INTERIM MEDIA PROTECTION GOALS PROPOSAL

FOR HOUSATONIC RIVER, REST OF RIVER

Submitted by:
General Electric Company
Pittsfield, MA

September 6, 2005

Prepared with assistance from:

AMEC Earth & Environmental
Portland, ME

BBL Sciences, Inc.
Petaluma, CA and Houston, TX

ENVIRON International Corporation
Portland, ME

Branton Environmental Consulting
Vancouver, BC

LWB Environmental Services
Oak Ridge, TN

Table of Contents

List of Tables

Appendices

Appendix A: Use of Ranges of Interim Media Protection Goals

Appendix B: Attachments 1 through 13

Attachment 1	Risk-based Media Concentrations for Direct Contact With Floodplain Soil In High-Use Recreational Areas (EPA Assumptions)
Attachment 2	Risk-based Media Concentrations for Direct Contact With Floodplain Soil In Medium-Use Recreational Areas (EPA Assumptions)
Attachment 3	Risk-based Media Concentrations for Direct Contact With Floodplain Soil In Low-Use Recreational Areas (EPA Assumptions)
Attachment 4	Risk-based Media Concentrations for Direct Contact With Floodplain Soil In the Bank Fishing Scenario (EPA Assumptions)
Attachment 5	Risk-based Media Concentrations for Direct Contact With Floodplain Soil In Dirt Biking/ATVing Scenario (EPA Assumptions)
Attachment 6	Risk-based Media Concentrations for Direct Contact with Floodplain Soil in Marathon Canoeing Scenario (EPA Assumptions)
Attachment 7	Risk-based Media Concentrations for Direct Contact with Floodplain Soil-Recreational Canoeing Scenario (EPA Assumptions)
Attachment 8	Risk-based Media Concentrations for Direct Contact with Floodplain Soil-Waterfowl Hunting Scenario (EPA Assumptions)
Attachment 9	Risk-based Media Concentrations for Direct Contact with Floodplain Soil-Farmer Scenario (EPA Assumptions)
Attachment 10	Risk-based Media Concentrations for Direct Contact with Floodplain Soil-High Use Commercial Groundskeeper Scenario (EPA Assumptions)
Attachment 11	Risk-based Media Concentrations for Direct Contact with Floodplain Soil-Low-Use Commercial Groundskeeper Scenario (EPA Assumptions)
Attachment 12	Risk-based Media Concentrations for Direct Contact with Floodplain Soil-Utility Worker Scenario (EPA Assumptions)
Attachment 13	Risk-based Media Concentrations for Direct Contact with Sediment-Sediment Exposure Scenario (EPA Assumptions)

Appendix C: Attachments 14 through 19

Attachment 14	Risk-based Media Concentrations for PCBs in Massachusetts and Connecticut Bass Tissue-Fish Consumption Scenario (EPA Assumptions)
Attachment 15	Risk-based Media Concentrations for PCBs in Connecticut Trout Tissue-Fish Consumption Scenario (EPA Assumptions)
Attachment 16	Risk-based Media Concentrations for PCBs in Waterfowl Tissue-Waterfowl Consumption Scenario (EPA Assumptions)

1.0 INTRODUCTION

1.1 General

This Interim Media Protection Goals Proposal (IMPG Proposal) is submitted by the General Electric Company (GE) pursuant to Special Condition II.C of the Reissued Resource Conservation and Recovery Act (RCRA) Corrective Action Permit that was issued by the U.S. Environmental Protection Agency (EPA) to GE on July 18, 2000 (Reissued RCRA Permit) as part of the comprehensive settlement embodied in the Consent Decree (CD) for the GE-Pittsfield/Housatonic River Site, which was entered by the U.S. District Court in Massachusetts on October 27, 2000. The Reissued RCRA Permit applies to releases of polychlorinated biphenyls (PCBs) and other hazardous wastes or hazardous constituents that have migrated from the GE Facility in Pittsfield, Massachusetts, to the "Rest of River" area. The Rest of River area consists of the portion of the Housatonic River and its floodplain downstream of the confluence of the East and West Branches of the river (located approximately two miles downstream from the GE Facility) and to which releases of hazardous waste or hazardous constituents from the GE Facility are migrating or have migrated, except for the actual or potential lawn areas of current residential properties, which GE has already agreed to address under the CD through a separate Removal Action.

As provided in the CD, EPA conducted a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA) of the Rest of River area. Those draft assessments were then subject to peer review. Following the peer reviews, EPA revised the draft risk assessment reports, issuing a revised draft ERA in November 2004 (EPA, 2004a) and a revised draft HHRA in February 2005 (EPA, 2005a). After a public comment period on new information in those revised drafts, EPA issued Responsiveness Summaries for the ERA in March 2005 (EPA, 2005b) and for the HHRA in June 2005 (EPA, 2005c), concluding in both cases that no further changes to the risk assessment reports were warranted and that the November 2004 ERA and February 2005 HHRA, together with the Responsiveness Summaries, should be considered the final risk assessments for the Rest of River.

The Reissued RCRA Corrective Action Permit requires that, following completion of this process, GE must submit an IMPG Proposal presenting proposed media-specific Interim Media

Protection Goals (IMPGs) for PCBs and other hazardous constituents that have migrated to the Rest of River area from the GE Facility.

After EPA review and approval of the IMPG Proposal, as well as completion of the peer review process on validation of a PCB fate, transport, and bioaccumulation model being developed by EPA for the Rest of River, GE will submit a Corrective Measures Study (CMS) Proposal. That Proposal will identify various potential remedial alternatives (corrective measures) for the Rest of River and set forth a plan to study and evaluate those alternatives. Following EPA approval of the CMS Proposal, GE will carry out the CMS and submit a CMS Report, which will present an evaluation of the potential corrective measures and include a recommendation as to which corrective measures or combination of measures should be implemented. EPA will then review the CMS Report and, ultimately, propose and, after public comment, select Performance Standards and corrective measures for the Rest of River, to be implemented as a Remedial Action under the CD.

1.2 Overview

Under the Reissued RCRA Permit, IMPGs are to consist of preliminary goals that will be used in the CMS in evaluating potential remedial alternatives for the Rest of River. They are not cleanup standards or Performance Standards for the Rest of River remedy, which will be developed in connection with the selection of that remedy. The feasibility of attaining the IMPGs is not considered in the IMPG Proposal; rather, that factor is to be considered and balanced along with several other factors (listed in the Permit) in evaluating remedial alternatives in the CMS. The Permit's requirements for the IMPG Proposal and the role of the IMPGs in the CMS process are discussed further in Section 1.3.

Consistent with the Reissued RCRA Permit, this IMPG Proposal presents a combination of numerical concentration values and narrative descriptive goals for the protection of both human health and ecological receptors, taking into account EPA's risk assessments. From a human health standpoint, it addresses direct human contact with sediments and floodplain soil and human consumption of fish, waterfowl, and agricultural products from the Rest of River area. From an ecological standpoint, this IMPG Proposal addresses several groups of ecological receptors, including benthic invertebrates, amphibians, fish, and certain species of birds and mammals. It presents numerical concentration values for PCBs (and, in some cases, dioxin toxicity equivalents) in sediments, floodplain soil, fish tissue, and/or other biota tissue as

relevant to these human and ecological receptors. A description of the constituents, media, and exposure pathways covered in this Proposal is provided in Section 1.4.

To allow for full evaluation of an appropriate array of remedial alternatives in the CMS, this IMPG Proposal presents ranges of numerical concentration values, rather than single numbers, for each pathway and/or receptor. For the health-based values, these ranges include values based on different risk levels within EPA's acceptable cancer risk range, as well as non-cancer-based values, and they also include values based on different sets of exposure assumptions (representing individuals with reasonable maximum exposure and those with average exposure). For the ecologically based values, the ranges include various effect thresholds from the site-specific studies used in the ERA or, for species for which there are no such studies, values based on ranges of effect levels from the literature. This approach of using ranges of values is discussed further in Section 1.5 and Appendix A.

Given the Permit requirement to take into account EPA's risk assessments, this IMPG Proposal includes two separate sets of such ranges, as discussed further in Section 1.6. The first set, presented in Section 2, consists of ranges of numerical concentration values that have been calculated based directly on use of the exposure assumptions, toxicity values, and data interpretations from EPA's HHRA and ERA. This approach, however, does not reflect GE's agreement with those assumptions, values, and interpretations. To the contrary, as discussed in prior comments to EPA, GE believes that many of those assumptions, values, and interpretations overstate exposures and risks to human and ecological receptors in the Rest of River; and GE preserves that position. In addition, this Proposal sets forth, in Section 3, an alternative set of concentration ranges that have been based on the use of many (but not all) of the inputs used in EPA's risk assessments, combined with certain exposure assumptions, toxicity values, and data interpretations that GE believes are more supportable and more consistent with actual site conditions and any related risk and with the underlying data. Section 3 provides a rationale for such alternative assumptions, values, and interpretations.

Finally, Section 4 of this Proposal describes potential chemical-specific applicable or relevant and appropriate requirements (ARARs) for media in the Rest of River area and discusses their relationship with the IMPGs.

1.3 Applicable Requirements

The requirements for the IMPG Proposal are set forth in Special Condition II.C of GE's Reissued RCRA Permit. In relevant part, those requirements are as follows:

- "The proposed IMPGs shall consist of preliminary goals that are shown to be protective of human health and the environment and that will serve as points of departure in evaluating potential corrective measures in the subsequent Corrective Measures Study . . . . Such IMPGs are not necessarily equivalent to cleanup standards or Performance Standards and may be modified or revised in the selection of Performance Standards and associated corrective measures."

- "IMPGs shall be proposed for the following media in the Rest of River area: sediments, surface water, floodplain soils, biota, and air (PCBs only)." (As discussed further below, based on surface water and ambient air data from the Rest of River and screening-level risk evaluations contained in the HHRA, there is no need to propose risk-based IMPGs for surface water and air.)

- "The constituents to be addressed by the proposed IMPGs shall be limited to those which have migrated to the Rest of River area from the GE Facility. Such constituents may be further limited to include only those constituents identified by EPA in its [HHRA] and its [ERA] as contributing to the baseline risk."

- "The proposed IMPGs for sediments, surface water, and floodplain soils shall include numerical concentration-based goals for constituents in such media, based on the assessment of direct contact of humans (i.e., incidental ingestion and/or dermal contact) with such media. They may also include narrative descriptive goals for such media based on such direct contact pathways."

- "The proposed IMPGs for biota consumed by humans shall include numerical concentration-based goals for constituents in the edible tissue of such biota, based on the assessment of human consumption of such biota. They may also include narrative descriptive goals for such biota based on such human consumption pathways. [GE] may also propose descriptive IMPGs for sediments, surface water, and/or floodplain soils based on an extrapolation from the human-consumption-based IMPGs for biota."

- "[GE] shall also propose IMPGs for relevant media based on the assessment of exposures and risks to ecological receptors. Such IMPGs shall consist of either numerical concentration-based goals or narrative descriptive goals, or a combination of these types of goals."

- "The IMPG Proposal shall include a justification demonstrating that the proposed IMPGs, if achieved, would ensure protection of human health and the environment, taking into account EPA's [HHRA] and its [ERA]."

- "The IMPG Proposal shall take into account applicable or relevant and appropriate federal and state requirements" (i.e., federal and state ARARs).

The Reissued RCRA Permit also specifies the role of the IMPGs in the CMS. It provides that, in the CMS Proposal, GE must identify the corrective measures it proposes to study and provide a justification for the selection of those measures, and that this justification "shall consider the ability of such corrective measures to achieve the IMPGs" (Special Condition II.E). The Permit further requires that, in the CMS Report, GE must evaluate alternatives according to two tiers of factors (Special Condition II.G). The first tier consists of "General Standards" that all alternatives must meet. This tier does not include attainment of the IMPGs; rather, it includes overall protection of human health and the environment, control of sources of releases, and compliance with federal and state ARARs (or, when an ARAR would not be met, the basis for a waiver of the ARAR). The second tier consists of "Selection Decision Factors," which must be balanced against one another in evaluating alternatives. These factors include the ability of the alternatives to achieve the IMPGs, along with several other factors – namely, long-term reliability and effectiveness; reduction of toxicity, mobility, or volume of wastes; short-term effectiveness (including impacts to nearby communities, workers, or the environment during implementation); implementability; and cost.

This IMPG Proposal does not consider the feasibility of achieving the IMPGs nor does it consider any of the other Selection Decision Factors set forth in the Reissued RCRA Permit. Those factors will be considered in the CMS phase of the process.

1.4 Constituents, Media and Pathways Covered

This IMPG Proposal presents a combination of numerical risk-based concentrations and narrative descriptive goals. For PCBs, which are the principal contaminant of potential concern (COPC) in the Rest of River area, this Proposal sets forth numerical risk-based values for a number of media and exposure pathways. From the human health standpoint, EPA's HHRA contained three separate assessments – an assessment of direct human contact with soil or sediment, an assessment of fish and waterfowl consumption, and an assessment of agricultural products consumption. Consistent with those three assessments and with the requirements in the Reissued RCRA Permit, this Proposal presents health-based numerical values for PCBs in:

- Floodplain soil and sediment based on direct human contact with those media;
- Edible fish and waterfowl tissue based on human consumption of fish and waterfowl; and

- Edible agricultural products based on human consumption of those products.

From an ecological standpoint, EPA's ERA evaluated potential exposures and risks to a variety of ecological receptors. This IMPG Proposal presents numerical risk-based concentration values for PCBs based on the assessment of those ecological receptors for which the ERA found significant risks due to PCBs. Specifically, this Proposal presents such PCB values for the following media:

- Sediments based on risks to benthic invertebrates;
- Vernal pool and backwater sediments based on risks to frogs;
- Floodplain soil based on risks to short-tailed shrews;
- Fish tissue based on risks to fish;
- Dietary items consumed by mink and otter;
- Fish tissue based on consumption by osprey;
- Fish tissue based on consumption by bald eagles; and
- Aquatic invertebrates based on consumption by wood ducks.

GE has also evaluated the need for risk-based values for PCBs in surface water based on direct human contact with the river water and for PCBs in ambient air based on inhalation of PCBs by humans. For surface water, the HHRA contained a conservative screening-level evaluation of potential risks due to direct contact (HHRA, Vol. I, Sec. 5.2). In this evaluation, EPA developed very conservative screening risk-based concentrations (SRBCs), using conservative exposure assumptions for incidental ingestion of surface water, combined with stringent target risk benchmarks of a $1x10^{-6}$ cancer risk (the lower end of EPA's cancer risk range) and a non-cancer Hazard Index (HI) of 0.1 (10 times more stringent than the target HI recommended in EPA guidance). This evaluation resulted in SRBCs for PCBs of 27 parts per billion (ppb) based on cancer risks and 18 ppb based on non-cancer impacts. EPA then compared those SRBCs with the maximum detected concentration of PCBs in the surface water of the Housatonic River in the Rest of River area, which was 1.5 ppb. Since that maximum concentration was well below the conservative SRBCs, EPA eliminated the surface water pathway from further

quantitative evaluation in the direct contact risk assessment (HHRA, Vol. I, p. 5-7). In light of this conservative screening analysis, there is no need in this IMPG Proposal to develop risk-based numerical concentration values for PCBs in surface water based on direct contact.

For PCBs in ambient air, the HHRA likewise presented a conservative screening-level assessment of potential risks due to inhalation (HHRA, Vol. I, Sec. 5.1). This assessment involved comparison of PCB concentrations measured in ambient air at this site with preliminary remediation goals (PRGs) developed by EPA Region IX for PCBs in ambient air, which assumed exposure to PCBs in the air 24 hours per day, 350 days per year for 30 years, and used a target cancer risk of $1x10^{-6}$. That PRG is 3.4 nanograms per cubic meter (ng/m^3). Based on this comparison, the HHRA found that "the average [total] PCB concentration in ambient air [in the area] was lower than the conservative PRG, [and] therefore, the potential risks to individuals who live or recreate along the Housatonic River in the Rest of River study area was determined to be below 1E-06 and outside the EPA risk range" (HHRA, Vol. I, p. 5-3). The HHRA thus concluded that "the air concentrations of PCBs do not pose a human health risk for individuals living near or using the Housatonic River for recreational purposes" (HHRA, Vol. I, p. 5-4). For these reasons, there is no need in this IMPG Proposal to develop risk-based concentrations for PCBs in ambient air.

In addition, GE has evaluated the need to address constituents other than PCBs in this IMPG Proposal. The principal such constituents for which EPA's HHRA and ERA provide quantitative assessments are polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), as well as the so-called "dioxin-like" congeners of PCBs. For these constituents, Toxicity Equivalency Quotients (TEQs) are calculated using certain specified Toxicity Equivalency Factors (TEFs), which convert the various PCDD and PCDF compounds and the "dioxin-like" PCB congeners into toxic equivalents of the most potent PCDD congener – 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) – for assessment.[1]

In assessing human health risks, EPA calculated only potential cancer risks for TEQs, since there is no current non-cancer Reference Dose for TEQs. The HHRA included such TEQ risks in its main quantitative assessment of fish and waterfowl consumption pathways. However, for the direct contact and agricultural products consumption risk assessments, the HHRA included

[1] As stated in prior comments to EPA (AMEC and BBL, 2003, 2005; GE, 2003), GE does not believe that current scientific information supports the inclusion of PCBs in the TEQ approach for the assessment of human health effects.

TEQs only in its uncertainty analyses, not in the main risk assessments. Accordingly, this IMPG Proposal includes numerical risk-based values for TEQs in edible fish and waterfowl tissue, based on consumption by humans; but it does not include such values for TEQs in sediment or soil based on direct human contact or in agricultural products based on human consumption.

For ecological risks, the ERA included a quantitative assessment of potential TEQ risks for some receptors but not others. This IMPG Proposal includes numerical risk-based values for those ecological receptors for which: (a) the ERA found significant risks due to TEQs; (b) those TEQ risks were found to be greater or more certain than the risks due to PCBs; and (c) the ERA developed Maximum Acceptable Tissue Concentrations (MATCs) for TEQs.

For constituents other than PCBs and TEQs, the HHRA included detailed screening evaluations for each of the three risk assessments, involving consideration of frequency of detection, frequency and magnitude of exceedances of PRGs or other risk-based concentrations, and comparison to background concentrations (HHRA, Vol. IIIA, Sec. 2.5; Vol. IV, Secs. 2.7.1 & 2.8.1; Vol. V, Sec. 2.1.1). These constituents included metals, polycyclic aromatic hydrocarbons (PAHs), and, in some cases, pesticides and herbicides. Based on these evaluations, the HHRA eliminated all such constituents from the quantitative assessments (except for mercury in fish, for which there is no evidence that its presence in the Rest of River is attributable to migration from the GE Facility), although it did present a qualitative evaluation of direct contact risks from some of these constituents (Vol. IIIA, Sec. 5.4). Moreover, the HHRA noted that the metals in question in floodplain soil and sediments, as well as the PAHs in floodplain soil, do not appear to be related to releases from the GE facility (HHRA, Vol. IIIA, pp. 2-10, 2-11, 2-15), and that the metals and PAHs are not considered site-wide contaminants (Vol. V, p. 2-14). The ERA did retain certain metals and PAHs for its assessments of risks to benthic invertebrates, frogs, and fish (PAHs only) (ERA, Vol. 1, pp. 3-12, 4-15, 5-9); but it found that the risks from those constituents were low (benthic invertebrates and fish – Vol. 1, pp. 3-66, 5-54) or gave them no attention (frogs). For other wildlife, the ERA screened out all constituents except PCBs and TEQs (ERA, Vol. 2, p. 6-3). In these circumstances, based on review of the Reissued RCRA Permit requirements and discussions with EPA, this IMPG Proposal does not present values for these constituents.

1.5 Use of Ranges

To allow for full evaluation of an appropriate array of potential corrective measures in the CMS, this IMPG Proposal does not provide single-number IMPGs. Rather, this Proposal presents ranges of numerical risk-based concentration values (referred to herein as "Risk-based Media Concentrations" or RMCs), based on varying inputs and assumptions. For the health-based values, the ranges of RMCs include values based both on use of Reasonable Maximum Exposure (RME) assumptions and on use of Central Tendency Exposure (CTE) assumptions; and for each set of assumptions, the ranges include cancer-based values based on three excess lifetime cancer risk levels within EPA's acceptable cancer risk range – namely, $1x10^{-6}$, $1x10^{-5}$, and $1x10^{-4}$ – as well as non-cancer-based values using a Hazard Index (HI) of 1. For the ecologically based values, the ranges of RMCs include various effect thresholds from the site-specific studies used in the ERA – which vary depending on the particular study, the endpoint, and the size of the effect (e.g., an EC20 representing a 20% effect or an EC50 representing a 50% effect) – or, for species for which there are no site-specific studies, values based on ranges of toxicity reference values (TRVs) from the literature.

