC\ CLASS)} = e\ Exp\ [\Sigma\ \ln WV_{(REPRESENTATIVE\ SPECIES)}/n]$$

Where: n = The number of representative species in a given taxonomic class for which species-specific wildlife values were calculated.

The current effort, although deriving wildlife values only for avian species, also used the GLWQI equation to calculate the geometric mean of the species-specific wildlife values. These equations are presented below, along with the lowest calculated value for each contaminant (Table 5). In each case, these lowest values were derived from the calculations for the Peregrine Falcon.

i) PCBs

Mean of calculated Wildlife Values: $WV_{(AVIAN)} = e^{[(\ln 459\ pg/L + \ln 1512\ pg/L + \ln 72\ pg/L)/3]}$

$WV_{(AVIAN)} =$ **368 pg/L**

Lowest Wildlife Value: $WV_{(AVIAN)} =$ **72 pg/L**

ii) DDTr

Mean of calculated Wildlife Values: $WV_{(AVIAN)} = e^{[(\ln 22\ pg/L + \ln 50\ pg/L + \ln 4\ pg/L)/3]}$

$WV_{(AVIAN)} =$ **16 pg/L**

Lowest Wildlife Value: $WV_{(AVIAN)} =$ **4 pg/L**

iii) Mercury (MSRC Method)

Mean of calculated Wildlife Values: $WV_{(AVIAN)} = e^{[(\ln 1148.53\ pg/L + \ln 1138.64\ pg/L + \ln 528.57\ pg/L)/3]}$

$WV_{(AVIAN)} =$ **884 pg/L total mercury, unfiltered**

Lowest Wildlife Value: $WV_{(AVIAN)} =$ **528.57 pg/L total mercury, unfiltered**

Table 5. Summary of Calculated Wildlife Criteria Values
(All values rounded to two significant digits)

	Mean GLWQI Method	**Lowest** GLWQI Method	**Mean** MSRC Method	**Lowest** MSRC Method
PCBs	370 pg/L	**72 pg/L**	n/a	n/a
DDTr	16 pg/L	**4 pg/L**	n/a	n/a
Mercury	1300 pg/L	830 pg/L	880 pg/L	**530 pg/L**

IV. RECOMMENDATIONS

The methodology used to develop wildlife criteria in the GLWQI called for adopting the lower of two taxonomic-specific geometric means as regulatory water quality criteria for specific contaminants; however, using this approach with the calculated New Jersey Wildlife Values may not be stringent enough to protect wildlife species of concern. The primary focus of the current effort was to develop wildlife values to specifically protect the Bald Eagle and Peregrine Falcon. Due to its high position on the predator-prey food chain, the Peregrine Falcon may be significantly more susceptible to adverse impacts from exposure to bioaccumulative pollutants than the other two representative species. For each contaminant of concern, the wildlife value geometric means are greater than the individual values calculated for the Peregrine Falcon. Therefore, it is recommended that the lowest New Jersey Wildlife Values generated for each contaminant, including the lowest MSRC mercury value, be adopted as regulatory criteria.

The New Jersey Wildlife Value for total PCBs is: **72 pg/L**

The New Jersey Wildlife Value for total DDT and metabolites (DDTr) is: **4 pg/L**

The New Jersey Wildlife Value for total mercury is: **530 pg/L**

Although this report concentrated solely on avian species of concern, all proposed New Jersey Wildlife Values are lower than the corresponding GLWQI values. As there are no piscivorous mammals in New Jersey different from those examined during the GLWQI, or that occupy a trophic level comparable to the Peregrine Falcon's, adopting the proposed Wildlife Values should ensure protection for all at-risk species in New Jersey.

During the development of these New Jersey Wildlife Values, it became evident that the contaminant concentrations proposed would most likely be below any commonly used analytical laboratory detection limits currently available. This fact does not prohibit the adoption of the Wildlife Values into the Surface Water Quality Standards and their subsequent use in determining regulatory surface water discharge limits. However, the difficulty in precisely determining whether instream concentrations of these parameters will be above or below the Wildlife Values may complicate confirmation of Standards attainment. In the absence of lower analytical detection limits for these pollutants in water, an alternative approach may need to be developed to determine if instream concentrations (water or another model component, such as fish) are below, at, or exceeding the Wildlife Values (Kubiak, pers. comm., 2000). The model for the derivation of the proposed criteria can be used to assist in uncertainty reduction by not focusing solely on water concentrations. Specifically, back-calculating the model for these pollutants in fish tissue (for the appropriate trophic level), results in target fish concentrations. Evaluating monitoring results against target fish concentrations would increase certainty in evaluating proposed Wildlife Value instream concentrations using fish as the surrogate for water analyses. Such an approach is more powerful because of the BAF multiplier effect of the addressed pollutant's behavior in the environment. These objectives, and the following uncertainties, should be pursued in future efforts to ensure that New Jersey water quality and wildlife protection goals are met.