The use of ranges of RMCs allows for consideration of relevant site-specific factors in the CMS in selecting the goals to be used for evaluating potential corrective measures, and in evaluating an appropriate array of such measures. This point is discussed in more detail in Appendix A. For example, for health-based values, the National Contingency Plan (NCP) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) specifies that, for known or suspected carcinogens, concentration levels will be considered protective if they represent an excess lifetime cancer risk to an individual between 10^{-4} and 10^{-6} (40 CFR § 300.430(e)(2)(i)(A)(*2*)). EPA's guidance documents for actions under RCRA corrective action permits contain similar statements, as described in Appendix A. While the NCP and the RCRA corrective action guidance state further that the 10^{-6} risk level should be used as "the point of departure" for determining remediation goals, EPA's guidance also makes clear that that risk level need not be the target goal in all situations. To the contrary, as shown in Appendix A, EPA's guidance clarifies that other risk reduction goals within EPA's risk range may be appropriately identified as target or preliminary remediation goals for use in remedial action evaluations at particular sites, depending on site-specific conditions and other relevant factors. In other words, the requirement that the 10^{-6} cancer risk level is to be used as the point of departure *for determining remediation goals* does not make that level equivalent to the Reissued RCRA Permit's definition of IMPGs as goals "that will serve as points of departure *in*

evaluating potential corrective measures" in the CMS (emphasis added). Rather, other RMCs within EPA's cancer risk range – or, if lower, non-cancer-based values – may also be identified as IMPGs for particular areas and remedial scenarios. [2]

For the ecologically based values, as also shown in Appendix A, there is no comparable regulation or guidance on quantitative levels of risk reduction. Indeed, EPA guidance states that protective exposure levels for ecological receptors "are best established on a site-specific basis," and that "[t]here is no magic number that can be used" (EPA, 1999a). Rather, the selection of cleanup goals is dependent on the assessment endpoints selected and the risk assessment measures used, considering "the acceptable level of adverse effects for the receptors to be protected" and the overall goal "to reduce ecological risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota" (EPA, 1999a). Thus, various RMCs within the specified ranges may serve as IMPGs, depending on the type and size of effect to be prevented and the relevance of the endpoints to the protection of local populations and communities.

The use of ranges of RMC values is particularly appropriate in light of the substantial uncertainties underlying the risk assessments and the range of scientific opinion on the key inputs to those risk assessments. As the peer review panel on the HHRA recognized (see EPA, 2004b), there are large uncertainties both in the toxicity values used in the HHRA (given the need to extrapolate from animal-based values to humans) and in the exposure estimates made in that assessment (given the lack of site-specific empirical data to verify many of those assumptions). Similarly, in the ERA, the predicted risks are uncertain given the absence of any obvious adverse effects on the fish and wildlife populations and communities in the Rest of River area, which appear to be abundant, diverse, and thriving. This uncertainty is particularly evident where the predicted risks were based entirely on modeled exposures and effects or other non-site-specific information. The use of RMC ranges allows these uncertainties to be considered during the CMS process.

---

[2] Moreover, even for non-cancer impacts, although the numerical RMCs in this Proposal are based on an HI of 1, such values should not be regarded as a bright line marking the level of adverse effects. As discussed in Appendix A, since the HI is the ratio of the predicted dose to the Reference Dose (RfD) and the latter is typically calculated by applying multiple uncertainty factors to the no-effect or lowest-effect level in the underlying study, an HI greater than 1 is not necessarily indicative of unacceptable non-cancer hazards. Given this fact, remediation goals may, in appropriate cases, include non-cancer-based values that reflect HIs greater than 1. Indeed, as noted in Appendix A, there are precedents from other sites in this EPA Region supporting a non-cancer HI range from 1 to 10.

Moreover, the use of such ranges is consistent with the fact that there is a wide range of scientific opinion on most of the inputs and interpretations in the HHRA and the ERA, as evidenced by the substantial divergence of opinions among the peer reviewers on such issues (see EPA, 2004b, 2004c). The use of ranges reflects this broad spectrum of views, as well as the underlying uncertainties that they represent.

1.6 Exposure and Toxicity Assumptions and Data Interpretations

As noted above, the Reissued RCRA Permit requires that the proposed IMPGs must "tak[e] into account" the risk assessments conducted by EPA. Given that requirement, GE has developed two separate sets of RMC ranges. Section 2 presents ranges of numerical RMCs that have been calculated based directly on the assumptions and interpretations used in EPA's risk assessments. Specifically, for the health-based values, the ranges of RMCs presented in Section 2 were derived through backcalculations using the same RME and CTE exposure assumptions and toxicity values used in the HHRA, and they include values reflecting three excess cancer risk levels plus non-cancer impacts using those inputs. For the ecologically based values, the ranges of RMCs presented in Section 2 include the MATCs specified in the ERA (for receptors which MATCs were developed by EPA), plus: (a) for species for which the ERA relies on site-specific studies, values reflecting various other effects thresholds from those studies, as reported in the ERA; or (b) for species for which there are no site-specific studies, values based on the ERA's selected range of literature-based TRVs.

However, as discussed in GE's prior comments, GE does not agree with many of the exposure assumptions, toxicity values, and other interpretations and analyses used in the HHRA and ERA. To the contrary, as explained in GE's comments on the HHRA (AMEC and BBL, 2003, 2005; GE, 2003), GE believes that many of the exposure assumptions in the HHRA, particularly in combination, are not supported by site conditions or the data and substantially overestimate exposures in the Rest of River area, and that the animal-based PCB toxicity values and TEQ approach used in the HHRA overstate the carcinogenic potential and non-carcinogenic impacts of PCBs in humans. Similarly, as explained in GE's comments on the ERA (BBL et al., 2003a, 2005; GE, 2004), GE believes that many of the interpretations, analyses, assumptions, and toxicity values used in the ERA are not supported by the data and substantially overestimate exposures and risks to ecological receptors in the Rest of River area.

Accordingly, Section 3 of this proposal sets forth an alternative set of RMC ranges based on the use of exposure assumptions, toxicity values, and data interpretations that GE believes are more scientifically supportable and more consistent with site conditions and the underlying data. In developing these alternate values, GE has "taken into account" the HHRA and ERA, because it has used the same exposure scenarios and receptors used in those EPA risk assessments and has carefully considered and evaluated the assumptions and other inputs used in those risk assessments. In fact, in developing these values, GE has used many of the same assumptions and parameter values used in the HHRA and ERA. Where alternative assumptions, parameter values, or data interpretations have been used, they are identified in Section 3, and a rationale is provided to explain why GE believes that such assumptions, parameter values, or data interpretations are more supportable.[3] This approach is consistent with the Permit requirement to "tak[e] into account" the risk assessments, because the Permit's use of that phrase, rather than a requirement that the IMPG Proposal must be "based on" or be developed "in accordance with" the HHRA and ERA, indicates clearly that GE is not required to utilize the same assumptions, parameter values, and data interpretations used in the HHRA and ERA, but rather to take them into consideration.

GE believes that both sets of RMC ranges meet the Permit requirement to be protective of human health and the environment. For the RMC ranges presented in Section 2, since those ranges rely on EPA's conservative exposure assumptions, toxicity values, and data interpretations, it can be concluded that, for the particular scenarios, receptors, and risk or effect levels to which they apply and given the assumptions used, the RMCs calculated are protective of human health or the environment (as applicable). However, for the reasons noted above, GE does not agree that those values are *necessary* to protect human health or the environment.

[3] It should be noted that, for the human health-based values presented in Section 3, GE has used toxicity values derived from animal studies. Specifically, it has used the same Cancer Slope Factors (CSFs) used in the HHRA, which were derived from rat studies; and it has used a non-cancer Reference Dose (RfD) derived from the same rhesus monkey study used by EPA to develop its RfD, but with different uncertainty factors that GE has previously proposed to EPA (AMEC and BBL, 2003, Attachment N). Despite the use of these animal-based values, GE continues to believe, as shown in its prior comments (AMEC and BBL, 2003, Attachments J and K), that the weight of evidence from human epidemiological studies demonstrates that: (a) there is little credible evidence that PCBs have caused any type of cancer in highly exposed occupational cohorts and virtually no evidence that PCBs could cause cancer in humans at environmental exposure levels; and (b) with the possible exception of dermal and ocular effects in highly PCB-exposed workers, there is no credible evidence of a causal relationship between PCB exposure and adverse non-cancer effects in humans. Accordingly, the health-based RMCs presented in Section 3 are still highly conservative.

Rather, GE believes that those values are overly conservative for their particular application, in that they are more stringent than necessary to protect human health and the environment.

For the RMC ranges presented in Section 3, for the reasons given in the specific discussions of the alternative inputs in Section 3, GE believes that the alternative exposure assumptions, toxicity values, and data interpretations used are fully supported by the scientific evidence and are, in fact, still conservative.[4] In consequence, GE believes that the resulting RMCs are likewise fully protective of human health and the environment for the particular scenarios, receptors, and risk or effect levels to which they apply.

For these reasons, use of the alternative RMCs in these ranges as IMPGs would be consistent with the requirements of the Reissued RCRA Permit.

1.7 Narrative Descriptive Goals

In addition to providing numerical RMCs as described above, this IMPG Proposal provides narrative descriptive goals for each of the pathways assessed in the HHRA (i.e., direct contact with soils and sediments, fish and waterfowl consumption, and agricultural products consumption), as well as for each of the ecological receptors for which numerical values are provided.

1.8 ARARs

Finally, Section 4 of this IMPG Proposal identifies and discusses potential chemical-specific ARARs for PCBs and TEQs for media in the Rest of River area. As shown in that section, while a number of chemical-specific regulatory criteria may ultimately be listed as ARARs for the Rest of River remedy, those criteria would not constitute or affect the IMPGs because GE has developed site-specific RMCs that address the same receptors and pathways addressed by those criteria and that are fully protective of human health and the environment.

[4] See, e.g., Note 3 above.

2.0 RMCs BASED ON EPA'S RISK ASSESSMENTS

This section presents ranges of RMCs that have been derived using the EPA-developed exposure assumptions and toxicity values from EPA's HHRA and the MATCs and other threshold effect levels or TRVs set forth in EPA's ERA. As noted in Section 1.6, use of this approach does not reflect GE's agreement with or acceptance of those assumptions and other values. GE preserves its position, set forth in its prior comments, that many of those assumptions and values overstate exposures and risks to human and ecological receptors in the Rest of River area. Moreover, as noted in Section 1.3, these RMCs have been developed without consideration of the feasibility of achieving those levels; that factor will be considered and balanced along with the other balancing factors listed in the Reissued RCRA Permit (e.g., long-term and short-term effectiveness, implementability, cost) in evaluating potential corrective measures in the CMS.

2.1 RMCs for PCBs in Floodplain Soil/Sediment Based on Direct Contact by Humans

In accordance with the Reissued RCRA Permit, numerical concentration-based RMCs have been developed for PCBs in floodplain soil and sediments. These are based on direct contact of humans with such media (via incidental ingestion and dermal contact).

2.1.1 Methodology

Numerical RMCs have been derived through backcalculations using the exposure assumptions and toxicity values that were used in the HHRA. A range of RMCs for PCBs has been calculated for each of the exposure scenarios and receptors (i.e., age groups) evaluated in the Direct Contact Assessment in the HHRA.[5] Estimates have been derived using both EPA's RME assumptions and its CTE assumptions. RMCs based on potential cancer risks have been derived for each receptor using three risk levels within EPA's target cancer risk range (10^{-6}, 10^{-5} and 10^{-4}). RMCs based on potential non-cancer impacts have been derived for each scenario

[5] As noted in Section 1, RMCs have not been calculated for TEQs in soil or sediment based on direct human contact because EPA's Direct Contact Assessment in the HHRA discussed TEQs only in its uncertainty analysis and did not include them in the main risk assessment.

and each receptor using a target HI of 1. This approach results in a range of eight RMCs for each exposure scenario-receptor combination.

RMCs have been developed for 15 direct contact scenarios. The scenarios and receptors for which RMCs have been derived are as follows:

- Residential use in portions of residential properties other than riverbanks, areas with steep slopes, and wetland areas – Adults, older children, young children;
- Residential use in portions of residential properties consisting of riverbanks, steep slopes, or wetlands – Adults, older children, young children;
- High-use general recreation – Adults, older children, young children;
- Medium-use general recreation – Adult and older children;
- Low-use general recreation – Adults and older children;
- Bank fishing – Adults and older children;
- Dirt biking/ATVing – Older children;
- Marathon canoeist – Adults;
- Recreational canoeist – Adults and older children;
- Waterfowl hunting – Adults and older children;
- Agricultural use (based on direct contact by farmer) – Adults;
- High-use commercial groundskeeper – Adults;
- Low-use commercial groundskeeper – Adults;
- Utility Worker – Adults; and
- Sediment contact - Adults and older children.

As noted above, there are two residential use scenarios. The first applies to the portions of residential properties that consist of what the Consent Decree calls “Actual/Potential Lawns,” which are defined as all portions of residential properties in the Rest of River floodplain “except the riverbanks and those areas at which the wet nature or steep slope of the ground surface results in potential exposures that are inconsistent with residential use” (CD ¶ 4). The Actual/Potential Lawns areas at current residential properties downstream of the confluence of the East and West Branches are not part of the Rest of River under the Reissued RCRA Permit and the CD, but are subject to a separate Removal Action under the CD (CD ¶ 4 [definition of "Removal Actions Outside the River," subpara. 5(c)], CD ¶ 28.b). For these Actual/Potential Lawn areas, the CD establishes a Performance Standard of 2 mg/kg for PCBs in soil (CD ¶ 28.b(i); *Statement of Work for Removal Actions Outside the River* [Appendix E to CD] at p. 68), which the CD states was determined by EPA, the Massachusetts Department of Environmental Protection (MDEP), and the Connecticut Department of Environmental Protection (CDEP) to be protective of human health and the environment for such residential areas (CD, ¶ 8.b). The HHRA adopted that Performance Standard as the Screening Risk-Based Concentration for Actual/Potential Lawn areas (HHRS, Vol. I, p. 6-4); and it used the exposure and toxicity assumptions that were used in the CD to support that Performance Standard (CD, Appendix D, Attachment A) in assessing direct contact risks for areas that EPA concluded could become Actual/Potential Lawns in the future (HHRA, Vol. IIIA, pp. 4-48 to 4-51). In these circumstances, GE proposes to use the CD’s 2 mg/kg Performance Standard as the IMPG for areas where future use as a residential Actual/Potential Lawn is reasonably anticipated.

The second residential use scenario applies to the portions of residential properties that consist of riverbanks, wet areas, or steeply sloped areas. For these portions of both current and future residential properties, the HHRA used the exposure assumptions for the general recreational use scenario with the exposure frequency considered relevant for the particular area involved – which was generally, but not always, the exposure frequency for high-use general recreational areas (see HHRA, Vol. IIIA, pp. 4-48 to 4-51, 5-23, 5-45). For these portions of residential properties or reasonably anticipated future residential properties, GE proposes to use the RMCs calculated for the general recreation scenario for the use category which is most applicable to the area in question (i.e., high-use, medium-use, or low-use).

For the remaining direct contact scenarios listed above, the specific exposure parameters and assumptions used in calculating the RMCs for each scenario and receptor are detailed in

Attachments 1 through 13 (contained in Appendix B). These values used for these parameters are identical to the values used to develop the potential cancer risk and non-cancer hazard estimates for the direct contact pathways in the HHRA.

The cancer slope factors (CSFs) and reference dose (RfD) used in the RMC calculations are also the same as those used in the HHRA, which were taken from EPA's IRIS database. For the RME analysis for cancer effects, an upper bound CSF of 2 $(mg/kg\text{-}day)^{-1}$ for PCBs has been used. For the CTE analysis, the central estimate CSF of 1 $(mg/kg\text{-}day)^{-1}$ has been used, as was done in the HHRA. In the calculation of all non-cancer-based RMCs, EPA's chronic RfD of 2E-05 mg/kg-day for PCB Aroclor 1254 has been used. Finally, the relative oral and dermal absorption factors (ABS_o and ABS_d) for PCBs used in calculating the RMCs are the same as the values used in the HHRA.

Three target risk levels were used to derive a range of RMCs based on potential carcinogenic effects. These risk levels were 1 in 1,000,000 (10^{-6}), 1 in 100,000 (10^{-5}), and 1 in 10,000 (10^{-4}). These target risk levels were selected because they are consistent with EPA's target risk range for the selection of remedial goals, as noted in Section 1 above. To calculate the RMCs based on potential non-carcinogenic effects, a target Hazard Index (HI) of 1 was used.

The RMCs based on potential carcinogenic effects were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk}{CSF * (Exp_{ingestion} + Exp_{dermal})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

The RMCs based on potential non-carcinogenic effects were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) were calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} \frac{\left[\left(\left\{AF_1 * SA_1 * AD_1\right\} + \left\{AF_2 * SA_2 * AD_2\right\}\right)/\left(AD_1 + AD_2\right)\right] * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative oral absorption factor (unitless)
AF_1	=	Weighted dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Weighted dermal adherence factor during cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)

AT = Averaging time (days)

BW = Body weight (kg)

The RMCs have been derived based on the assumption that they will be applied as averages, rather than not-to-exceed values, consistent with the approach used in the Direct Contact Assessment in the HHRA. There are various methods for calculating such averages – e.g., use of spatial averaging techniques, use of the 95% upper confidence limit on the mean. The issue of the appropriate technique to use in calculating the averages when comparing the RMCs with existing soil concentrations at particular properties or areas will be addressed in the CMS.

2.1.2 Proposed RMCs

The proposed numerical RMCs for PCBs in floodplain soil and sediment, based on direct human contact using the assumptions in the HHRA, are set forth in Table 2-1. This table presents receptor-specific RMCs for each scenario. The RMCs for residential use scenarios are discussed above. For the remaining scenarios, supporting calculations are provided in Attachments 1 through 13 (in Appendix B), which are referenced in Table 2-1. There are eight RMCs for each receptor evaluated. These include three cancer-based RMCs and one non-cancer-based RMC for the RME scenario, and three cancer-based RMCs and one non-cancer-based RMC for the CTE scenario.

In addition to the numerical RMCs, GE proposes the following narrative IMPG for direct contact:

> ***To reduce the average PCB concentrations in floodplain soils and sediments in the Rest of River as necessary so that they do not present significant risks of harm to the health of individuals who contact such soil or sediment directly, taking into account the accessibility of the soil and sediment and the actual and reasonably anticipated future uses of the areas.***

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment), Using Assumptions in HHRA

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Residential (reasonably anticipated Actual/Potential Lawn areas)	All	RME	150 d/yr	2 (per Consent Decree)			
Residential (banks, steep slopes, wet areas)	All	Both	Variable	Use RMCs for general recreation scenarios based on appropriate exposure frequencies for parcel-specific conditions			
High-use general recreation *See Att. 1*	Young child (high use)	RME	90 d/yr	1.3	13	134	4.6
		CTE	30 d/yr	18	184	1,842	32
	Young child (low use)	RME	15 d/yr	8.0	80	802	27
		CTE	15 d/yr	37	368	3,684	63
	Older child	RME	90 d/yr	3.9	39	388	27
		CTE	30 d/yr	51	514	5,143	176
	Adult	RME	90 d/yr	1.4	14	143	38
		CTE	30 d/yr	63	630	6,305	234

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment), Using Assumptions in HHRA

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Medium-use general recreation *See Att. 2*	Young child	Not assessed		NA	NA	NA	NA
	Older child	RME	60 d/yr	5.8	58	582	40
		CTE	30 d/yr	51	514	5,143	176
	Adult	RME	60 d/yr	2.1	21	215	58
		CTE	30 d/yr	63	630	6,305	234
Low-use general recreation *See Att. 3*	Young child	Not assessed		NA	NA	NA	NA
	Older child	RME	30 d/yr	12	116	1,165	80
		CTE	15 d/yr	103	1,029	10,286	353
	Adult	RME	30 d/yr	4.3	43	429	115
		CTE	15 d/yr	126	1,261	12,610	468

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment), Using Assumptions in HHRA

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Bank fishing *See Att. 4*	Older child	RME	30 d/yr	6.2	62	619	42
		CTE	10 d/yr	52	524	5,237	180
	Adult	RME	30 d/yr	2.6	26	256	56
		CTE	10 d/yr	70	702	7,015	220
Dirt biking/ATVing *See Att. 5*	Older child	RME	90 d/yr	2.0	20	205	14
		CTE	30 d/yr	29	290	2,901	99
Marathon canoeist *See Att. 6*	Adult	RME	150 d/yr	0.78	7.8	78	13
		CTE	90 d/yr	5.8	58	575	25
Recreational canoeist *See Att. 7*	Older child	RME	30 d/yr	6.2	62	619	42
		CTE	15 d/yr	35	349	3,491	120
	Adult	RME	60 d/yr	1.2	12	121	28
		CTE	30 d/yr	13	129	1,286	73

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment), Using Assumptions in HHRA

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Waterfowl hunting *See Att. 8*	Older child	RME	14 d/yr	41	408	4080	140
		CTE	7 d/yr	233	2325	23,253	399
	Adult	RME	14 d/yr	9.0	90	904	196
		CTE	7 d/yr	75	752	7,518	537
Agricultural use (based on direct contact by farmer) *See Att. 9*	Adult	RME	40 d/yr	1.2	12	118	43
		CTE	10 d/yr	42	419	4,195	348
High-use commercial (groundskeeper scenario) *See Att. 10*	Adult	RME	150 d/yr	1.8	18	177	25
		CTE	150 d/yr	17	166	1,664	57
Low-use commercial (groundskeeper scenario) *See Att. 11*	Adult	RME	30 d/yr	8.9	89	885	126
		CTE	15 d/yr	166	1,664	16,642	571

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment), Using Assumptions in HHRA

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Utility worker *See Att. 12*	Adult	RME	5 d/yr	17	169	1,694	242
		CTE	5 d/yr	209	2,093	20,933	718
Sediments *See Att. 13*	Older child	RME	36 d/yr	4.5	45	453	31
		CTE	12 d/yr	36	365	3,645	125
	Adult	RME	36 d/yr	1.3	13	135	40
		CTE	12 d/yr	28	280	2,800	152

2.2 RMCs for Fish and Waterfowl Tissue Based on Human Consumption

Numerical concentration-based RMCs have been developed for PCBs and TEQs in the edible tissue of fish and waterfowl based on human consumption of fish and waterfowl. Such RMCs have been derived using both deterministic and probabilistic approaches.

2.2.1 Methodology

RMCs have been calculated for both PCBs and TEQs that may be present in bass fillets, trout fillets, and duck breast tissue.[6] For each tissue type, separate RMCs have been developed based on the assumptions and parameters used in EPA's deterministic Fish and Waterfowl Consumption Assessment (HHRA, Vol. IV). In addition, RMCs based on probabilistic techniques have been developed using the one-dimensional Monte Carlo (1-D Monte Carlo) model used in the HHRA.

For each type of edible tissue, RMCs have been derived for cancer risks based on combined adult and childhood exposure. This is the same approach that was used in the HHRA. As for the direct contact RMCs, three risk levels within EPA's target risk range (10^{-6}, 10^{-5}, and 10^{-4}) have been used to derive a range of RMCs for the carcinogenic endpoint for both PCBs and TEQs. In addition, non-cancer RMCs for PCBs have been separately derived for adults and children using an HI of 1. Consistent with the HHRA, non-cancer RMCs were not developed for TEQs, since TEQs were not quantitatively assessed for non-cancer impacts in the HHRA.

RMCs have been developed for six fish and waterfowl consumption scenarios (with adults and children considered in each). These scenarios are as follows:

- RMCs for PCBs based on consumption of bass;
- RMCs for PCBs based on consumption of trout;
- RMCs for PCBs based on consumption of waterfowl;

[6] Although data are also available on the concentrations of these contaminants in duck livers, the HHRA based its risk analysis on the consumption of duck breast tissue (HHRA, Vol. I, p. 8-12); Vol. IV, p. 7-15). It also noted that while the concentrations in duck livers are slightly higher than those in duck breasts, the risks from consumption of duck livers would be considerably lower due to a lower consumption rate (HHRA, Vol. IV, pp. 7-15 - 7-17). Thus, RMCs have not been calculated for duck livers.

- RMCs for TEQs based on consumption of bass;
- RMCs for TEQs based on consumption of trout; and
- RMCs for TEQs based on consumption of waterfowl.

The scenario- and age-specific point estimate and probabilistic assumptions and parameters used are detailed in Attachments 14 through 19 (contained in Appendix C). While Table 6-2 of the HHRA (HHRA, Vol. IV, p. 6-15) only provides an input distribution for adult fish consumers for use in the probabilistic analysis, the text (HHRA, Vol. IV, p. 6-25) reports that EPA assumed that children ate fish at half the rate of adults. Thus, a distribution based on one-half the adult consumption rate distribution was developed and used in the 1-D Monte Carlo for young children.

The CSFs and RfD used in developing the RMCs for PCBs are the same as those used in developing the direct contact RMCs, as described in Section 2.1.1, which are identical to those used in the HHRA. There is currently no CSF or RfD published in EPA's IRIS database for 2,3,7,8-TCDD, upon which the TEQ approach is based. The cancer potency of this chemical is being evaluated as part of the Dioxin Reassessment being conducted by EPA and is currently under review by the National Academy of Sciences (NAS). Thus, as was done in the HHRA, the EPA's previously published CSF of 150,000 $(mg/kg\text{-}day)^{-1}$ (EPA, 1997b) was used to calculate the cancer-based RMCs for TEQs in this analysis. Due to the lack of an RfD for 2,3,7,8-TCDD, non-cancer-based RMCs have not been developed for TEQs.

Three target risk levels were used to derive a range of RMCs based on potential carcinogenic effects. These risk levels were 10^{-6}, 10^{-5}, and 10^{-4}, consistent with EPA's target risk range. As for the direct contact pathways, a target HI of 1 was used to calculate the RMCs based on potential non-carcinogenic effects.

The deterministic and probabilistic RMCs for fish and waterfowl tissue based on potential for carcinogenic effects were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * ABS_o * CF * (1 - LOSS) * \left[\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right]}$$

The deterministic and probabilistic RMCs for fish and waterfowl tissue based on potential for non-cancer effects were derived using the following general equation:

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * CF * (1 - LOSS) * \left[\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right]}$$

Where:

RMC_{cancer}	=	RMC for the cancer endpoint at a target risk level (mg/kg)
RMC_{nc}	=	RMC for the non-cancer endpoint at a target HI (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic effects (days)
AT_{nc}	=	Averaging time for noncarcinogenic effects (days)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
EF	=	Exposure frequency (days/year)
FI	=	Fraction ingested from the river (unitless)
ABS_o	=	Oral absorption factor (unitless)
CF	=	Unit conversion factor (1E-03 kg/g)
LOSS	=	Fraction of constituent lost due to cooking (unitless)
IR_a	=	Fish/waterfowl ingestion rate for adults (g/day)
IR_c	=	Fish/waterfowl ingestion rate for children (g/day)
ED_a	=	Exposure duration for adults (years)
ED_c	=	Exposure duration for children (years)
BW_a	=	Body weight for adults (kg)
BW_c	=	Body weight for children (kg)

It should be noted that the approach used for deriving RMCs for waterfowl consumption based on the probabilistic analysis was slightly different from that used in the deterministic analysis

and shown in the above equation, but was the same as the approach used in the HHRA. Instead of providing ingestion rates (IR) in units of g/day and exposure frequency (EF) in units of days/year, EPA used an EF in units of meals/year and an IR of grams/meal (HHRA, Vol. IV, p. 6-58). Thus, while the product of these two factors still resulted in units of g/year (as it does in the above equation), the inputs were slightly different. These inputs are summarized in Attachments 16 and 19 (in Appendix C).

2.2.2 Proposed RMCs

The proposed numerical RMCs for PCBs and TEQ in edible fish and waterfowl tissue, based on consumption by humans, are set forth in Table 2-2. Supporting calculations for each scenario are provided in Attachments 14 through 19 (in Appendix C) and are referenced in Table 2-2. The RMCs presented for the probabilistic analyses represent, for the RME, the 5th percentile of the output distribution (which would be exceeded by 95 percent of the calculated output values) and, for the CTE, the 50th percentile of the output distribution.

GE also proposes the following narrative IMPG for fish and waterfowl consumption:

> ***To reduce the average PCB and TEQ concentrations in the edible portion of fish and waterfowl in the Rest of River as necessary so that they do not present significant risks of harm to the health of individuals who consume such fish and waterfowl, taking into account the actual and reasonably foreseeable frequency of their consumption of such fish and waterfowl from the Rest of River.***

Table 2-2. RMCs for Fish & Waterfowl Tissue Based on Human Consumption, Using Assumptions in HHRA

Tissue Type and Constituent	Assessment Type	RME or CTE	RMCs (in mg/kg for PCBs and ng/kg for TEQ)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer – Child	Non-Cancer – Adult
Bass fillets – PCBs *See Att. 14*	Deterministic	RME	0.0019	0.019	0.19	0.026	0.062
		CTE	0.049	0.49	4.9	0.19	0.43
	Probabilistic	RME (5^{th} percentile)	0.0026	0.026	0.26	0.040	0.047
		CTE (50^{th} percentile)	0.031	0.31	3.1	0.49	0.53
Trout fillets – PCBs *See Att. 15*	Deterministic	RME	0.0048	0.048	0.48	0.069	0.16
		CTE	0.11	1.1	11	0.40	0.93
	Probabilistic	RME (5^{th} percentile)	0.0070	0.070	0.70	0.11	0.14
		CTE (50^{th} percentile)	0.067	0.67	6.7	1.0	1.1

Table 2-2. RMCs for Fish & Waterfowl Tissue Based on Human Consumption, Using Assumptions in HHRA

Tissue Type and Constituent	Assessment Type	RME or CTE	RMCs (in mg/kg for PCBs and ng/kg for TEQ)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer – Child	Non-Cancer – Adult
Duck breast – PCBs *See Att. 16*	Deterministic	RME	0.0084	0.084	0.84	0.12	0.28
		CTE	0.066	0.66	6.6	0.25	0.58
	Probabilistic	RME (5th percentile)	0.0075	0.075	0.75	0.12	0.12
		CTE (50th percentile)	0.072	0.72	7.2	1.2	0.87
Bass fillets – TEQ *See Att. 17*	Deterministic	RME	0.025	0.25	2.5	NA	
		CTE	0.32	3.2	32	NA	
	Probabilistic	RME (5th percentile)	0.034	0.34	3.4	NA	
		CTE (50th percentile)	0.42	4.2	42	NA	

Table 2-2. RMCs for Fish & Waterfowl Tissue Based on Human Consumption, Using Assumptions in HHRA

Tissue Type and Constituent	Assessment Type	RME or CTE	RMCs (in mg/kg for PCBs and ng/kg for TEQ)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer – Child	Non-Cancer – Adult
Trout fillets – TEQ *See Att. 18*	Deterministic	RME	0.065	0.65	6.5	NA	
		CTE	0.70	7.0	70	NA	
	Probabilistic	RME (5th percentile)	0.094	0.94	9.4	NA	
		CTE (50th percentile)	0.90	9.0	90	NA	
Duck breast – TEQ *See Att. 19*	Deterministic	RME	0.11	1.1	11	NA	
		CTE	0.44	4.4	44	NA	
	Probabilistic	RME (5th percentile)	0.10	1.0	10	NA	
		CTE (50th percentile)	0.96	9.6	96	NA	

2.3 RMCs for PCBs in Agricultural Products Based on Human Consumption

In accordance with the Reissued RCRA Permit, numerical concentration-based RMCs have been developed for agricultural biota consumed by humans. These RMCs are based on human consumption of such products.

2.3.1 Methodology

RMCs have been derived through backcalculations using the exposure assumptions and toxicity values in the Agricultural Products Consumption Assessment in the HHRA. Consistent with that assessment, RMCs have been calculated for PCBs in cow milk, beef cow tissue, poultry meat, and poultry eggs for both commercial and backyard farms.[7] For each type of farm, RMCs have been calculated for cancer risks (for adults and children combined, as in the HHRA) at three levels within EPA's risk range (10^{-6}, 10^{-5}, and 10^{-4}), and for non-cancer impacts (for adults and children separately), using a Hazard Index of 1. In addition, RMCs have been calculated for homegrown produce consumed by humans – specifically, exposed fruit, exposed vegetables, and root vegetables. For these specific farm products, based on discussions with EPA, RMCs have been calculated for children only and have been based on non-cancer health effects.

RMCs have been developed for the following agricultural products consumption scenarios:

- Consumption of cow milk at commercial dairy farm (adults and children)
- Consumption of cow milk at backyard dairy farm (adults and children)
- Consumption of beef at commercial beef farm (adults and children)
- Consumption of beef at backyard beef farm (adults and children)
- Consumption of poultry meat at commercial poultry farm (adults and children)
- Consumption of poultry meat at backyard poultry farm (adults and children)
- Consumption of poultry eggs at commercial poultry farm (adults and children)

[7] As noted in Section 1, RMCs have not been calculated for TEQs in agricultural products because EPA's Agricultural Products Consumption Assessment in the HHRA discussed TEQs only in its uncertainty analysis and did not include them in the main risk assessment.

- Consumption of poultry eggs at backyard poultry farm (adults and children); and
- Consumption of homegrown produce (exposed fruit, exposed vegetables, and root vegetables) at both commercial and backyard produce farms (children only).

The specific exposure parameters and assumptions used in calculating the RMCs for these scenarios are presented in Attachments 20 through 28 (contained in Appendix D). The values used for these parameters are the same as the values used to develop the potential cancer risk and non-cancer hazard estimates for the agricultural products consumption pathways in the HHRA. For the animal products, the exposure assumptions differ slightly between commercial and backyard farms. For the agricultural produce, however, the exposure assumptions for a child do not differ between commercial and backyard farms, and thus the calculated RMCs apply to both types of farms.

The CSFs and RfD used in developing these RMCs are the same as those used in developing the direct contact RMCs, as described in Section 2.1.1, which are the same as those used in the HHRA and published in EPA's IRIS database.

As with the RMCs discussed in previous sections, three target risk levels were used to derive a range of RMCs based on potential carcinogenic effects – 10^{-6}, 10^{-5}, and 10^{-4}, consistent with EPA's target risk range – and a target HI of 1 was used to calculate the RMCs based on potential non-carcinogenic effects.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting agricultural food products were derived using the following equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * FI * ABS_o * EF}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$

IR_{adj}	=	Age-adjusted ingestion rate (kg-year/kg-day) [8]
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting agricultural food products were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * FI * ABS_o * EF * ED}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)
FI	=	Fraction ingested that is attributable to the Site (unitless)
ABS_o	=	Relative oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)

The above equations were used to calculate cancer-based and non-cancer-based RMCs based on exposure to the animal food products – i.e., cow milk, beef cow tissue, poultry meat, and poultry eggs.

For the agricultural produce, as noted above, RMCs have been calculated based only on non-cancer impacts to children. Hence, only the non-cancer equation shown above was used. For such produce, the HHRA calculated risks and HIs separately for exposed fruit, exposed vegetables, and root vegetables and then summed them to produce risks and HIs for total produce (HHRA, Vol. V, Table 4-10). In backcalculating RMCs for these products, separate RMCs have first been calculated for each type of produce, using the above non-cancer equation

[8] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

and a target HI of 1. Such RMCs would be applicable to situations where the child eats only one type of produce grown in the floodplain, which is likely, for example, at a commercial farm that grows only one of those produce types. By contrast, it is unlikely that a child would eat all three types of produce grown in the floodplain at the rates assumed in the HHRA for each produce type, particularly at the upper bound rates used in the RME analysis. However, to take account of the unlikely event that a child may do so, RMCs have also been calculated for total produce (i.e., all three food groups combined) using the following equation:

$$RMC(Total)_{noncancer} = \frac{HI}{((Exp_{ing\_exposedfruit} \div RfD) + (Exp_{ing\_exposedvegetable} \div RfD) + (Exp_{ing\_rootvegetable} \div RfD))}$$

Where:

$RMC(Total)_{noncancer}$ = RMC (total produce) based on non-cancer endpoint (mg/kg)

HI = Target hazard index (unitless)

RfD = Reference dose (mg/kg-day)

Exp_{ing} = Exposure due to produce consumption (kg/kg-day)

And

$$Exp_{ing} = \frac{IR * AF * FI * ABS_o * EF * ED}{AT}$$

Where:

IR	=	Produce-specific ingestion rate (kg/kg-day)
AF	=	Regional consumption adjustment factor (unitless)
FI	=	Fraction ingested that is attributable to the Site (unitless)
ABS	=	Relative oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)

As noted above, since the exposure assumptions for a child consuming agricultural produce do not differ between commercial and backyard farms, the calculated RMCs apply to both commercial and backyard farms.

2.3.2 Proposed RMCs

The proposed numerical RMCs for PCBs in edible farm animal and plant tissue based on consumption by humans are set forth in Table 2-3. For animal tissues, consideration of both cancer and non-cancer endpoints was used to derive the RMCs, resulting in three cancer-based RMCs and two non-cancer-based RMCs in children and adults for the RME scenario and the same for the CTE scenario. For exposures due to consumption of plant tissues (exposed fruits, exposed vegetables, and root vegetables), RMCs were calculated based on potential non-cancer effects in children, and separate RMCs are provided for each produce type and for total produce. Supporting calculations for all the RMCs are provided in Attachments 20 through 28 (in Appendix D), which are referenced in Table 2-3.

In addition to the numerical RMCs provided in Table 2-3, GE proposes the following narrative RMC for agricultural products consumption:

> ***To reduce the average PCB concentrations in the edible tissue of cows (milk and meat), chickens (meat and eggs), and fruits and vegetables on farms in the Rest of River as necessary so that they do not present significant risks of harm to the health of farmers and residents (with backyard farms) who consume such animal products, taking into account the frequency of their consumption of such products from the Rest of River.***

Table 2-3. RMCs for PCBs for Agricultural Products Based on Human Consumption, Using Assumptions in HHRA

Tissue Type	Farm Type	RME or CTE	IMPGs (in mg/kg)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer Child	Non-Cancer Adult
Cow milk *See Atts. 20 & 21*	Commercial dairy	RME	0.000026	0.00026	0.0026	0.0003	0.0014
		CTE	0.00012	0.0012	0.012	0.00047	0.0017
	Backyard dairy	RME	0.00003	0.0003	0.003	0.0003	0.001
		CTE	0.00017	0.0017	0.017	0.00047	0.0012
Beef cow tissue *See Atts. 22 & 23*	Commercial beef	RME	0.00018	0.0018	0.018	0.0043	0.0079
		CTE	0.00083	0.0083	0.083	0.0056	0.0092
	Backyard beef	RME	0.00026	0.0026	0.026	0.0043	0.0073
		CTE	0.0015	0.015	0.15	0.0056	0.0074
Poultry meat *See Atts. 24 & 25*	Commercial poultry	RME	0.00024	0.0024	0.024	0.0072	0.01
		CTE	0.0014	0.014	0.14	0.0089	0.016
	Backyard poultry	RME	0.00043	0.0043	0.043	0.0072	0.012
		CTE	0.0025	0.025	0.25	0.0089	0.013

Table 2-3. RMCs for PCBs for Agricultural Products Based on Human Consumption, Using Assumptions in HHRA

Tissue Type	Farm Type	RME or CTE	IMPGs (in mg/kg)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer Child	Non-Cancer Adult
Poultry eggs *See Atts. 26 & 27*	Commercial poultry	RME	0.00055	0.0055	0.055	0.011	0.025
		CTE	0.0025	0.025	0.25	0.013	0.031
	Backyard poultry	RME	0.00082	0.0082	0.082	0.011	0.025
		CTE	0.0044	0.044	0.44	0.013	0.026
Exposed fruit *See Att. 28*	Commercial or backyard fruit farm	RME	Not calculated (NC)			0.11	NC
		CTE	NC			0.12	NC
Exposed vegetables *See Att. 28*	Commercial or backyard farm with exposed vegetables	RME	NC			0.024	NC
		CTE	NC			0.031	NC
Root vegetables *See Att. 28*	Commercial or backyard farm with root vegetables	RME	NC			0.03	NC
		CTE	NC			0.041	NC

Table 2-3. RMCs for PCBs for Agricultural Products Based on Human Consumption, Using Assumptions in HHRA

Tissue Type	Farm Type	RME or CTE	IMPGs (in mg/kg)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer Child	Non-Cancer Adult
All produce *See Att. 28*	Commercial or backyard farm with all three types of above produce	RME	NC			0.012	NC
		CTE	NC			0.015	NC

2.4 RMCs Based on Ecological Receptors

This Section 2.4 presents RMCs for each ecological receptor for which the ERA found significant risks – namely, benthic invertebrates, frogs, shrews, fish, mink and otter, ospreys, bald eagles, and wood ducks. In each case, the discussions in this section present: (1) a narrative descriptive goal for the receptor group; (2) the basis for the ERA's determination of threshold levels (including the MATC, if any); and (3) proposed numerical concentration-based RMCs. These proposed RMCs are based on the ERA, although in many cases they do not simply adopt the MATC specified in the ERA, but rather set forth a range of RMCs reflecting various other thresholds from the studies used in the ERA. For receptor groups for which the ERA did not generate MATCs (i.e., ospreys and wood ducks), RMCs were calculated by solving the ERA's exposure equations for the concentration terms, yielding the prey concentrations that result in doses equal to the ranges of effects metrics identified in the ERA.

2.4.1 Proposed RMCs for Sediments Based on Risks to Benthic Invertebrates

The narrative IMPG for the protection of benthic invertebrates is:

> ***To reduce the PCB concentrations in sediments as necessary so that they do not prevent the presence of diverse and abundant communities of benthic invertebrates in the Rest of River, consistent with habitat limitations.***

Numerical RMCs have been developed for PCBs in sediments based on potential risks to benthic invertebrates. No RMCs are proposed for TEQs since the ERA did not assess TEQ risks to benthic invertebrates.

In assessing risks to benthic invertebrates in the Rest of River, the ERA relied on site-specific toxicity tests and a site-specific benthic community study, all conducted by EPA contractors, as the primary basis for developing threshold effect concentrations for PCBs in sediments (ERA, Vol. 4, pp. D-59 - D-63, D-94 - D-96). Based on those data, the ERA identified a variety of effect thresholds for different test species and/or endpoints and including both concentrations associated with 20% effects (EC20s) and those associated with 50% effects (EC50s) – as well as, in some cases, no observed effect levels (NOELs) and lowest observed effect levels (LOELs). The ERA then evaluated those thresholds to select particular threshold levels for each set of studies and ultimately a MATC for sediment, as discussed below.

The ERA identified a number of sediment effects thresholds from the chronic toxicity tests that evaluated growth, emergence, survival, and reproduction of *Chironomus tentans* (midge) and *Hyalella azteca* (amphipod). These thresholds were based on comparison of the results from test stations within the Primary Study Area (PSA) of the Rest of River (from the confluence of the East and West Branches to Woods Pond Dam) to test stations in two reference areas (located on the East Branch of the River upstream of the GE facility and on the West Branch of the River, respectively). These thresholds are summarized in Table 2-4, using: (a) the "most synoptic" sediment data, which were collected concurrent with the toxicity tests; (b) for endpoints measured multiple times, data from the longest exposure period; (c) for similar endpoints, the most sensitive; and (d) where different, the mean of comparisons to the two reference areas.