V. DISCUSSION OF UNCERTAINTIES

The goal of this inter-agency effort was to develop New Jersey-specific numeric surface water quality criteria for the protection of at-risk wildlife species. However, to make numeric criteria site-specific requires a great deal of additional field data on resident bird species. These data are limited, but increasing, in New Jersey. Critical information needed for criteria calculation includes: adult body weights, food ingestion rates, prey species composition, and prey species trophic levels. In addition, bioaccumulation and biomagnification factors should be confirmed using New Jersey-specific data. Using all available New Jersey-specific information, this report presents derived maximum allowable surface water concentrations, which should adequately protect wildlife in the State. However, certain steps should be taken to close the following data gaps, prioritized in descending order of importance.

1. Prey Species Composition and Trophic Level (TL):
   Bald Eagle - % TL_3 fish, % TL_4 fish, % piscivorous birds, % other
   Peregrine Falcon - % piscivorous birds (and TL of prey fish), % non-piscivorous birds
   Ospreys - % TL_3 fish, % TL_4 fish

2. Confirm BAFs and BMFs: research needed to compare water toxicant concentrations and prey species body burdens (requires additional monitoring and analysis of regional prey items). Future modeling can be linked with development and use of Biota-Sediment Accumulation Factors (BSAFs), for more problematic waters where additional field monitoring data must be gathered (i.e., toxicant levels in sediments, forage fish, and prey fish species). There is now sufficient understanding of the BSAF concept for development of congener-specific data for the

dioxin-like, PCBs (U.S. Environmental Protection Agency, 2000b). This will complement existing and newly developed State of New Jersey data on eagles (Clark et al., 1998) as well as other species.

3. Food ingestion rates, based on visual observations of prey size (fish taken by Bald Eagles and Ospreys) or published body weights (piscivorous birds taken by Bald Eagles and Peregrine Falcons). Forage to Bird Egg BMFs can also be determined to complement data generated in 1 and 2 above.

4. Effects of PCB congeners on piscivorous wildlife. Studies are necessary to develop dose-response curves for individual, group, or total congeners. Bird egg NOAELs and LOAELs should be adopted as they become available from controlled toxicity studies and field-derived ecotoxicological investigations for the species of concern to New Jersey. Egg (tissue-based) criteria will complement efforts to reduce uncertainty in the above activities and allow for complementary modeling and iterative refinement/validation of the current model.

5. Investigate methylmercury/total mercury ratios in ambient water from various locations in New Jersey, as well as methylmercury concentrations in the tissues of common fish prey species. This information will allow for further refinement of mercury BAFs, and possibly of New Jersey-specific DOC effects on bioavailability.

6. Adult body weights for New Jersey-resident birds.

Items 1, 3, and 5 should be investigated around nest sites with known current or historical problems (*i.e.*, observed reproductive failures and contaminated surroundings).

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B. PERSONAL COMMUNICATIONS

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Appendix A
Summary of Studies Examining Toxic Effects of PCB Congeners

Species	Exposure Duration	LOAEL (mg/kg-day)	NOAEL (mg/kg-day)	PCB Congener or Mixture	Toxic Effect Observed	Reference
Ring-Necked Pheasants	10 weeks	0.086	0.0086	105	Elevated EROD, BROD, MROD in chicks. No reproductive effects.	Hornung *et.al*., 1998
Chicken	8 weeks	0.016	??	Total PCBs	Embryo mortality, decreased hatching rates; deformities	Summer *et.al*., 1996
Mallards	5 weeks	5.17	1.04	1254	Decreased plasma total triiodothyronine (T3); elevated EROD and PROD (no direct toxicity at this dose)	Fowles *et.al*., 1997
American kestrel	4 weeks	0.36 21.4 28.6	One dose per congener	126 105 153	Elevated EROD and AE; Elevated APND; Elevated APND and AE	Elliott *et.al*., 1991
Japanese Quail	8 weeks	0.27 16.2 21.6	One dose per congener	126 105 153	Elevated EROD Elevated EROD, 4-CBP, and HP Elevated EROD, and HP	Elliott *et.al*., 1990
American Kestrels (nestlings) (Model for eagles)	10 days	0.05 0.25		126	Liver enlargement; mild necrosis; elevated EROD, MROD and PROD; lymphoid depletion in the spleen Increasing liver necrosis, decreased bone growth, decreased spleen wt., degenerative lesions of the thyroid	Hoffman *et.al*., 1996

EROD: ethoxyresorufin-O-dealkylase; BROD: benzyloxyresorufin-O-dealkylase; MROD: methyloxyresorufin-O-dealkylase; PROD: pentoxyresorufin-O-deethylase; APND: aminopyrine N-demethylase; 4-CBP: 4-chlorobiphenyl hydroxylase; HP: hepatic porphyrins; AE = aldrin epoxidase.