Table 2-4. Summary of Effects Thresholds from the Site-Specific Benthic Invertebrate Toxicity Tests

Endpoint	Sediment PCB Conc. (mg/kg)			
	NOEL	**LOEL**	**EC20 (by probit)**	**EC50 (by probit)**
Chironomus – 20-day ash-free dry weight	NC	NC	2.0	4.7
Chironomus – 20-day survival	< 8.7	8.7	< 8.7	< 8.7
Chironomus – 43-day emergence	< 8.7	8.7	< 8.7	< 8.7
Hyalella – 42-day dry weight	72	> 72	66.3 (NC)	> 72
Hyalella – 42-day survival	≤ 8.7	20	3.1	22.8
Hyalella – 42-day total young	≤ 8.7	20	3.9	11.1

Summarized from ERA, Vol. 4, Tables D.3-7 and D.3-8, using: (a) the "most synoptic" sediment data; (b) endpoints from the longest exposure period when endpoints were measured multiple times, (c) the more sensitive endpoint when similar endpoints were measured; and (d) where relevant, the mean of comparisons to the two reference areas.

The ERA used the lowest EC20 and EC50 values from Table 2-4 (i.e., 2 and 4.7 mg/kg, respectively) to represent the "intermediate risk" and "high risk" thresholds from the chronic toxicity tests (ERA, Vol. 1, p. 3-41; Vol. 4, p. D-62). Although no NOEL or LOEL was calculated for *Chironomus* 20-day ash-free dry weight (which was the basis for these risk thresholds), the NOEL and LOEL for *Chironomus* 20-day dry weight (a similar measure) were < 72 mg/kg and

72 mg/kg, respectively (ERA, Vol. 4, Table D.3-8), substantially higher than the calculated EC20 and EC50 values, suggesting that *Chironomus* growth is not impaired by PCB exposure at the EC20 and EC50 values used in the ERA.

To evaluate the potential effects of PCBs in the benthic community study, the EPA employed three types of analyses: (1) comparison of benthic community parameters measured at the study sites and reference sites; (2) analysis of the relationship between PCB concentrations in sediments and benthic community parameters to determine if there was an exposure-response relationship; and (3) application of the species sensitivity distribution (SSD) (ERA, Vol. 4, pp. D-74). Potential effects of PCBs were evaluated separately for sites with coarse- and fine-grained sediment. A variety of effects thresholds were identified based on comparisons between study sites and reference sites and the SSD. Three different diversity indices were used. The thresholds identified in the ERA are summarized in Table 2-5:

Table 2-5. Summary of Effects Thresholds from the Site-Specific Benthic Invertebrate Community Study

Endpoint	Sediment PCB Conc. (mg/kg)	
	EC20	EC50
Coarse Sediments		
Species sensitivity distribution	2.3	4.1
Taxa richness	13.4	141
Total abundance	5.8	37.3
Diversity indices: -- Shannon Wiener H' -- Simpson's Index -- Modified Simpson's Index	 4.7 70.3 23.5	Outside range of measured PCBs
Fine Sediments		
Species sensitivity distribution	6.4	No effect
Taxa richness	> 14.1	No effect
Total abundance	> 14.1	No effect
Diversity indices: -- Shannon Wiener H' -- Simpson's Index -- Modified Simpson's Index	 (58.7) (275) 22.8	Outside range of measured PCBs

Summarized from ERA, Vol. 4, pp. D-80, D-81, D-91; Attachment D-8, Table 3. EC20 values in parentheses exceed the maximum replicate PCB concentration and therefore represent extrapolations outside the range of regression.

The ERA used the geometric mean of the five lowest EC20 values (2.3, 6.4, 13.4, 5.8, and 4.7 mg/kg), which is 5.6 mg/kg, as the "intermediate risk" threshold; and it used the geometric mean of the three EC50 values (4.1, 141.5, and 37.3 mg/kg), which is 27.9 mg/kg, as the "high risk" threshold (ERA, Vol. 1, p. 3-57; Vol. 4, p. D-96) (ERA, Vol. 1, p. 3-41; Vol. 4, p. D-62). In generating these thresholds, the ERA incorporated neither the unbounded no effects concentrations (i.e., EC50s for SSD, taxa richness, and total abundance in fine sediments) nor effects concentrations that were outside the range of measured PCBs (i.e., EC50s for diversity indices for coarse and fine sediments).

The ERA then combined the "intermediate risk" thresholds from the toxicity tests (2 mg/kg) and the benthic community data (5.6 mg/kg) to establish a MATC of 3 mg/kg for PCBs in sediments to protect benthic invertebrates (ERA, Vol. 1, p. 3-59; Vol. 4, p. D-99).

Given the wide range of effects concentrations reported in the ERA, GE proposes a range of sediment RMCs for benthic invertebrates based on the ERA. Specifically, GE proposes a range of RMCs from 2 mg/kg to over 100 mg/kg, which encompasses the various threshold values presented in Tables 2-4 and 2-5. In evaluating the sediment concentrations within that RMC range, GE believes that the results from the benthic community study are more directly relevant to the overall goal of maintaining the presence of diverse and abundant communities of benthic invertebrates in the Rest of River.

2.4.2 Proposed RMCs for Vernal Pool and Backwater Sediments Based on Risks to Frogs

The narrative IMPG for the protection of amphibians is:

> ***To reduce the PCB concentrations in the sediments of vernal pools and backwaters in the Rest of River as necessary so that they do not prevent those areas from supporting a sustainable reproducing population of amphibians.***

Numerical RMCs have been developed for PCBs in vernal pool and backwater sediments based on potential risks to amphibians. No RMCs are proposed for TEQs since the ERA did not assess TEQ risks to amphibians.

The ERA relied on data from EPA's site-specific wood frog study (FEL, 2002) to determine effects thresholds for PCBs in sediment for protection of amphibians (ERA, Vol. 5, pp. E-142 - E-145). This study involved three phases and evaluated a wide range of endpoints related to survival, development, and maturation of wood frog egg masses, larvae, and metamorphs. In Phase 1, egg masses were collected from Housatonic River vernal pools and three reference pools and were exposed in the laboratory to various treatments, including water and sediment from their natal pools; and egg mass viability as well as larval growth, development, and metamorphosis were evaluated. In Phases II and III, larvae and metamorphs (respectively) were collected from the same pools and evaluated for growth, development, metamorphosis, malformations/abnormalities, and (in Phase III) sex ratio. In all three phases, most of the endpoints evaluated showed no effects of PCB exposure. The ERA identified thresholds for

those endpoints that did show significant effects in the study, as summarized in Table 2-6. Such thresholds were calculated based both on average measured PCB concentrations in the pond sediments and on spatially weighted mean exposure concentrations (calculated in the ERA in an effort to take account of variability in PCB levels in the ponds).

Table 2-6. Summary of EC20 and EC50s from EPA's site-specific wood frog study

Endpoint	Sediment PCB Conc. (mg/kg)			
	EC20		EC50	
	Avg.	S.W. mean	Avg.	S.W. mean
Phase I larval malformations	> 62	> 32.3	> 62	> 32.3
Phase III metamorph abnormalities	3.61	3.27	59.3	38.6
Phase III skewed sex ratio	0.52	0.61	10.9	9.54

Summarized from ERA, Vol. 5, Table E.4-1 (Avg. = values calculated from averages of 2 measured PCB concentrations; S.W. mean = values calculated from spatially weighted mean PCB concentrations).

The ERA concluded that the EC20 for sex ratio was not biologically relevant (ERA, Vol. 1, p. 4-53; Vol. 5, pp. E-116, E-142) and therefore established the next lowest effect level, 3.27 mg/kg (using the spatially weighted means), as the MATC for vernal pool sediments (ERA, Vol. 1, p. 4-53; Vol. 5, p. E-144).

Based on the ERA and considering the available data, GE proposes a range of sediment RMCs for protection of amphibians. In determining that range, the EC20 value for sex ratio was excluded due to the lack of biological relevance. However, the proposed range encompasses the remaining thresholds listed in Table 2-6, which range from 3.27 to 38.6 mg/kg using the spatially weighted PCB concentrations, and from 3.61 to > 62 mg/kg using the average measured PCB concentrations. The upper end of the range is supported by the absence of PCB-related effects on survival, growth, or metamorphosis of wood frogs (ERA, Vol. 1, p. 4-46, Table 4.4-5; Vol. 5, E-84 to E-86), as well as by the absence of an effect of the malformations on the net output of abnormality-free metamorphs (BBL et al., 2003a,b).

2.4.3 Proposed RMCs for Floodplain Soil Based on Risks to Northern Short-Tailed Shrews

The narrative IMPG for the protection of northern short-tailed shrews (*Blarina brevicauda*) is:

> ***To reduce the PCB concentrations in floodplain soils as necessary so that they do not prevent the presence of an abundant and sustainable population of shrews in the Rest of River floodplain, to the extent that such a population can be supported by available habitat.***

Numerical RMCs have been developed for PCBs in floodplain soil based on potential risks to the short-tailed shrew. Similar RMCs have not been developed for TEQs, because the ERA predicted no appreciable risks to the short-tailed shrew from TEQs (ERA, Vol. 2, pp. 10-42).

The ERA based its PCB MATC on survival data from the site-specific population demography study of short-tailed shrews conducted by Boonstra and Bowman (2003) (ERA, Vol. 2 p. 10-43; Vol. 6, p. J-82). That study reported no effects of PCBs on any endpoint measured (i.e., density, survival, sex ratio, reproduction rates, growth, and body weight) at floodplain soil concentrations up to a spatially weighted average concentration of 43.5 mg/kg PCBs (Boonstra and Bowman, 2003). However, a supplemental analysis by EPA found a statistically significant negative relationship between PCB concentrations in the soil and shrew survival (ERA, Vol. 6, pp. J-54 to J-55). In addition, the ERA presented a hockey stick regression of the arithmetic mean soil data versus combined male and female survival data from the Boonstra and Bowman study (Figure J.4-9). Based on the hockey stick regression, the ERA established a MATC of 21.1 mg/kg for floodplain soil in short-tailed shrew habitat (ERA, Vol. 2, p. 10-43; Vol. 6, p. J-82). The ERA acknowledged, however, that its supplemental analysis may have been influenced by habitat differences among grids, small sample sizes, effects of flooding, the analytical methods used, and the relatively small number of treatments (ERA, Vol. 6, p. J-55). The ERA also noted that if the same hockey stick regression analysis is conducted on the spatially weighted average soil data (rather than the arithmetic mean data), the results are only borderline significant (p=0.051) (EPA, 2005b, p. 62). In any event, the ERA did not disagree with the study's finding of no effects on any of the other endpoints measured.

Based on the ERA and these data, GE proposes a range of RMCs for PCBs in floodplain soil to address potential risks to short-tailed shrews. This range extends from 21.1 mg/kg (EPA's

MATC) to > 43.5 mg/kg, the highest estimated floodplain soil PCB concentration (spatially weighted) in the site-specific shrew population demography study. As noted above, the effects on survival calculated in the ERA from this study are subject to several qualifications, and the value of 43.5 mg/kg is the no observed adverse effect level (NOAEL) for all of the other measured endpoints, which showed no statistically significant effects. The lack of such effects is consistent with EPA's small mammal surveys, which found that short-tailed shrews were the most abundant small mammal captured in the floodplain (ERA,Vol. 6, p. J-58), and with Boonstra and Bowman's conclusion that the short-tailed shrew densities observed in their study are the highest ever reported (Boonstra and Bowman, 2003).

2.4.4 Proposed RMCs for Fish Tissue Based on Risks to Fish

The narrative IMPG for the protection of fish is:

> ***To reduce PCB and TEQ concentrations in fish as necessary so that they do not prevent the presence of healthy and self-sustaining populations of fish in the Rest of River, to the extent that such a population can be supported by available habitat.***

Numerical RMCs have been developed for PCBs and TEQs in fish tissue (whole body) based on risks to fish. Although the ERA found that both PCBs and TEQs present risks to fish at the same magnitude and certainty, RMCs have also been developed for TEQs because the ERA established MATCs for both PCBs and TEQs.

In developing site-specific effect thresholds for PCBs and TEQs in fish, the ERA relied primarily on a two-phase site-specific study that evaluated the reproductive toxicity of PCBs, TEQs and other compounds to fish. Phase I of the study quantified PCB and TEQ concentrations in Housatonic River adult largemouth bass and evaluated effects in their offspring (i.e., survival, developmental parameters, and cytochrome P450 induction) (Tillitt et al., 2003a). Phase II of the study was designed to test whether PCBs and TEQs were causally linked to the endpoints evaluated in Phase I (Tillitt et al., 2003b). In Phase II, extracts from Housatonic River fish, as well as other chemical standards (2,3,7,8-TCDD and 3,3',4,4',5-pentachlorobiphenyl (PCB 126)) and negative controls, were injected into eggs from non-native largemouth bass, medaka and rainbow trout. The treated eggs and the fry that hatched from them were reared in the laboratory and monitored for the same endpoints evaluated in Phase I.

For Phase I of EPA's fish toxicity study, the ERA reported a PCB effect threshold (in the range of 10% to 30% effects) of 45 mg/kg wet weight (ww) PCBs or 38 ng/kg ww TEQs for largemouth bass (ERA, Vol. 1, p. 5-25; Vol. 5, p. F-55). For Phase II, the ERA identified a variety of egg-based effect levels (ED50 concentrations in eggs) for the three species, depending on the river location from which the extract was taken, the life stage at which the effect was seen, and the particular trial (ERA, Vol. 5, Table F.3-10). The ERA used the average of these effect thresholds, 131 mg/kg ww PCB and 100 ng/kg ww TEQ, as the egg-based effect thresholds for Phase II (for warmwater species and rainbow trout combined) (ERA, Vol. 1, p. 5-34; Vol. 5, pp. F-60, F-63). The ERA then converted these egg concentrations to estimated adult whole-body tissue concentrations by multiplying them by a factor of 0.5, yielding tissue-based thresholds of 66 mg/kg ww PCB and 50 ng/kg ww TEQ (ERA, Vol. 1, p. 5-34; Vol. 5, p. F-63). Finally, the ERA combined the Phase I threshold of 45 mg/kg ww PCB or 38 ng/kg ww TEQ and the estimated Phase II threshold of 66 mg/kg ww PCB or 50 ng/kg ww TEQ to establish MATCs of 55 mg/kg ww PCB and 44 ng/kg ww TEQ for all species in the PSA, (ERA, Vol. 1, pp. 5-44 to 5-45; Vol. 5, pp. F-64, F-97).

For fish downstream of the PSA, the ERA established MATCs only for PCBs. For warmwater fish, the ERA adopted the above PCB MATC of 55 mg/kg; and for coldwater fish, the ERA established a PCB MATC of 14 mg/kg by dividing the warmwater MATC by 4 (ERA, Vol. 1, pp.5-58, 5-63; Vol. 5, pp. F-98, F-99).

The ERA also recognized that field surveys conducted of fish in the PSA, including a fish abundance/biomass assessment conducted for EPA (Woodlot, 2002) and a largemouth bass population and reproduction study conducted for GE (R2, 2002; Reiser et al., 2004), showed no evidence of adverse population-level effects on the local populations of fish (ERA, Vol. 1, p. 5-64; Vol. 5, pp. F-96, F-106).

Based on the above-referenced data and EPA's interpretation of those data, GE proposes a range of RMCs for protection of fish. For fish in the PSA, the proposed range encompasses the ERA's threshold effect concentrations for largemouth bass in Phase I of the study, 45 mg/kg ww PCB and 38 ng/kg ww TEQ, and the ED50 values from Phase II. Based on review of the data from Phase II (ERA, Vol. 5, Table F.3-10), the ED50 values for largemouth bass eggs were 185 mg/kg ww PCB and 118 ng/kg ww TEQ, and the means of the ED50 values for medaka and rainbow trout eggs were 144 and 86 mg/kg ww PCB and 114 and 62 ng/kg ww TEQ, respectively. When EPA's egg-to-whole body conversion factor is applied to those

concentrations, the resulting tissue concentrations are 92 mg/kg ww PCB and 59 ng/kg ww TEQ for largemouth bass, 72 mg/kg ww PCB and 57 ng/kg ww TEQ for medaka, and 43 mg/kg ww PCB and 31 ng/kg ww TEQ for rainbow trout. In summary, the range of RMCs is from 43 to 92 mg/kg ww for PCBs and from 31 to 59 ng/kg ww for TEQs.

For fish downstream of the PSA, consistent with the ERA, GE proposes ranges of RMCs only for PCBs. For warmwater fish in this area, GE proposes to use the same range of PCB RMCs identified above, excluding the rainbow trout data; this range is 45 to 92 mg/kg ww. For coldwater species downstream of the PSA, GE proposes to use a range of PCB RMCs that would extend from 14 mg/kg ww, EPA's MATC, to 43 mg/kg ww, the rainbow trout tissue threshold from Phase II of the study, as described above.

2.4.5 Proposed RMCs for Prey Items Consumed by Mink and Otter

The narrative IMPG for the protection of mink and otter is:

> ***In areas of appropriate habitat, to reduce the PCB concentrations in Housatonic River fish and other mink and otter prey items from the Rest of River, as necessary, so that they do not prevent the presence of sustainable populations of mink and otter that use the Rest of River as part of their home range.***

Numerical concentration-based RMCs have been developed for PCBs in the tissue of prey items consumed by mink and otter. According to the ERA, fish make up an average of about 23% of the mink diet and about 80% of the otter diet (ERA, Vol. 6, pp. I-16, I-29, I-35). Thus, the RMCs developed would apply to the average PCB levels in all prey items (combined) consumed by the mink and otter. RMCs have not been developed for TEQs in prey because the ERA did not predict greater risks to mink and otter from TEQs than from PCBs (both were considered high – see ERA, Vol. 2, p. 9-53; Vol. 6, p. I-114) and did not develop a MATC for TEQs in mink or otter diet (see ERA, Vol. 6, pp. I-113, I-114).

In developing a MATC for PCBs in the diet of mink and otter, the ERA utilized data from the mink feeding study conducted by EPA contractors (Bursian et al., 2003). In that study, farm-raised mink were fed a diet containing fish from the PSA at five concentrations ranging from 0.34 mg/kg to 3.7 mg/kg PCBs for two months prior to mating and through mating and whelping of the kits. A subset of kits was also fed that diet for six months after whelping. Endpoints

evaluated included survival, reproduction, development, and growth. The study reported a LOAEL for 6-week kit survival of 3.7 mg/kg PCBs in diet and a NOAEL of 1.6 mg/kg (Bursian et al., 2003; ERA, Vol. 6, p. I-61). A supplemental probit analysis by EPA yielded a 20% effect level (LC20) for 6-week kit survival of 0.984 mg/kg PCBs in diet (ERA, Vol. 2, p. 9-51; Vol. 6, pp. I-52, I-106). The ERA established a MATC at that level for PCBs in the diet of mink and otter (ERA, Vol. 2, pp. 9-51, 9-54; Vol. 6, pp. I-106, I-114).[9]

Based on the ERA and the results from EPA's mink feeding study, GE proposes a range of RMCs from 0.984 mg/kg (the MATC) to 3.7 mg/kg (the LOAEL) for PCBs in the total diet of mink and otter that is derived from the Rest of River area.

2.4.6 Proposed RMCs for Fish Tissue Based on Consumption by Ospreys

The narrative IMPG for the protection of ospreys is:

> ***In areas of appropriate habitat, to reduce PCB concentrations in Housatonic River fish as necessary so that they do not prevent the presence of a population of ospreys in the Rest of River, taking into account the home range of such osprey.***

Numerical RMCs have been developed for PCBs in fish tissue based on fish consumption by osprey. Similar RMCs have not been developed for TEQs, because the ERA predicted lower risks to the osprey from TEQs than from PCBs and indeed characterized the TEQ risks as unclear (ERA, Vol. 2, p. 8-42 Vol. 6, pp. H-73, H-74). Separate PCB RMCs have been developed for breeding and transient ospreys in the Rest of River area.

The ERA evaluated potential risks to ospreys based on modeled exposures and effects (ERA, Vol. 2, pp. 8-10 - 8-13, 8-17; Vol. 6, pp. H-23 - H-28, H-46 - H-47). This endpoint can be expressed as a ratio of modeled dose to a toxicity reference value (TRV). Such ratios are hereafter referred to as hazard quotients (HQs). To generate RMCs, the equation used in the ERA to calculate the HQ was solved for the fish concentration term, holding the HQ value at a target level of 1.0 and using a range of TRVs (as described below). Specifically, the following equation and assumptions were used to generate RMCs for osprey. In cases where the ERA

[9] Although the ERA sometimes refers to this MATC as applicable to PCBs in fish (Vol. 2, p. 9-51; Vol. 6, p. I-106), that is because the only dietary item in the mink feeding study that came from the Rest of River area was fish; and the ERA makes clear in its summaries that the MATC actually applies to the overall diet of mink and otter (Vol. 2, p. 9-54; Vol. 6, p. I-114).

employed a probability distribution function, deterministic RMCs were calculated using average values reported in the ERA.

$$RMC_{fish} = THQ * TRV / (FT * FIR)$$

Where:

RMC_{fish} = Concentration of PCBs in fish that will not cause exceedance of TRV (mg/kg)
THQ = Target hazard quotient (unitless)
TRV = Toxicity reference value (mg/kg bw/d)
FT = Foraging time (unitless)
FIR = Normalized food intake rate (kg/kg bw/d)

As previously noted, the target HQ (THQ) was set at 1.0 to ensure that the dose does not exceed the TRV. Three TRVs were employed. The first, 0.12 mg/kg bw/d, reflects the ERA's interpretation (Vol. 2, p. 8-17; Vol. 6, p. H-47) of the effects metric for the most sensitive avian receptor, the white leghorn chicken (Lillie et al., 1974). The second, 7.0 mg/kg bw/d, reflects the ERA's interpretation (Vol. 2, p. 8-17; Vol. 6, p. H-47) of the effects metric (LOAEL for minor effects) for the most tolerant avian receptor, the American kestrel (Fernie et al., 2001). The third, 3.6 mg/kg bw/d, is the midpoint of the other two TRVs.

RMCs were initially calculated based on the assumption that 100% of the osprey's foraging time (FT) is within the Rest of River (ERA, Vol. 2, p. 8-11; Vol. 6, pp. H-23, H-24). Fish were assumed to comprise 100% of the osprey's diet (ERA, Vol. 2, p. 8-13; Vol. 6, p. H-26).

The osprey's food intake rate (FIR) was calculated in a manner consistent with the ERA (Vol. 2, p. 8-17; Vol. 6, p. H-25), based on the following equation:

$$FIR = (FMR * CF) / (AE * G * BW)$$

Where:

FIR = Normalized food intake rate (kg/kg bw/d)
FMR = Free metabolic rate (kJ/d)
CF = Conversion factor (0.239 kcal/kJ)
AE = Assimilation efficiency (unitless)
BW = Body weight (kg)
G = Gross energy (kcal/kg)

The assimilation efficiency (AE) was assumed to be 0.79, (ERA, Vol. 2, p. 8-12; Vol. 6, p. H-25, Tables H.2-9, H.2-10), based on Karasov (1990), Stalmaster and Gessaman (1982), Castro et

al. (1989), and Ricklefs (1974). Gross energy (G) was assumed to be 1,200 kcal/kg (ERA, Vol. 2, p. 8-12; Vol. 6, p. H-25, Tables H.2-9, H.2-10), based on Thayer et al. (1973).

Consistent with the ERA (Vol. 2, p. 8-11; Vol. 6, p. H-24), free metabolic rate (FMR) was calculated as follows:

$$FMR = a * BW^{b}$$

Where:

FMR	=	Free metabolic rate (kJ/d)
a	=	Slope (kJ/g-d)
BW	=	Body weight (g)
b	=	Power (unitless)

The ERA estimated FMR probabilistically, employing distributions for a and b based on EPA's reanalysis of the data reported by Nagy et al. (1999), assuming an underlying normal distribution for each (ERA, Vol. 6, p. H-25, Tables H.2-9, H.2-10). In this deterministic analysis, average values reported in the ERA (Vol. 6, p. H-25, Tables H.2-9, H.2-10) for all three terms were applied. Thus, a slope of 8.5, body weight of 1,696 g, and power of 0.768 were used to estimate FMR.

Based on the methods and exposure assumptions used in the ERA, together with the range of PCB TRVs used in the ERA to evaluate osprey (0.12 mg/kg bw/d for chickens to 7.0 mg/kg bw/d for kestrels), the resulting range of RMCs for PCBs in fish is 0.32 mg/kg to 18 mg/kg, with a midpoint of 9.4 mg/kg.

These RMCs are applicable only to ospreys breeding in the Rest of River, since they are based on the assumption that 100% of the osprey's foraging time is within the Rest of River. In fact, most ospreys that currently breed in Massachusetts nest along the coast. EPA's Ecological Characterization (ERA, Vol. 3, Section III, pp. 5-9 - 5-10) and the ERA (Vol. 6, pp. H-22) indicate that no breeding ospreys were observed in the PSA during three years of field work. During three seasons of intensive field activities on the PSA, ospreys were observed on only six occasions (ERA, Vol. 3, Section III, pp. 5-9 - 5-10). All observations occurred in late summer or early fall, concurrent with fall migration period for ospreys. The Ecological Characterization

concluded that all observations were of transient (i.e., migratory) individuals, rather than breeding individuals.[10]

For these reasons, numerical RMCs have also been calculated for transient ospreys in the Rest of River, such as those passing through the area while migrating. These RMCs were based on the assumption that ospreys are present in the Rest of River only 3 days per year (0.8% of the year), if they stop over while migrating. The assumption of a 3-day stopover is quite conservative, in that stopovers during migration are reportedly unusual north of Florida (Martel et al., 2003). Through satellite tracking, these authors found that ospreys migrate an average of 111 to 380 km per day and that stopovers occurred in "stepping stone" areas prior to extended transits over the Caribbean Sea en route to Venezuela. Martel et al.'s (2003) observations regarding distance traveled per day and limited stopovers during migration are supported by online data (http://www.bioweb.uncc.edu/bierregaard/migration1.htm#INTRODUCTION) for North American ospreys, as well as by published accounts of ospreys in Europe (Hake et al., 2001; Kjellen et al., 2001).

Applying a value of 0.008 for the FT term in the first equation above, and using all other exposure assumptions and TRVs consistent with those used in the ERA and described above, yields RMCs for PCBs in fish in the range of 39 mg/kg to 2,301 mg/kg, with a midpoint of 1,170 mg/kg. These RMCs are applicable to transient ospreys in the Rest of River area.

The RMCs for ospreys are quite uncertain. Since the ERA evaluated ospreys solely based on modeled exposures and effects (i.e., HQs), there are no site-specific studies to corroborate or refute the conclusions of the modeling. Moreover, the effects metrics applied to the osprey HQs were not based on ospreys or closely related species and, instead, reflected white leghorn chickens and American kestrels under the assumption that they represent most sensitive and most tolerant avian species, respectively.

---

[10] Other sources also indicate that ospreys observed in this region may be transients. A press release from the Massachusetts Division of Fish and Wildlife (http://www.state.ma.us/dfwele/Press/prs9708.htm) notes that the westernmost osprey nest in the state in 1997 was located in Westborough (more than 80 miles east of Pittsfield). The Massachusetts Audubon Society reported that the only osprey pairs breeding inland in Massachusetts in 2002 were located in Pepperell (approximately 85 miles east of Pittsfield) and again in Westborough (pers. comm. with Wayne Petersen, Sept. 11, 2003). The Breeding Bird Survey, a nationwide annual survey of breeding populations throughout the United States conducted since 1966 and overseen by the U.S. Geological Survey, has never recorded ospreys breeding in western Massachusetts (www.mbr-pwrc.usgs.gov). *Birds of Massachusetts* (Veit and Petersen, 1993), a comprehensive breeding bird atlas, indicates that ospreys breed in Massachusetts only along the Atlantic Coast. That atlas also notes that fall migrations over western Massachusetts occur in high numbers, with a maximum of 66 individuals recorded at Mount Tom in Holyoke on September 20, 1963.

In conclusion, the PCB RMCs for ospreys breeding within the Rest of River (if any), based on the ERA, range from 0.32 mg/kg to 18 mg/kg in fish tissue, with a midpoint of 9.4 mg/kg. The RMCs for transient ospreys range from 39 to 2,301 mg/kg, with a midpoint of 1,170 mg/kg.

2.4.7 Proposed RMCs for Fish Tissue Based on Consumption by Bald Eagles

The narrative IMPG for the protection of bald eagles is:

> ***In areas of appropriate habitat, to reduce PCB concentrations in Housatonic River fish as necessary so that they do not have adverse reproductive effects on bald eagles in the Rest of River, taking into account the home range of such eagles.***

Numerical concentration-based RMCs have been developed for PCBs in fish tissue (whole body) consumed by bald eagles in the Rest of River. Similar RMCs have not been developed for TEQs because the ERA did not predict greater risks to bald eagles from TEQs than from PCBs (both were considered high – see ERA, Vol. 2, p. 11-46; Vol. 6, p. K-88) and did not develop a MATC or other threshold concentrations for TEQs in fish based on consumption by bald eagles (see ERA, Vol. 6, pp. K-68 - K-69). Separate PCB RMCs have been developed for resident bald eagles (i.e., those breeding or wintering in the Rest of River area) and for transient bald eagles (i.e., those migrating through the area).

The ERA evaluated potential PCB risks to bald eagles based on modeled exposures and effects – i.e., HQs. It did so in two ways: (1) by comparison of modeled total daily intake (TDI) for adult eagles to a literature-based toxicity threshold using a surrogate species, the American kestrel (in this case, a calculated NOAEL of 0.7 mg/kg bw/day based on application of an uncertainty factor of 10 to the LOAEL from Fernie et al., 2001); and (2) by comparison of modeled eagle egg tissue concentrations to a literature-based toxicity threshold from a field study of bald eagles (20 mg/kg, based on Stratus (1999) (ERA, Vol. 6, pp. K-53 - K-54, K-68 - K-69). Since the latter was based on a study of bald eagles, rather than a surrogate species, the ERA used the egg-based HQs to characterize risks to bald eagles and to derive a MATC. Specifically, the ERA established a MATC of 30.41 mg/kg PCBs in fish as the concentration in fish at which an adult bald eagle's TDI would result in an egg concentration that exceeds the egg-based TRV of 20 mg/kg (ERA, Vol. 2, p. 11-50; Vol. 6, p. K-69). The ERA noted that the TDI used in this derivation was calculated assuming that eagles wintering in the area would consume 83.4% fish

and 16.1% waterfowl and that the waterfowl PCB concentration was zero since the waterfowl would have migrated there (ERA, Vol. 2, p. 11-50; Vol. 6, p. K-69).

GE proposes to use the ERA's MATC of 30.41 mg/kg as the RMC for PCBs in fish consumed by resident bald eagles. That RMC is applicable only to resident bald eagles since it is based on a foraging time of 1.0.

In addition, a separate RMC has been developed for transient bald eagles that are present in the Rest of River area for only a short time. That RMC has been based on the assumption that the transient bald eagles would forage in the Rest of River 3 days per year (0.8% of the year) as they are migrating. When the MATC of 30.41 mg/kg is divided by 0.008, the resultant RMC for transient bald eagles is 3,801 mg/kg PCBs in fish.

The RMCs for bald eagles are quite uncertain because the ERA evaluated bald eagles based solely on modeled exposures and effects (i.e., HQs), and thus there are no site-specific studies to corroborate or refute the conclusions of the modeling.

2.4.8 Proposed RMCs for Aquatic Invertebrates Based on Consumption by Wood Ducks

The narrative IMPG for the protection of wood ducks is:

> ***In areas of appropriate habitat, to reduce PCB and TEQ concentrations in Housatonic River aquatic invertebrates as necessary so that they do not prevent the presence of a population of wood ducks in the Rest of River.***

Numerical RMCs have been developed for aquatic invertebrates based on their consumption by wood ducks. Such RMCs have been developed for both total PCBs and TEQs, because the ERA concluded that, while the predicted risks from both PCBs and TEQs are similar in magnitude (intermediate to high), the certainty of the predicted TEQ risks to wood ducks is slightly higher than that for PCBs (ERA, Vol. 2, pp. 7-67, 7-68; Vol. 5, p. G-130, Tables G.4-22, G.4-23).

The general methodology used to generate the numerical RMCs for wood ducks reflects the ERA's evaluation of potential risks to wood ducks based on modeled exposures and effects, or HQs. The wood duck HQs for PCBs were "dose-based," in that they were calculated as the ratio of modeled doses to dose-based TRVs (ERA, Vol. 2, pp. 7-10, 7-52, 7-53; Vol. 5, pp. G-86,

G-88, G-89). Accordingly, the RMCs for PCBs were calculated in the same manner. The HQs for TEQs, in contrast, were "egg-based," in that they were calculated as the ratio of modeled concentrations of TEQs in wood duck eggs to egg-based TRVs (ERA, Vol. 2, pp. 7-11, 7-53 to 7-57; Vol. 5, pp. G-86, G-89 to G-91). Therefore, derivation of the TEQ RMCs required calculation of the dose to adults that yields a maternal body burden that in turn results in the egg-based TRV. Microsoft Excel's solver function was used to simultaneously solve a system of equations by varying the prey concentration to find the maximum egg concentration that equals the egg-based TRV.

All exposure and toxicity assumptions employed in the derivation of RMCs were consistent with the ERA. The specific methodologies and inputs used to generate the RMCs for PCBs and TEQs are detailed in Attachment 29 (contained in Appendix E). As shown in that attachment, the PCB RMCs were based on three dose-based TRVs: one reflecting the ERA's interpretation of the effects metric for the most sensitive avian receptor (the white leghorn chicken); the second reflecting the ERA's interpretation of the effects metric for the most tolerant avian receptor (the American kestrel); and the third as the midpoint of the other two TRVs. For the TEQ RMCs, three egg-based TRVs were used: one reflecting the lower end of the range of thresholds identified in White and Seginak's (1994) field study on reproductive effects of TEQs on wood ducks; the second reflecting the upper end of that range of thresholds; and the third as the midpoint of the other two TRVs.

Using these procedures, the range of RMCs for PCBs in wood duck prey is 0.44 mg/kg to 26 mg/kg, with a midpoint of 13 mg/kg. The range of RMCs for TEQs in wood duck prey is 1.7×10^{-5} mg/kg to 4.2×10^{-5} mg/kg, with a midpoint of 2.9×10^{-5} mg/kg. These TEQ RMCs are equal to a range of 17 nanograms per kilogram (ng/kg) to 42 ng/kg, with a midpoint of 29 ng/kg.

The RMCs for wood ducks are quite uncertain. Since risks to wood ducks were calculated solely through HQs, no site-specific studies either corroborate or refute the conclusions of the modeling. Moreover, conservative assumptions were applied to compensate for the uncertainties. The uncertainties in these RMCs and the conservative assumptions used are discussed in more detail in Attachment 29 (in Appendix E).

3.0 RMCs BASED ON ALTERNATIVE ASSUMPTIONS

As previously noted, GE believes that many of the exposure assumptions and toxicity values used in the HHRA are not supported by site conditions or available data and overstate potential human exposures and risks in the Rest of River area. Similarly, as also noted above, GE believes that many of the data interpretations, analyses, assumptions, and toxicity values used in the ERA are not supported by the data and overestimate risks to ecological receptors in the Rest of River. As a result, GE has developed ranges of alternative numerical RMCs based on exposure assumptions, toxicity values, and data interpretations and analyses that it believes to be more representative of site- and scenario-specific conditions and/or better supported by the underlying data. These alternative RMCs are presented in this section. The proposed narrative IMPGs are the same as those presented in Section 2.

In developing these alternative numerical RMCs, GE has "taken into account" the HHRA and ERA, because it has used the same exposure scenarios and receptors used in those risk assessments and has carefully considered and evaluated the assumptions and other inputs used in those risk assessments. In fact, in developing these values, GE has used many of the same assumptions and parameter values used in the HHRA and ERA. Where alternative assumptions, parameter values, or data interpretations have been used, they are identified in this section, and a rationale is provided to explain why GE believes that such assumptions, parameter values, or data interpretations are more supportable. As noted above, GE believes that these alternative RMCs are conservative and fully protective of human health and the environment for the particular scenarios, receptors, and risk or effect levels to which they apply, and that use of the alternative RMCs in the ranges specified in this section as IMPGs would be consistent with the requirements of the Reissued RCRA Permit. Again, however, it should be noted that the development of these alternative RMCs has not considered the feasibility of achieving those levels; that factor will be considered and balanced along with other factors in evaluating potential corrective measures in the CMS.

3.1 Alternative RMCs for PCBs in Floodplain Soil/Sediment Based on Direct Contact by Humans

Alternative RMCs have been developed for PCBs for the same 15 direct contact scenarios described in Section 2.1.1.

3.1.1 Methodology

As discussed in Section 2.1.1, there are two residential scenarios. For the scenario involving exposure at areas that are reasonably anticipated to be Actual/Potential Lawns of residential properties in the future, GE proposes to use the CD's 2 mg/kg Performance Standard as the IMPG, for the same reasons discussed in Section 2.1.1.[11] For the scenario involving exposure at the portions of residential properties that consist of riverbanks, wet areas, or steeply sloped areas, the alternative RMCs are the same as the alternative RMCs calculated for the general recreation scenario (discussed below) for the use category that is most applicable to the area in question (i.e., high-use, medium-high-use, medium-use, or low-use). For the remaining 13 direct contact scenarios, alternative RMCs have been derived using both RME and CTE assumptions. For each set of assumptions, RMCs based on potential cancer risks have been derived for each receptor using three risk levels within EPA's target risk range (10^{-6}, 10^{-5}, and 10^{-4}), and RMCs based on potential non-cancer impacts have been derived for each receptor using a target HI of 1.

The specific alternative exposure parameters, assumptions, and toxicity values used in calculating the alternative RMCs for each non-residential scenario and receptor are detailed in Attachments 30 through 42 (contained in Appendix F). The values used for these parameters are identical to the values used in the Direct Contact Assessment in the HHRA, except for the following:

- Soil ingestion rates for all age groups in the recreational scenarios and for adults in the utility worker and farmer scenarios;
- Fraction of soil ingested from the Site for some of the general recreation scenarios;
- Exposure frequencies for the general recreation, dirt biking/ATVing, and sediment exposure scenarios; and
- Non-cancer Reference Dose (RfD) for PCBs.

[11] As noted in Section 2.1.1, the Actual/Potential Lawn portions of current residential properties downstream of the confluence are not part of the Rest of River area subject to this IMPG Proposal, but are subject to a separate Removal Action under the CD, with a PCB Performance Standard of 2 mg/kg in soil.

The alternative values used for these parameters and the rationale for their selections are discussed in the following subsections.

3.1.1.1 Soil Ingestion Rates

The HHRA used upper-bound soil ingestion rates derived from studies by Calabrese and colleagues. However, newer and improved soil ingestion studies conducted by these same investigators show that these rates are overstated and support rates of about half those used in the HHRA.

In characterizing RME exposure to floodplain soils in the recreational scenarios, the HHRA generally used upper-bound soil ingestion rates of 200 mg/day for young children and 100 mg/day for older children and adults, based on studies conducted prior to 1997 and discussed in EPA's *Exposure Factors Handbook* (EPA, 1997a) (HHRA, Vol. IIIA, p. 4-28). However, as discussed in more detail in Attachment E to GE's 2003 comments on the draft HHRA (AMEC and BBL, 2003), improved, more recent studies of soil ingestion by both children and adults, which were conducted by the same investigators (Calabrese, Stanek, and colleagues) who conducted the studies on which EPA's upper-bound estimates are based, indicate that these daily soil ingestion rates are overestimated.

Stanek and Calabrese (2000) used an improved study protocol to reevaluate soil ingestion by young children. Improvements over previous studies included: (a) a relatively large study group of 64 children; (b) improved particle size measurements that focused attention on soil of smaller particle size; (c) a longer study duration of 365 days; (d) the use of a relevant age group of 1 to 4 year old children; (e) use of a random sample of the population for that age group; and (f) better control for input/output error. This study, which was published in the peer-reviewed literature, indicated that a more reasonable upper-bound soil ingestion rate for young children should be around 100 mg/day, and that a rate of 20 mg/day, based on the median value from the study, is appropriate as a central tendency estimate of ingestion (see Calabrese, 2003 [Exhibit E.1 to AMEC and BBL, 2003]). These respective values have been used as the RME and CTE soil ingestion rates for young children in GE's alternative analysis.

Similarly, the Stanek et al. (1997) study of adults included several improvements in study protocol over earlier studies. These improvements included: (a) a larger number of subjects (10) and days of participation (28); (b) an improved study design that considered seven consecutive days of fecal sampling; (c) improved selection of soil tracers; (d) a broader range of

soil ingestion validation; and (e) an enhanced capacity for additional assessments including particle size of soil ingested. According to Calabrese (2003), the 95th percentile value from this study (331 mg/day) is uncertain, unstable, and artificially inflated, because it was driven by the fecal sampling for one subject on the first day of the study, which reflected a 3-4 day accumulation rather than a single day of accumulation, as was assumed in the calculation of soil ingestion rates. In fact, the fecal weight for this individual on the first day was four times higher than the fecal weight for this individual on any of the other days of sampling during the study period. Instead, Calabrese (2003) recommended use of the 75th percentile value from this study, 49 mg/day, as an appropriate basis of an upper bound soil ingestion rate of 50 mg/day for adults and older children. Calabrese also recommended an ingestion rate of 10 mg/day, based on the mean soil ingestion rate (6 mg/day) observed in the 1997 study as a central tendency estimate. Values of 50 and 10 mg/day have been used to develop RMCs for RME and CTE exposures, respectively, to adults/older children in GE's alternative analysis.

As noted above, Calabrese (2003) explained that the 95th percentile soil ingestion rate (331 mg/day) from the Stanek et al. (1997) study of adults was a highly unreliable and inflated estimate of consumption. Despite this limitation, the HHRA based its "enhanced" soil ingestion rate for utility workers on this inflated value (HHRA, Vol. IIIA, p. 4-75). In addition, the HHRA selected an "enhanced" soil ingestion rate of 200 mg/day for the farmer scenario (HHRA, Vol. IIIA, p.4-72).

GE does not agree with EPA's choice of enhanced soil ingestion rates for utility workers and farmers. The enhanced rate of 330 mg/day for utility workers is not supportable for the reasons discussed above. In addition, there is no empirical basis for the 200 mg/day soil ingestion rate used for farmers.

Soil ingestion by adults is considered to be a result of hand-mouth transfer of soil during activities such as eating. As a result, the amount of soil ingested during farming and utility work activities is likely to be dependent upon the amount of soil that is adhered to the hands during hand-to-mouth activities. As discussed in Attachment E of GE's 2003 comments on the HHRA (AMEC and BBL, 2003), recent information on the adherence of soil to the hands of farmers and utility workers indicates that soil adherence is similar for these two groups. It is reasonable to conclude, therefore, that any enhanced soil ingestion rates used to evaluate them should also be similar.

GE has used a soil ingestion rate of 137 mg/day to evaluate both the farmer and utility worker scenarios. This value is based on reported soil adherence to the hands of farmers and utility workers (EPA, 2001) and the assumptions used by Hawley (1985) concerning hand-to-mouth behaviors in adults. This soil ingestion rate, which has a stronger empirical basis than either of the "enhanced" soil ingestion rates used in the HHRA, is also consistent with the soil ingestion rate for utility workers that was used by EPA to derive its performance standards for areas outside the Rest of River (EPA, 1999b).

3.1.1.2 Fraction of Soil Ingested from Site

In the RME evaluations for the recreational scenarios, the HHRA included no adjustment to account for the fraction of total daily soil ingestion that comes from areas that are not in or near the floodplain (e.g., home, school, work, other recreational areas, etc.) (see HHRA, Vol. IIIA, Table 4-12). For recreational activities that are relatively short in duration, such an adjustment needs to be made to reflect that fact that the total volume of soil ingested in a day will be derived from a combination of the floodplain areas and areas wholly unrelated to the floodplain that are contacted during each day of exposure. As discussed in Attachment E of GE's 2003 comments (AMEC and BBL, 2003), such an adjustment is supported by EPA (1989a) guidance and was previously made by EPA, which used a “fraction ingested” factor of 0.5 in developing its PCB cleanup standards for recreational use areas outside the river at the GE-Pittsfield/Housatonic River Site (see EPA, 1999b). GE believes that a similar adjustment should be made in evaluating the general recreational scenarios in the Rest of River floodplain and consequently has used a factor of 0.5 for both the RME and CTE evaluation in this alternative analysis.

3.1.1.3 Exposure Frequency

GE has used alternative exposure frequencies for some of the direct contact exposure scenarios, based on the physical characteristics of the exposure areas (EAs) of the Site and the likely uses of those areas. Alternative frequencies have been derived for the medium-use and low-use general recreation scenarios and a fourth general recreational scenario (medium-high-use) has been added to reflect that variations in exposures that are likely to occur considering conditions at individual EAs. In addition, alternative exposure frequencies also have been used for the dirt biking/ATVing and sediment exposure scenarios. For all other exposure scenarios, the RME and CTE exposure frequencies used in deriving the alternative RMCs are identical to those exposure frequencies used in the HHRA (Vol. IIIA).

General Recreation

The HHRA evaluated high-use, medium-use, and low-use general recreation scenarios (HHRA, Vol. IIIA, Sec. 4.5.3.2). As discussed in the HHRA (Vol. IIIA, p. 4-53), EPA considered an EA to be a high-use area if general recreation activities were observed by EPA and/or GE personnel or consultants and one or more of the following criteria were met:[12]

- Existing trails or easements are present on the EA or the potential exists for development of trails in the future;
- EA is readily accessible from nearby homes, roads, railroad tracks, and other access points;
- EA is a well-known recreational area; or
- Access to the EA is unimpeded (e.g., it is not isolated from access points).

As described in the HHRA, it was necessary for an EA to meet only one of the above criteria in order to be considered a high-use area. GE believes, however, that there should be a fourth general recreation scenario as there are EAs within the floodplain where easy access is available but use is still likely to be more limited due to a lack of trails or other recreational facilities. EPA acknowledged this situation in the HHRA when it only evaluated the potential for exposure to young children in high-use areas "where there were well-defined trails that are frequently used, such as designated nature areas and parks, or where young children were observed by EPA and/or GE personnel" (HHRA, Vol. IIIA, p. 4-20). While EPA evaluated older children and adults for all EAs that met at least one of the above criteria, GE believes that the same features that would limit a young child's use of a potentially high-use area (i.e., lack of defined trails) would also limit usage by older children and adults. Thus, in those areas, frequencies for all age groups would be reduced.

[12] Vol. IIIA, p. 4-53 of the HHRA states that high use was assumed if recreational activities were observed and one or more of the subsequently listed criteria were met. In the EA-specific discussions, however, it appears that it was not necessary for activities to be actually observed in order for an EA to be considered a high-use area, so long as at least one of the additional criteria was met (e.g., proximity to nearby homes and known recreational areas).

As a result, GE has developed RMCs for four general recreation scenarios to reflect these site-specific conditions. GE's high-use scenario, for which the exposure frequency is identical to EPA's high-use scenario, includes a high level of usage for young children and is applicable to those areas with easy access and known recreational activities or facilities. Specifically, like EPA, GE has used an RME exposure frequency of 90 days/year (3 days/week for 30 weeks) for 65 years, and a CTE exposure frequency of 30 days/year (1 day/week for 30 weeks) for 31 years. All of the assumptions used in evaluating this scenario are presented in Attachment 30 (in Appendix F).

RMCs for the additional medium-high-use scenario, which includes a reduced exposure frequency for all age groups and includes features of both the high-use and medium-use scenarios evaluated in the HHRA, are intended to be used to evaluate those EAs where access is available but features of the EA are likely to reduce the level of usage when compared with high-use areas (Attachment 30; in Appendix F)). For this scenario, GE has used the exposure frequency of 15 days/year for 6 years for both the RME and CTE evaluation of young children (consistent with the approach used in the HHRA). Because GE believes that these conditions would also affect usage by older children and adults, GE has used an RME exposure frequency of 60 days/year for 59 years, and a CTE exposure frequency of 21 days/year for 25 years to develop RMCs for older children and adults. These frequencies are based on the assumption that the RME individual might spend two days/week in these areas and that the CTE individual might spend 3 days/month during the 7-month exposure period in these areas.

GE has also used alternative exposure frequencies for the low-use and medium-use recreation scenarios. The HHRA considered areas to be low use areas if they are remotely located from residences and/or there are no readily accessible points of entry (HHRA, Vol. IIIA, p. 4-53). However, the HHRA assigned an RME frequency of one day/week to these low-use areas and a CTE exposure frequency of one day every other week (HHRA, Vol. IIIA, p. 4-53). EAs that are remote and have no ready access are not likely to have such regular usage, particularly when there are many other, more accessible recreational areas nearby that may be used instead. GE's low-use scenario reflects the lower exposure frequency that is likely to occur in such more isolated and inaccessible EAs. It assumes an RME exposure frequency of 15 days/year (2 days/month during the 7-month exposure period) for 59 years, and a CTE exposure frequency of 7 days/year (1 day/month during the 7-month exposure period) for 25 years.

GE's medium-use scenario is similar to EPA's low-use scenario and uses exposure frequencies for adults and older children of 30 days/year for 59 years (RME) and 15 days/year for 25 years (CTE). These frequencies are based on the assumptions that RME individuals may be in these areas 1 day/week during the 30-week exposure period, and that CTE individuals may be in these areas 2 days/month during this same period.

To summarize, GE has used the following exposure frequencies in developing alternative RMCs ranges for the general recreational exposure scenarios:

- High-use recreation - adults, older children and young children - 90 days/year for the RME scenario and 30 days/year for the CTE scenario for all age groups.

- Medium-high-use recreation - adults, older children and young children - 60 days/year for the RME scenario and 21 days/year for the CTE scenario for adults and older children, and 15 days/year (RME and CTE) for young children.

- Medium-use recreation - adults and older children - 30 days/year for the RME scenario and 15 days/year for the CTE scenario.

- Low-use recreation - adults and older children - 15 days/year for the RME and 7 days/year for the CTE.

Dirt Biking/ATVing

The HHRA used an RME exposure frequency of 90 days/year to evaluate potential risks to the Dirt Biker/ATVer. This exposure frequency was based on the assumption that an individual between the ages of 7 and 18 years participates in dirt-biking/ATVing 3 days/week for 7 months/year (Vol. IIIA, p. 4-57).

GE does not believe that this RME frequency is appropriate for these individuals. While it is possible that adolescents may ride their dirt bikes or ATVs 3 days/week during the summer months (June through August), when they have a substantial amount of free time, it is not likely that this frequency will occur during the remaining four months of the exposure period (April, May, September and October) when these individuals are involved in school, sports, and other after-school activities. Because of competing activities and interests during the months when school is in session, it is likely that even the most avid dirt bikers/ATVers, would only have an opportunity to ride those vehicles on the weekend. Thus, for this analysis, GE has assumed

that RME dirt bikers/ATVers ride these vehicles 3 days/week from June through August, and 2 days/week for the other four months. This results in an exposure frequency of 72 days/year, which has been used to derive a range of RMCs for the RME dirt biking/ATVing scenario. The CTE exposure frequency used in GE's analysis is identical to the CTE exposure frequency used in the HHRA.

Sediment Exposure

The HHRA assumed that, for the RME scenario, exposure to sediments in the river occurs 3 days/week during the three summer months (HHRA, Vol. IIIA, p. 4-69). As discussed in its comments on the HHRA (AMEC and BBL, 2003), GE believes that such a high frequency of exposure to river sediments is unlikely to occur except under scenarios, such as marathon canoeing, recreational canoeing, hunting or fishing, which are already being evaluated. Apart from those activities, sediment exposure is likely to be far less frequent than assumed in the HHRA. For this analysis, GE has used an RME exposure frequency of 24 days/year to evaluate potential sediment exposures. This is based on the assumption that such exposures could potentially occur as frequently as 2 days/week during the summer months. The exposure frequency of 12 days/year, used in the CTE analysis, is identical to the CTE exposure frequency used in the HHRA.

3.1.1.4 Toxicity Values for PCBs

To assess both cancer risks and non-cancer hazards, the HHRA used PCB toxicity values – i.e., Cancer Slope Factors (CSFs) for cancer risks and a Reference Dose (RfD) for non-cancer hazards -- that have been developed by EPA based on animal studies. This reliance on animal studies and default toxicological assumptions, to the exclusion of evidence from human epidemiological studies, may be responsible for one of the greatest sources of uncertainty in the HHRA. It is widely recognized, as well as intuitively plain, that human data, together with animal bioassays and mode-of-action data, are critical to an evaluation of the toxicity of a chemical Cook, 1982; Dinman and Sussman, 1983; Layard and Silvers, 1989; EPA, 1998, 2005d). Many chemicals do not have the same effect in humans as they do in animals, and even when similar effects do occur, the potency of a compound in humans often differs from its potency in animals. Both positive and negative epidemiological studies allow a direct determination of these differences. Moreover, for evaluating a body of epidemiological data on a particular chemical, EPA (1998a, 2005d) endorses a weight-of-evidence approach in which the available studies are evaluated in the context of well-accepted criteria for causation.

Formal weight-of-evidence evaluations using this approach have been conducted for both the potential cancer effects of PCBs and the potential non-cancer effects of PCBs and were discussed in GE's previous comments to EPA (AMEC and BBL, 2003). The cancer report (Golden and Shields, 2001) provides an assessment of the clinical and epidemiological evidence relating to whether PCBs cause cancer in humans, including 19 studies of whether PCBs are associated with an increased risk of any type of cancer in humans and 20 studies that have sought an association between PCBs and breast cancer. The report concludes that the collective weight-of-evidence from these studies demonstrates that exposure to PCBs is not a risk factor for breast cancer, that there is little credible evidence that PCBs have caused any type of cancer in highly exposed occupational cohorts, and that there is virtually no evidence that PCBs could cause cancer in humans at environmental exposure levels. The non-cancer report (Bernier et al., 2001) provides a comprehensive critical assessment of the 24 studies of the six major cohorts of children that serve as the primary source of data for evaluating potential effects of PCBs on growth or neurodevelopment in children, as well as 84 occupational and environmental studies (primarily of adults) that investigated potential associations between PCB exposure and effects on 14 different organs or organ systems. This report concludes that, with the possible exception of dermal and ocular effects in highly PCB-exposed workers, there is no credible evidence of a causal relationship between PCB exposure and adverse non-cancer health effects in humans.

In a recent study, Silkworth et al. (2005) confirmed that human cells are many times less sensitive than the cells of the laboratory animals used in developing the toxicity values for PCBs (rats for the CSF and rhesus monkeys for the RfD) to the gene expression that is believed to lead to toxicity from exposure to PCBs. These researchers tested inter-species sensitivity by characterizing cytochrome P450 gene expression in cultures of fresh hepatocytes from human donors, rhesus monkeys, rats, and HepG2 human hepatoma cells that had been exposed to one of three aryl hydrocarbon receptor (AhR) ligands: Aroclor 1254, PCB 126, and TCDD. The donor and HepG2 human cell lines were at least 100 times less sensitive to either PCB Aroclor 1254 or PCB 126 than were rat or rhesus monkey cells. This study further demonstrates that use of the animal-based toxicity values overestimates the health effects of PCBs and related compounds in humans, potentially by several orders of magnitude.

For these reasons, GE believes that EPA's upper-bound CSF for PCBs, which was used in the HHRA, overestimates the carcinogenic potential of PCBs in humans. Nevertheless, in the

absence of a quantitative alternative CSF at the present time, GE has conservatively used the default upper-bound CSF value of 2 $(mg/kg\text{-}day)^{-1}$ to develop the alternative cancer-based RMCs for the RME scenarios, and the central tendency CSF of 1 $(mg/kg\text{-}day)^{-1}$ to develop RMCs for the CTE scenarios.

GE has not, however, used the chronic RfD of 2E-05 mg/kg-day that was used in the HHRA to evaluate potential non-cancer hazards of PCBs, as it believes that this RfD overestimates potential non-cancer hazards of PCBs by a factor of at least 10. As discussed in detail in GE's previous comments to EPA (AMEC and BBL, 2003, Attachment N), that RfD was developed by EPA based on the application of various uncertainty factors (UFs) to the results of a long-term monkey dosing study; and two of those UFs are inappropriate: (1) the UF of 3 to adjust for inter-species extrapolation (monkey to humans); and (2) the UF of 3 to adjust for use of a supposedly subchronic study to estimate chronic effects. The first of these UFs is unwarranted because the empirical data indicate that monkeys are in fact *more* sensitive than humans to the PCB effects observed in the underlying study (dermal, ocular, and immunological effects). This conclusion is further supported by the recent findings of Silkworth et al. (2005) that human cells are many times less sensitive than rhesus monkey cells to the effects of PCBs. The UF to adjust from subchronic to chronic exposure duration is also unwarranted, because the monkeys in the underlying study were dosed for greater than 5 years. EPA (2005e) defines a chronic exposure study as one in which repeated exposure occurs by the oral, dermal, or inhalation route for more than approximately 90 days to 2 years in typically used laboratory animal species. This information indicates that the study should be considered equivalent to a chronic study and that no adjustment for exposure duration is necessary in calculating the PCB RfD.

As discussed in previous comments to EPA (AMEC, 2001; AMEC and BBL, 2003, Attachment N), even accepting the use of the same underlying monkey study used by EPA to develop its RfD, elimination of these inappropriate UFs would result in a revised chronic RfD of 2E-04 mg/kg-day, which is 10 times higher than the current RfD. This value is still highly conservative since it does not incorporate an adjustment factor in the opposite direction per the findings of Silkworth et al. (2005). Nevertheless, GE believes that this revised chronic RfD of 2E-04 mg/kg-day is a more supportable estimate of the non-carcinogenic potential of PCBs than the current RfD, and it has used this value to derive the alternative non-cancer-based RMCs for the direct contact scenarios.

3.1.2 Proposed Alternative RMCs

The proposed alternative numerical RMCs for PCBs in floodplain soil and sediment, based on direct human contact, are set forth in Table 3-1. This table presents receptor-specific RMCs for each scenario. Supporting calculations are provided in Attachments 30 through 42 (in Appendix F), which are referenced in Table 3-1. There are eight RMCs for each receptor evaluated. These include three cancer-based RMCs and one non-cancer-based RMC for the RME scenario, and three cancer-based RMCs and one non-cancer-based RMC for the CTE scenario.

Table 3-1. Alternative RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/ Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Residential (reasonably anticipated Actual/Potential Lawn areas)	All	RME	150 d/yr	2 (per Consent Decree)			
Residential (banks, steep slopes, wet areas)	All	Both	Variable	Use alternative RMCs for general recreation scenarios based on appropriate exposure frequencies for parcel-specific conditions			
High-use general recreation *See Att. 30*	Young child	RME	90 d/yr	3.1	31	307	105
		CTE	30 d/yr	28	282	2,817	483
	Older child	RME	90 d/yr	8.6	86	857	588
		CTE	30 d/yr	76	759	7,586	2,601
	Adult	RME	90 d/yr	2.9	29	291	781
		CTE	30 d/yr	87	870	8,696	3,230

Table 3-1. Alternative RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/ Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Medium-high-use recreation *See Att. 30*	Young child	RME	15 d/yr	18	184	1,842	632
		CTE	15 d/yr	56	563	5,635	966
	Older child	RME	60 d/yr	13	129	1,286	882
		CTE	21 d/yr	108	1,084	10,837	3,716
	Adult	RME	60 d/yr	4.4	44	436	1,171
		CTE	21 d/yr	124	1,242	12,423	4,614
Medium-use general recreation *See Att. 31*	Young child	Not assessed		NA	NA	NA	NA
	Older child	RME	30 d/yr	26	257	2,571	1,763
		CTE	15 d/yr	152	1,517	15,172	5,202
	Adult	RME	30 d/yr	8.7	87	872	2,342
		CTE	15 d/yr	174	1,739	17,392	6,460

Table 3-1. Alternative RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/ Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Low-use general recreation *See Att. 32*	Young child	Not assessed		NA	NA	NA	NA
	Older child	RME	15 d/yr	51	514	5,143	3,527
		CTE	7 d/yr	325	3,251	32,512	11,147
	Adult	RME	15 d/yr	17	174	1,744	4,684
		CTE	7 d/yr	373	3,727	37,268	13,843
Bank fishing *See Att. 33*	Older child	RME	30 d/yr	7.7	77	768	527
		CTE	10 d/yr	59	588	5,880	2,016
	Adult	RME	30 d/yr	3.1	31	305	663
		CTE	10 d/yr	77	768	7,678	2,413
Dirt biking/ATVing *See Att. 34*	Older child	RME	72 d/yr	6.0	60	604	414
		CTE	30 d/yr	49	491	4,905	1,682
Marathon canoeist *See Att. 35*	Adult	RME	150 d/yr	0.78	7.8	78	133
		CTE	90 d/yr	6.3	63	630	270

Table 3-1. Alternative RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/ Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Recreational canoeist *See Att. 36*	Older child	RME	30 d/yr	7.7	77	768	527
		CTE	15 d/yr	39	392	3,920	1,344
	Adult	RME	60 d/yr	1.5	15	145	332
		CTE	30 d/yr	14	141	1,408	804
Waterfowl hunting *See Att. 37*	Older child	RME	14 d/yr	58	581	5,813	1,993
		CTE	7 d/yr	376	3,764	37,642	6,453
	Adult	RME	14 d/yr	12	124	1,237	2,685
		CTE	7 d/yr	112	1,124	11,239	8,028
Agricultural use (based on direct contact by farmer) *See Att. 38*	Adult	RME	40 d/yr	1.5	15	149	546
		CTE	10 d/yr	42	419	4,195	3,476
High-use commercial (groundskeeper scenario) *See Att. 39*	Adult	RME	150 d/yr	2.8	28	282	402
		CTE	150 d/yr	25	250	2,502	858

Table 3-1. Alternative RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/ Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Low-use commercial (groundskeeper scenario) *See Att. 40*	Adult	RME	30 d/yr	14	141	1,408	2,011
		CTE	15 d/yr	250	2,502	25,024	8,580
Utility worker *See Att. 41*	Adult	RME	5 d/yr	31	312	3,119	4,455
		CTE	5 d/yr	209	2,093	20,933	7,177
Sediments *See Att. 42*	Older child	RME	36 d/yr	8.2	82	818	561
		CTE	12 d/yr	40	401	4,011	1,375
	Adult	RME	36 d/yr	2.3	23	235	698
		CTE	12 d/yr	30	302	3,016	1,637

3.2 Alternative RMCs for Fish and Waterfowl Tissue Based on Human Consumption

This section describes GE's proposed ranges of alternative RMCs for PCBs and TEQs in fish and waterfowl tissues based on human consumption.

3.2.1 Methodology

The methodology used to develop the ranges of alternative RMCs for fish and waterfowl tissues is identical to the approach used in Section 2.2.1. Numerical concentration-based RMCs have been developed for PCBs and TEQs in the edible tissue of fish and waterfowl based on human consumption using the equations outlined in that section. For each type of edible tissue, RMCs have been derived for cancer risks based on combined adult and childhood exposure. This is the same approach that was used in the HHRA. Three risk levels within EPA's target risk range (10^{-6}, 10^{-5}, and 10^{-4}) have been used to derive a range of RMCs for the carcinogenic endpoint for both PCBs and TEQs. In addition, non-cancer RMCs for PCBs have been separately derived for adults and children using an HI of 1. Consistent with the HHRA, non-cancer RMCs were not developed for TEQs, since TEQs were not quantitatively assessed for non-cancer impacts in the HHRA.

Alternative RMCs have been derived using both deterministic and probabilistic approaches. In the deterministic approach, alternative RMCs were calculated for both PCBs and TEQs that may be present in bass fillets, trout fillets, and duck breast tissue. Specifically, ranges of alternative deterministic RMCs have been developed for the following six fish and waterfowl consumption scenarios (with adults and children considered in each):

- RMCs for PCBs based on consumption of fish (bass) from standing reaches of the river;
- RMCs for PCBs based on consumption of fish (trout and bass) from running reaches of the river;
- RMCs for PCBs based on consumption of waterfowl;
- RMCs for TEQs based on consumption of fish (bass) from standing reaches of the river;

- RMCs for TEQs based on consumption of fish (trout or bass) from running reaches of the river; and

- RMCs for TEQs based on consumption of waterfowl.

In addition, fish tissue RMCs for PCBs and TEQs, based on probabilistic techniques, have been developed using AMEC's Microexposure Event (MEE) probabilistic model, which was discussed in detail in GE's previous comments on the draft HHRA (AMEC and BBL, 2003). Discrete ranges of probabilistic RMCs for PCBs and TEQs have been developed for fish harvested from running reaches of the river and from standing reaches of the river.

The scenario- and age-specific deterministic and probabilistic assumptions and parameters used are detailed in Attachments 43 through 48 (contained in Appendix G). While many of the input parameters are the same as those used in the Fish and Waterfowl Consumption Assessment in Volume IV of the HHRA, there are differences in the input values used for the fish consumption rates, the treatment of cooking loss for fish in the probabilistic analysis, the fraction of resident waterfowl consumed from the river, the cooking loss factor for waterfowl, and the toxicity values used. Each of these is discussed in the following sections.

3.2.1.1 Fish Consumption Rates

The HHRA based its estimated fish consumptions rates on data from the Maine angler survey reported by Ebert et al. (1993) (HHRA, Vol. IV, pp. 4-38 to 4-50). The Maine angler survey was specifically designed to provide a basis for estimating fish consumption rates for sport anglers, based on the types of waterbodies that they fished. The survey results reported by the authors (Ebert et al., 1993) included discrete fish consumption rate distributions for fish consumers, depending upon the types of waterbodies from which the consumed fish were obtained. These discrete distributions were developed for fish consumed from all types of waterbodies combined (all waters), and for fish consumed that were obtained only from running waterbodies (rivers and streams). In addition, a supplemental report (ChemRisk, 1991) provided a consumption rate distribution for those consumed fish that were obtained from standing waterbodies (lakes and ponds). All of these reports and the raw data were provided to EPA by the authors of the study.

Nevertheless, the HHRA evaluated fish consumption based on species of fish consumed (bass from all reaches of the river or trout from a single reach of the river), rather than the type of

waterbody fished. As is demonstrated in the Maine angler survey data, however, fish consumption rates are largely influenced by type of waterbody fished, rather than by the species consumed. In addition, the fish consumption rate estimates used to evaluate bass in each reach for the HHRA were taken from the "all waters" consumption rate distribution despite the fact that the "all waters" consumption rates cannot be considered representative of single reaches of a river. Finally, the HHRA selected only that subset of anglers (138 out of 1612 participating anglers) who reported that they did not share any of the fish they caught with any other individual, and assumed that the consumption behaviors of these individuals are representative of the consumption behaviors of the larger recreational angler population.

GE supports the use of the Maine angler survey data as the basis for the fish consumption rates to be used in the HHRA and in developing the RMCs for fish tissue. However, as discussed in detail in GE's comments on the draft HHRA (AMEC and BBL, 2003, Attachment G; GE, 2003; AMEC and BBL, 2005), GE does not believe that the HHRA has made appropriate use of those data. Rather, it believes that these data should be used in the way in which they were intended; i.e., they should not be based on a small subset of anglers and should not be applied to individual species but instead should be applied based on the type of fishery being evaluated. Thus, it is most appropriate to apply the complete river/stream fish consumption rate data from the Maine angler survey data to the running reaches of the Housatonic River. For those reaches of the river that are impounded, it is appropriate to select fish consumption rates from the complete distribution of consumption rates in the Maine angler survey that were based on fish consumed from lakes and ponds.

In its Responsiveness Summary to the peer review of the HHRA, EPA indicated that it used the "all waters" consumption rate distribution for all reaches of the river because Housatonic River anglers could consume fish from multiple reaches of the river during the year (EPA, 2004b, p. 24). This rationale ignores the fact that the HHRA specifically evaluates the discrete potential risks resulting from the consumption of fish from individual reaches, not the river as an aggregate. This is demonstrated by EPA's use of a discrete exposure point concentration (EPC) for each reach and the assumption that 100 percent of the fish consumed by the RME individual being evaluated in each reach is obtained from that single reach. Thus, the type of fishing and consumption that are associated with each reach are highly relevant and are closely tied to the physical characteristics of the waterbody being fished, as was demonstrated in the Maine angler survey. Since EPA's approach does not allow for a fraction of the fish to be

obtained from other locations, it is contradictory and inappropriate to use the "all waters" consumption rates based on the assumption that anglers will obtain fish from multiple reaches. Instead, the fish consumption rate distribution that is most representative of the characteristics of each individual reach should be employed, along with the reach-specific EPCs, to provide a more representative estimate of potential risks to individuals who obtain fish from that reach.

In addition, GE does not support the use consumption rates based only on the non-sharing subset of the Maine angler fish consumers, because there is no indication that their behavior or demographic characteristics are representative of the behavior and demographic characteristics of the larger, general population of recreational anglers who consume sport-caught fish in Maine or in the study area. As a result, while the non-sharing consumption rates used in the HHRA may be representative of the subset of Housatonic River anglers who also do not share any of their catch, this is likely to be a very small subset of the total population who may consume fish from the river. They cannot be considered representative of the entire consumer population.

EPA stated that it used this non-sharing approach due to its concern that the consumption rates reported in the Maine angler survey, which were derived by averaging total fish mass consumed in a household over the number of reported consumers in that household, might underestimate consumption by adult males (assumed by EPA to be the RME consumers) who might consume more fish than women and children (HHRA, Vol. IV, p. 4-52; EPA, 2004b, p. 23; see also EPA, 2005c, p. 45). EPA does not recognize, however, that the RME consumer is not necessarily limited to an adult male. Given that fish consumption rates are generally related to body weights (i.e., larger individuals must consume larger portions to maintain their body weights), it is reasonable to assume that larger individuals, male or female, consume more fish than smaller individuals, regardless of age or gender. Thus, while averaging the total mass of fish consumed over the number of individuals who shared in consumption may underestimate consumption by the individuals with the largest body masses, it is likely to overestimate consumption by individuals who have smaller body masses.

The purpose of the HHRA is to evaluate potential risks to the potentially exposed population of Housatonic River fish consumers, which includes men, women and children who share their fish and men, women and children who do not. Thus GE believes that the HHRA should be based on the entire population of Housatonic River fish consumers, not a small subset of them. As a result, GE supports the use of the consumption rate distributions published by Ebert et al.

(1993) (for rivers and streams) and ChemRisk (1991) (for lakes and ponds), which include all fish consumers from sharing and non-sharing households, for the alternative RMCs.

Deterministic Analysis

For the deterministic analysis, GE has selected consumption rates based on the type of river reach being evaluated. For those reaches of the river that are impounded, GE has used an RME consumption rate of 16 g/day and a CTE consumption rate of 1.7 g/day. These rates represent the 95th and the 50th percentile of the consumption rate distributions for fish obtained from lakes and ponds (ChemRisk, 1991).[13] For those reaches of the river that are flowing, GE has used an RME consumption rate of 12 g/day and a CTE consumption rate of 1 g/day based on the 95th and 50th percentile rates reported for flowing waters by Ebert et al. (1993).

The Maine angler survey data do not provide specific consumption rate estimates for young children. While the HHRA assumed that young children eat fish at half the rates of adults (HHRA, Vol. IV, p. 4-54), there are data available to indicate it is more likely that young children eat fish at a rate of approximately 40 percent of the rate of adults (AMEC and BBL, 2003). If such a fraction were applied to the adult rates from the Maine angler survey, the result would be RME and CTE consumption rates of 5 g/day and 0.4 g/day, respectively, for flowing reaches of the river, and 6 g/day and 0.7 g/day, respectively, for standing reaches of the river.

Moreover, as discussed in GE's most recent comments on the HHRA (AMEC and BBL, 2005), specific data are available on the consumption of sport-caught fish by children (Knuth et al., 1998 and unpublished raw data), and these data provide a reasonable basis for estimating the rates of consumption of sport-caught fish from the Housatonic River by young children. While, as EPA (2005c, p. 49) noted, the fish consumption rate information collected by Knuth et al. (1998) was for children aged 8 to 14 years (an older age group of children than was evaluated in the HHRA), there is no reason to believe that these consumption rates would underestimate consumption by younger children. In fact, it is most reasonable to assume that they would tend to overestimate consumption by children under the age of 7 years, who tend to eat smaller portion sizes.

[13] The ChemRisk (1991) analysis reported a 95th percentile consumption rate of 15 g/day. However, a reanalysis of the raw data by AMEC resulted in a 95th percentile value of 16 g/day for anglers who consumed fish from lakes and ponds. This higher rate was used as the consumption rate estimate for the RME adult consuming fish from the impounded portions of the river.

AMEC's analysis of the Knuth et al. (1998) raw data indicates that the average rate of sport-caught fish consumption was approximately 2 g/day and the 95th percentile rate was in the range of 3 to 4 g/day. This mean rate of 2 g/day is higher than the rates of 0.4 - 0.7 g/day estimated using the 40 percent multiplier discussed above, and the 95th percentile rate of 3-4 g/day is slightly lower than the rates of 5 - 6 g/day estimated using the 40 percent multiplier. GE believes, however, that they provide reasonable and conservative estimates of consumption by the target population. Thus, for fish consumption by young children in the alternative deterministic analysis, GE has used an RME rate of 4 g/day and a CTE rate of 2 g/day.

The input parameters used in calculating the range of alternative deterministic RMCs for fish tissue based on human consumption are provided in Attachments 43 and 44 (in Appendix G) for fish obtained from standing and flowing reaches of the river, respectively.

Probabilistic Analysis

To calculate the RMCs based on the MEE analysis, AMEC directly used the fish consumption rate distributions, based on the Maine angler survey data, that were provided by Ebert et al. (1993) for rivers/streams and by ChemRisk (1991) for lakes/ponds. These distributions were presented in detail in GE's 2003 comments (AMEC and BBL, 2003, Exhibit H.1, Table 2) and distributions are summarized in Attachments 43 and 44 (in Appendix G) for standing and flowing reaches of the river, respectively.

3.2.1.2 Cooking Loss Distribution for Fish

For the alternative deterministic analysis of fish consumption, GE has used the same cooking loss factor used in the HHRA, which calculated a CTE cooking loss of 25% in PCB concentrations in fish tissues and then used that factor in both the RME and CTE analyses (HHRA, Vol. IV, p. 4-63). Thus, a 25% cooking loss factor was used in the alternative deterministic analysis for both RME and CTE scenarios.

For the probabilistic analysis, as discussed in detail in Exhibit H.1 of GE's 2003 comments (AMEC and BBL, 2003), the cooking loss factors used in the MEE model were selected based on the species consumed and the probability that a particular cooking method would be used for that species. Table 3 of that exhibit provides the probabilities that individual cooking methods would be selected for an individual species, based on cooking method information provided in

the Maine angler survey. Depending upon the cooking method selected for each meal consumed, the following cooking loss factors were used, as reported in Table 5 of Exhibit H.1 (AMEC and BBL, 2003).

- Fry - cooking loss factor of 37%;
- Bake - cooking loss factor of 13%;
- Broil/Grill - cooking loss factor of 18%;
- Poach/Boil/Soup - cooking loss factor of 12%; and
- Raw - cooking loss factor of zero (no loss).

3.2.1.3 Fraction of Resident Waterfowl Consumed

The HHRA assumed that 100% of the waterfowl consumed by waterfowl hunters in the study area were resident ducks that spent 100% of their time in the study area (HHRA, Vol. IV, p. 4-39). As discussed in detail in GE's 2003 comments on the HHRA (AMEC and BBL, 2003), migration data available from Massachusetts Department of Fish and Wildlife indicate that it is likely that only about 40% of the waterfowl harvested in the study area are actually resident birds, with 60% of the birds harvested as they pass through the area during their migration. Since migratory birds would not be expected to accumulate PCBs or TEQs during their brief time in the study area, it is not appropriate to assume that 100 percent of the waterfowl consumed are resident birds.

For this alternative analysis, GE has assumed that 40% of the waterfowl consumed from the study area are resident birds. This fraction has been applied to both the RME and CTE scenarios.

3.2.1.4 Cooking Loss Factor for Waterfowl

Based on a paper by Amundson (1984) and the assumption that all pan drippings would be consumed, the HHRA assumed that there would be no reduction in tissue concentrations in waterfowl as a result of cooking (HHRA, Vol. IV, p. 4-89). As discussed in detail in GE's comments on the parameters used to evaluate the waterfowl consumption pathway, it is not likely that all pan drippings rendered during the cooking of waterfowl will be consumed or that

there will be no loss during cooking (AMEC, 2002; AMEC and BBL, 2003). Studies indicate that reductions in PCB levels in turkey and chicken are reduced by various cooking methods (Zabik, 1974, 1990). These studies showed that the greatest losses of PCBs (86% and 89%) occurred in abdominal adipose tissue while somewhat lower but still substantial losses (30% to 47%) occurred in the remaining chicken parts. Zabik (1974) concluded that the rendering of fat was the "major mode of removal for PCBs since PCB levels expressed on a fat basis were similar." Duck tissue has a higher fat content than does chicken or turkey. Thus, it is reasonable to conclude that losses of PCBs from duck tissue during cooking would be at least as great as those losses reported to occur during the cooking of chicken or turkey.

It is unlikely that all rendered fat will be consumed after cooking of waterfowl. It is possible, however, that some amounts of the rendered fat might occasionally be used to make gravy. Thus, for both the RME and CTE analysis, a cooking loss factor of 30% has been used in developing the alternative RMCs for waterfowl. This is the lowest cooking loss (from a range of 30% to 89%) of PCBs reported by Zabik (1974, 1990).

3.2.1.5 Toxicity Values for PCBs and TEQ

As discussed in Section 3.1.1.4, GE believes that the toxicity criteria used in the HHRA are highly conservative and overestimate the toxic potential of PCBs. Despite these concerns, GE has used the upper bound and central estimate CSFs for PCBs [2 and 1 $(mg/kg\text{-}day)^{-1}$, respectively], which were used in the HHRA, to develop the range of cancer-based RMCs for the alternative deterministic analysis. However, for the same reasons discussed in Section 3.1.1.4, GE has used an alternative RfD of 2E-04 mg/kg-day to derive the alternative deterministic RMCs for fish and waterfowl tissues.

For the probabilistic analysis, GE has used the version of AMEC's MEE model that uses distributions of PCB toxicity values, as well as exposure parameter values, to characterize the substantial uncertainty associated with the dose-response values used in the HHRA. This approach is consistent with the views of all the peer reviewers that the HHRA did not adequately take account of the uncertainties in the toxicity values, which could be evaluated using probabilistic techniques (see EPA, 2004b, pp. 175 [Hattemer-Frey], 178 [Hoffman], 186

[McClellan], 188 [Washburn], 196-97 [Shull], 257 [Ryan], and 263-64 [Kissel]).[14] As discussed in Attachment H of GE's 2003 comments on the HHRA (AMEC and BBL, 2003), the magnitude of the uncertainty in the toxicity values used in the HHRA can be characterized in a probabilistic analysis by replacing point estimate uncertainty factors with distributions, as outlined by Swartout et al. (1998). Such consideration is consistent with the recommendations of EPA's Science Advisory Panel (SAP) under FIFRA which, in its evaluation of aggregate risks for pesticides, called for "a more quantitative risk assessment approach in which all of the safety factors are replaced by distributions based on the best available data from well studied cases" (EPA, 1999c, p. 37).

As discussed in detail in Attachment H and Exhibit H.2 to GE's 2003 comments (AMEC and BBL, 2003), this model uses a distribution of PCB CSFs, based on the available toxicological literature, to reflect the high level of uncertainty associated with the CSF; and it also uses a distribution of PCB RfDs, based on varying uncertainty factors, to capture the uncertainty associated with this toxicity criterion. The specific input values used are detailed in Attachments 43, 44, 46, and 47 (in Appendix G) and were derived as described in detail in Exhibits H.1 and H.2 of GE's 2003 comments (AMEC and BBL, 2003).

As discussed in Section 2.2.1, there is currently no CSF or RfD published in EPA's IRIS database for 2,3,7,8-TCDD, upon which the TEQ approach is based. Thus, as was done in the HHRA, the EPA's previously published CSF of 150,000 $(mg/kg\text{-}day)^{-1}$ (EPA, 1997b) was used to calculate the cancer-based RMCs for TEQs in fish and waterfowl tissue for both the deterministic and probabilistic analyses. Due to the lack of an RfD for 2,3,7,8-TCDD, non-cancer-based RMCs have not been developed for TEQs.

3.2.2 Proposed Alternative RMCs

The alternative numerical RMCs for PCBs and TEQs in edible fish and waterfowl tissue, based on consumption by humans, are set forth in Table 3-2. Supporting calculations for each scenario are provided in Attachments 43 through 48 (in Appendix G) and are referenced in Table 3-2. The RMCs presented for the probabilistic analyses represent, for the RME, the 5th

[14] As EPA has noted (EPA, 2004b, p. 37) and as the peer reviewers recognized, EPA's current guidance on probabilistic risk assessments does not provide for the use of distributions of toxicity values. However, that guidance is not binding; and as discussed in GE's comments on the HHRA (AMEC and BBL, 2003, Attachment H and Exhibit H.2) and recommended by the peer reviewers, use of such distributions is appropriate to provide a quantitative evaluation of the uncertainties associated with the dose-response values.

percentile of the output distribution (which would be exceeded by 95 percent of the calculated output values) and, for the CTE, the 50th percentile of the output distribution.

While the HHRA included dioxins, furans, and "dioxin-like" PCBs in its TEQ risk calculations, GE does not agree that PCB congeners should be included when the TEQ RMCs are applied. As discussed in detail in GE's comments on the HHRA (AMEC and BBL, 2003), GE believes that the potential contribution to cancer risk presented by the dioxin-like PCB congeners is already well characterized by the CSF for PCBs because the TEQ concentrations of those congeners in fish and waterfowl tissues do not exceed the TEQ concentrations in Aroclor 1254, upon which the CSF for PCBs is based. Thus, GE believes that the TEQ IMPGs that are ultimately applied to fish and waterfowl tissues should only include the TEQs presented by the dioxin and furan congeners that are measured in those tissues.

Table 3-2. Alternative RMCs for Fish & Waterfowl Tissue Based on Human Consumption

Tissue Type and Constituent	Assessment Type	RME or CTE	RMCs (in mg/kg for PCBs and ng/kg for TEQ)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer – Child	Non-Cancer – Adult
Fish fillets taken from standing reaches of the river - PCBs *See Att. 43*	Deterministic	RME	0.0040	0.040	0.40	1.0	1.2
		CTE	0.15	1.5	15	4	22
	Probabilistic w/ distributions of toxicity values	RME (95th percentile)	0.018	0.18	1.8	1.2	1.0
		CTE (50th percentile)	0.32	3.2	32	17	14
Fish fillets taken from flowing reaches of the river - PCBs *See Att. 44*	Deterministic	RME	0.0051	0.051	0.51	1.0	1.6
		CTE	0.18	1.8	18	4	37
	Probabilistic w/ distributions of toxicity values	RME (5th percentile)	0.021	0.21	2.1	1.5	1.2
		CTE (50th percentile)	0.55	5.5	55	25	25

Table 3-2. Alternative RMCs for Fish & Waterfowl Tissue Based on Human Consumption

Tissue Type and Constituent	Assessment Type	RME or CTE	RMCs (in mg/kg for PCBs and ng/kg for TEQ)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer – Child	Non-Cancer – Adult
Duck breast – PCBs *See Att. 45*	Deterministic	RME	0.030	0.30	3.0	4.3	10
		CTE	0.24	2.4	24	8.9	21
Fish fillets taken from standing reaches of the river – TEQ *See Att. 46*	Deterministic	RME	0.053	0.53	5.3	NA	
		CTE	1.0	10	103	NA	
	Probabilistic	RME (5^{th} percentile)	0.12	1.2	12	NA	
		CTE (50^{th} percentile)	1.6	16	160	NA	
Fish fillets taken from flowing reaches of the river – TEQ *See Att. 47*	Deterministic	RME	0.062	0.62	6.2	NA	
		CTE	1.4	14	142	NA	
	Probabilistic	RME (5^{th} percentile)	0.13	1.3	13	NA	
		CTE (50^{th} percentile)	2.7	27	267	NA	

Table 3-2. Alternative RMCs for Fish & Waterfowl Tissue Based on Human Consumption

Tissue Type and Constituent	Assessment Type	RME or CTE	RMCs (in mg/kg for PCBs and ng/kg for TEQ)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer – Child	Non-Cancer – Adult
Duck breast – TEQ	Deterministic	RME	0.40	4.0	40	NA	
See Att. 48		CTE	1.6	16	157	NA	

3.3 Alternative RMCs for PCBs in Agricultural Products Based on Human Consumption

Alternative numerical concentration-based RMCs for PCBs have been developed for the same agricultural products discussed in Section 2.3, based on human consumption of such products.

3.3.1 Methodology

The alternative RMCs are based on all of the same pathways, equations, parameters, and assumptions that were used in the HHRA and outlined in Section 2.3.1 and Attachments 20 to 28 (in Appendix D), with the exception of the non-cancer RfD for PCBs. For the reasons given in Section 3.1.1.1, GE does not support the PCB RfD of 2E-05 mg/kg-day used in the HHRA and believes that that RfD overestimates the non-carcinogenic potential of PCBs by at least a factor of 10. Thus, in this analysis, an alternative set of non-cancer-based RMCs has been derived using the alternative RfD of 2E-04 mg/kg-day.

As with the RMCs discussed in previous sections, three target risk levels were used to derive a range of RMCs based on potential carcinogenic effects (10^{-6}, 10^{-5}, and 10^{-4}) and a target HI of 1 was used to calculate the RMCs based on potential non-carcinogenic effects.

3.3.2 Proposed RMCs

The alternative RMCs for the agricultural pathways are presented in Table 3-3. This alternative analysis only affects the non-cancer-based RMCs for the agricultural pathways. As discussed in Section 3.1.1.4, GE believes that the CSFs for PCBs that were used in the HHRA overestimate the carcinogenic potential of PCBs in humans. Despite this reservation, those CSFs have been used in this analysis. As a result, the cancer-based RMCs presented in Table 3-3 are identical to the cancer-based RMCs presented in Table 2-3.

Table 3-3. Alternative RMCs for PCBs in Agricultural Products Based on Human Consumption

Tissue Type	Farm Type	RME or CTE	IMPGs (in mg/kg)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer Child	Non-Cancer Adult
Cow milk *See Atts. 20 & 21**	Commercial dairy	RME	0.000026	0.00026	0.0026	0.003	0.014
		CTE	0.00012	0.0012	0.012	0.0047	0.017
	Backyard dairy	RME	0.00003	0.0003	0.003	0.003	0.01
		CTE	0.00017	0.0017	0.017	0.0047	0.012
Beef cow tissue *See Atts. 22 & 23**	Commercial beef	RME	0.00018	0.0018	0.018	0.043	0.079
		CTE	0.00083	0.0083	0.083	0.056	0.092
	Backyard beef	RME	0.00026	0.0026	0.026	0.043	0.073
		CTE	0.0015	0.015	0.15	0.056	0.074
Poultry meat *See Atts. 24 & 25**	Commercial poultry	RME	0.00024	0.0024	0.024	0.072	0.1
		CTE	0.0014	0.014	0.14	0.089	0.16
	Backyard poultry	RME	0.00043	0.0043	0.043	0.072	0.12
		CTE	0.0025	0.025	0.25	0.089	0.13

* The supporting assumptions and calculations for these RMCs are the same as those set forth in the cited attachments except that a non-cancer RfD of 2E-04 mg/kg-day was used.

Table 3-3. Alternative RMCs for PCBs in Agricultural Products Based on Human Consumption

Tissue Type	Farm Type	RME or CTE	IMPGs (in mg/kg)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer Child	Non-Cancer Adult
Poultry eggs *See Atts. 26 & 27**	Commercial poultry	RME	0.00055	0.0055	0.055	0.11	0.25
		CTE	0.0025	0.025	0.25	0.13	0.31
	Backyard poultry	RME	0.00082	0.0082	0.082	0.11	0.25
		CTE	0.0044	0.044	0.44	0.13	0.26
Exposed fruit *See Att. 28**	Commercial or backyard fruit farm	RME	Not calculated (NC)			1.1	NC
		CTE	NC			1.2	NC
Exposed vegetables *See Att. 28**	Commercial or backyard farm with exposed vegetables	RME	NC			0.24	NC
		CTE	NC			0.31	NC
Root vegetables *See Att. 28**	Commercial or backyard farm with root vegetables	RME	NC			0.3	NC
		CTE	NC			0.41	NC
All produce *See Att. 28**	Commercial or backyard farm with all three types of produce	RME	NC			0.12	NC
		CTE	NC			0.15	NC

* The supporting assumptions and calculations for these RMCs are the same as those set forth in the cited attachments except that a non-cancer RfD of 2E-04 mg/kg-day was used.

3.4 Alternative RMCs Based on Ecological Receptors

This section presents alternative RMCs for each ecological receptor for which the ERA found significant risks – namely, benthic invertebrates, frogs, shrews, fish, mink and otter, ospreys, bald eagles, and wood ducks. These RMCs are based on the same underlying data sets used in the ERA, as well as a number of the same assumptions and procedures used in the ERA to evaluate those data; but they reflect, on several key points, data interpretations or input variables that GE believes are more scientifically supportable than those in the ERA. For each receptor, the discussions in this section reiterate the narrative descriptive goal for the receptor group (which, in each case, is the same as that presented in Section 2.4), and then present the basis for GE's determination of threshold values and the alternative numerical concentration-based RMCs.

3.4.1 Alternative RMCs for Sediments Based on Risks to Benthic Invertebrates

As described in Section 2.4.1, the overall goal for protection of benthic invertebrates is ***to reduce PCB concentrations in sediments as necessary so that they do not prevent the presence of diverse and abundant communities of benthic invertebrates in the Rest of River, consistent with habitat limitations***.

Numerical RMCs for sediments were presented in Section 2.4.1 based on the ERA's interpretation of site-specific studies on benthic invertebrates. This subsection proposes alternative numerical RMCs for PCBs in sediments, which GE believes are more consistent with the underlying data. No RMCs are proposed for TEQs because the ERA did not assess TEQ risks to benthic invertebrates.

Alternative RMCs were developed based on the same site-specific studies that were reported in the ERA, namely, the site-specific toxicity tests and the site-specific benthic community study (Vol. 1, pp. 3-25 - 3-42, 3-47 - 3-57, Vol. 4, pp. D-43 - D-63, D-74 -D-86, D-94 - D-96). For the toxicity tests, the ERA identified a variety of effect thresholds for different test species and endpoints. These thresholds include EC20 and EC50 values, as well as, in some cases, NOELs and LOELs, and are identified in Table 2-4 (in Section 2.4.1 above). GE believes that it is appropriate to use the geometric means of the values listed in Table 2-4 to establish a range

of alternative RMCs. Those geometric means are 7 mg/kg for the EC20 values, 13.7 mg/kg for the EC50 values, 13.3 mg/kg for the NOELs, and 18.5 mg/kg for the LOELs.[15]

EPA's Responsiveness Summary for the ERA takes the position that averaging procedures, such as the geometric mean, dilute the results of sensitive endpoints with the results of insensitive endpoints (EPA, 2005b, p. 31). In fact, however, the ERA makes extensive use of geometric means to describe the central tendencies of the various invertebrate data sets and in deriving the MATC (ERA, Vol 4, pp. D-96, D-118). The use of the geometric mean in developing the range of RMCs is thus consistent with the general practice employed in the ERA. In addition, use of these data is consistent with several peer reviewers' recommendation that all relevant data be used to develop toxicity thresholds (EPA, 2004c, pp. 116 & 154 [Thompson], 131 [Forbes], 142 [Sample]). Finally, the geometric mean allows consideration of the central tendency of the full set of relevant data, without putting undue weight on individual data points at the extremes of the distribution range. For these reasons, GE believes that it is appropriate to use the geometric mean of the values listed in Table 2-4 to establish a range of RMC. The proposed alternative range of RMCs derived from the toxicity test data is 7.0 to 18.5 mg/kg in sediments.

For the benthic community study, as discussed in Section 2.4.1, potential effects of PCBs were evaluated separately for sites with fine-grained sediments and high organic carbon content and sites with coarse-grained sediments and low organic carbon. This separation of data into coarse-grained and fine-grained sites provides a basis to control for differences in grain size and organic carbon between the upstream and impounded reaches of the PSA (ERA, Vol. 1, Section 3.2.3 and Figures 3.2-2 and 3.2-3). Such differences can significantly affect benthic community structure independent of PCB concentrations (BBL 2003a, Attachment C).

Based on the separate analyses of the data from the coarse-grained and fine-grained sites, GE has concluded that the benthic community study did not show any important PCB-related effects in either of these sediment types. For the coarse-grained sites, GE's contractors evaluated relationships between benthic community parameters and PCB concentrations, grain size and organic carbon using multiple regression analysis (BBL 2003a, Attachment C). These analyses demonstrated that PCB concentrations accounted for only a very small portion (in the range of

[15] When the threshold listed in Table 2-4 is $\leq$ or >, the numeric value was used in this calculation of geometric means. Values listed as "NC" were not used in these calculations.

1.0% to 6.8%) of the variability in the benthic community metrics and thus do not have a major or meaningful influence on the benthic community structure at the coarse-grained sites in the PSA. Results of regression analyses presented in the ERA indicated that PCB concentrations accounted for a somewhat higher, but still relatively small, portion of the overall variability in benthic community parameters at the coarse-grained sites. Based on EPA's analyses, R^2 values for these sites indicated that PCBs accounted for 13% to 17% of the variability in total abundance, 21 to 27% of the variability in taxa richness, and 5% to 21% of the variability in taxonomic diversity indices (ERA, Vol. 4, pp.. D-80, D-81, & Attachment D-8 Table 3).

For the fine-grained sites, the ERA found no significant relationship between PCBs and total abundance (ERA, Vol. 4, p. D-80) and only a borderline statistical relationship between PCBs and taxa richness, with PCBs explaining less than 7% of the variability in this metric (ERA, Vol. 4, p. D-81). For the regressions between PCB concentrations and the three benthic community taxonomic diversity indices at these sites, statistically significant relationships were found only with some methods for treating non-detect values and not others; and in any event, the R^2 values indicated that PCBs accounted for only 7% to 13% of the variability in these indices (ERA, Vol. 4, Attachment D-8, Table 3).

These results demonstrate that, for both the coarse- and fine-grained sites, habitat factors other than PCBs are responsible for the substantial majority of observed variability in benthic community structure. Given that benthic community structure is driven largely by factors other than PCBs, GE believes that it is appropriate to use the maximum concentrations of PCBs in sediments from coarse-grained sites and from fine-grained sites as RMCs for the benthic communities in these two distinct habitats. The maximum station-wide average concentrations of PCBs at the coarse-grained and fine-grained sediment sites are 42 mg/kg and 16 mg/kg, respectively (ERA, Vol. 4, Table D.2-2). The resulting RMC for the coarse-grained sites is thus >42 mg/kg, while that for the fine-grained sites is >16 mg/kg. As noted in Section 2.4.1, GE believes that the results from the benthic community study are more directly relevant than the toxicity test results to the overall goal of maintaining the presence of diverse and abundant communities of benthic invertebrates in the Rest of River.

3.4.2 Alternative RMCs for Vernal Pool and Backwater Sediments Based on Risks to Frogs

As noted in Section 2.4.2, the overall goal for protection of amphibians is ***to reduce PCB concentrations in the sediments of vernal pools and backwaters in the Rest of River as necessary so that they do not prevent those areas from supporting a sustainable reproducing population of amphibians***.

Numerical RMCs were presented in Section 2.4.2 based on the ERA's interpretation of EPA's site-specific study on wood frogs (*Rana sylvatica*) (FEL, 2002). GE previously demonstrated that that interpretation relied on a number of overly conservative assumptions (BBL et al., 2003a,b). GE believes that the alternative numerical RMCs proposed in this subsection are more consistent with the underlying data and provide a more technically appropriate basis for achieving the above goal. No RMCs are proposed for TEQs because the ERA did not assess TEQ risks to amphibians.

The RMCs presented here are based on the GE's interpretation and analysis of data from EPA's site-specific wood frog study (see BBL et al., 2003a,b). The study's three phases yielded data on a wide range of endpoints relevant to the survival, development and maturation of wood frog egg masses, larvae and metamorphs. The proposed RMCs are based on the results of the Phase I and Phase III portions of the study, because they were the only phases that can be evaluated in a way that integrates key responses (i.e., Phase I - malformations, metamorphosis and mortality) or that showed significant dose-response relationships with exposure to vernal pool sediments (e.g., Phase III – malformations and sex ratio).

Phase I Main Study

To understand the combined effects of malformations, mortality, and metamorphosis on the number of normal wood frog metamorphs produced per pond, GE conducted an independent analysis of the net abnormality-free metamorph output for target and reference ponds (i.e., the number of normal metamorphs produced per pond) for the Phase I toxicity study.[16] For all sites, the total metamorph output for each pond was calculated by subtracting the number of

[16] The Phase I Main Study was the only one appropriate for this analysis because both the total number of individuals that completed metamorphosis and the number of metamorphs that had abnormalities were documented. As a result, the total number of abnormality-free metamorphs that were produced from the eggs collected from each site could be determined. The other Phase I studies were not appropriate for this analysis.

metamorphs with abnormalities, regardless of whether the individual abnormality had a dose-response relationship with PCBs, from the total number of metamorphs produced. Regression analyses were used to test the relationship between the net metamorph output and sediment PCB concentrations used in the laboratory studies. There was no evidence of an exposure-response relationship between sediment PCB concentrations and net-metamorph output. Details of this analysis were provided in prior GE comments (BBL et al., 2003a, Attachment G). Based on these analyses, the highest concentration of PCBs in the pond sediments, which was an average measured concentration of 62 mg/kg and estimated to have a spatially weighted mean of 32.3 mg/kg (ERA, Vol. 5, Table E.4-1), represents an unbounded NOAEL. That level can be used as an alternative RMC based on the Phase I study.

Phase III Study

In the Phase III study, metamorphs collected from vernal pools in the Housatonic River floodplain were evaluated based on weight, abnormalities, and sex ratio. Significant relationships were found for both malformations and sex ratio (percent female), but not for weight (ERA, Vol. 5, p. E-91 - E-92)). For malformations, the ERA calculated the following effect thresholds for sediment PCB concentrations: an EC20 of 3.27 mg/kg using the spatially weighted means and 3.61 mg/kg using the average measured concentrations in the ponds; and an EC50 of 38.6 mg/kg using the spatially weighted means and 59.3 mg/kg using the average measured concentrations (ERA, Vol. 5, Table E.4-1). GE believes that the EC50 for malformations is a sufficiently conservative basis for the RMC as there is no evidence that the malformation rates observed affected survival or metamorphosis, and as noted above, review of the Phase I study indicates that the malformation rates did not affect net abnormality-free metamorph output. In addition, the relevance of the malformation rates to the population is questionable. A density-dependent effect, in which the loss of some individuals through malformations would likely be compensated for by increased survival in other individuals that otherwise might not have survived, would mitigate the effect of malformations on the population. Moreover, a statistical analysis conducted by GE (which excluded one site [Site 8-VP-1], due to its very small sample size [n=3]) showed no statistically significant relationship between tissue PCB concentrations (i.e., the delivered dose) and the malformation rate (BBL et al., 2003b), and this finding makes any conclusions regarding the relationship between sediment PCB concentrations and malformation rates unclear. For these reasons, basing an RMC for soil/sediment on the EC20 would be unreasonably conservative. We have thus based the

alternative RMC for Phase III malformations on the EC50 of 38.6 mg/kg in sediments (using the spatially weighted means), recognizing that there are uncertainties associated with that effects threshold.

Although the Phase III study also found a significant relationship between increasing PCB concentrations in sediment and the mean percentage of female metamorphs, those data were not used in establishing alternative RMCs. The ERA acknowledged that the biological relevance of sex ratio, at least at the 20% effect level, is unclear (ERA, Vol. 1, p. 4-53; Vol. 5, pp. E-116, E-142). Moreover, as discussed by BBL et al. (2003a,b), an evaluation of the multiple lines of evidence available for sex ratio indicates that there is no clear evidence of PCB-related effects for the following reasons:

- The results of the Phase III study are not consistent with the field data collected by Woodlot in 1999, which indicate that the sex ratios of breeding adult wood frogs were not skewed (44 to 52% female) (ERA, Vol. 5, Att. E.4, Table 5) and were within a range defined as normal by the principal investigators based on a review of the literature (FEL, 2002, p. 41; see also Gilbert et al., 1994; Merrell, 1977; Reeder et al., 1998; and Stebbins and Cohen, 1995).

- GE's statistical analysis showed no statistically significant relationship between tissue PCB concentrations and sex ratio.[17] As tissue PCB concentrations represent the delivered dose to the organism, the finding of no significance on a tissue basis makes any conclusions regarding the significance of the skewed sex ratio unclear.

- The percentage of female metamorphs in the Housatonic River floodplain (not vernal pool specific), calculated as the total number of females/total number of metamorphs collected, was not significantly different from that in the reference area.

- Sex ratios in amphibians can be affected by a number of environmental factors, including temperature, pH, and exposure to chemicals. Because the Phase III study evaluated metamorphs under natural environmental conditions, it is not possible to distinguish effects on sex ratios caused by natural conditions (e.g., temperature, pH) from those related to exposure to PCBs or other contaminants of potential concern. Sex ratios of wood frogs

[17] Again, Site 8-VP-1 was excluded from this analysis due to its very small sample size (n=3).

were not reported for Phase I, a controlled laboratory study where exposure-response relationships could have been rigorously tested.

Given these substantial issues with the sex ratio data, they do not provide an appropriate basis for the development of an RMC

Based on the foregoing data, GE proposes an alternative range of RMCs from 38.6 mg/kg (EC50 for Phase III malformations based on spatially weighted means) to 62 mg/kg (highest average measured concentration in Phase I, considered a NOAEL) for PCBs in vernal pool and backwater sediments. This range of RMCs is supported by the fact that, as the ERA acknowledges, the wood frog study showed no effects of PCBs on survival, growth, and metamorphosis (ERA, Vol. 1, p. 4-46, Table 4.4-5; Vol. 5, E-84 to E-86), and further by the fact that even the malformations found in the study do not appear to have affected the net output of abnormality-free metamorphs (BBL et al., 2003a). Moreover, as noted above, there are substantial issues with the sex ratio data that make them inappropriate as the basis for an RMC.

3.4.3 Alternative RMCs for Floodplain Soil Based on Risks to Northern Short-Tailed Shrew

As noted in Section 2.4.3, the overall goal for protection of northern short-tailed shrews is ***to reduce the PCB concentrations in floodplain soils as necessary so that they do not prevent the presence of an abundant and sustainable population of short-tailed shrews in the Rest of River floodplain, to the extent that such a population can be supported by available habitat*.**

Numerical RMCs were presented in Section 2.4.3 for PCBs in floodplain soil based on the ERA's interpretation of Boonstra and Bowman's (2003) site-specific study on potential risks to the short-tailed shrew population. GE previously commented on the substantial uncertainties in the analysis presented in the ERA (BBL et al., 2003a, 2005). GE believes that the alternative numerical RMC proposed here is more consistent with the underlying study. Similar RMCs have not been developed for TEQs, because the ERA predicted no appreciable risks to the short-tailed shrew from TEQs (ERA, Vol. 2, pp. 10-42).

Boonstra and Bowman's (2003) field study assessed whether PCBs were adversely affecting the population demography of short-tailed shrews living in their natural environment. The

investigators reported that there were no statistically significant relationships between any of the demographic parameters (i.e., density, survival, sex ratio, reproduction rates, growth and body weight) and the spatially weighted or arithmetic mean concentration of PCBs in floodplain soil in the sampling grids (Boonstra and Bowman, 2003). EPA subsequently reanalyzed the data from this study and found a statistically significant relationship between PCB concentrations in the study grids and shrew survival (ERA, Vol. 6, pp. J-54 - J-55, J-64 - J-66). In response, Dr. Boonstra reanalyzed the data using EPA's exposure assumptions and again found no statistically significant relationship between PCB concentrations and survival (BBL et al. 2003a, Attachment R). Finally, EPA performed a hockey stick regression of the arithmetic mean soil PCB data and shrew survival, and based thereon, it established a MATC of 21.1 mg/kg in soil (ERA, Vol. 6, p. J-82).

Based on review of all the data from and analyses of the Boonstra and Bowman (2003) study, GE believes that the weight of evidence from that study provides no evidence of significant or meaningful adverse effects of PCBs on Housatonic River shrew populations. This conclusion is supported by the following:

- In assessing the effects on survival, GE believes that Dr. Boonstra's reanalysis of the data is more appropriate than EPA's reanalysis. The model used in EPA's reanalysis (Bailer and Oris, 1997) was, according to the cited publication, specifically designed for application to laboratory experiments in which the responses of replicated groups of test organisms exposed to a chemical over a range of concentrations are compared to responses of unexposed control groups. Dr. Boonstra's study, in contrast, was a field study designed to compare shrew populations inhabiting sites with varying habitat quality and contrasting (high vs. low) PCB concentrations. The application of the Bailer and Oris model to Dr. Boonstra's data is contrary to the underlying assumption of this model (i.e., that PCBs are the only factors influencing the populations on each study site).

- In any event, as some of the peer reviewers noted, the fact that the statistical significance of the survival results depends on subtle differences between two statistical methods indicates than any such effect is "borderline" (EPA, 2004c, p. 294 [Forbes]) and "not strong" (EPA, 2004c, p. 298 [Thompson]).

- As noted in Section 2.4.3, the ERA acknowledged that if the same hockey stick regression analysis used to establish the MATC is conducted on the spatially weighted mean soil data

(rather than the arithmetic mean data), the results are only borderline significant (EPA, 2005b, p. 62).

- It is undisputed that this study showed no effects of PCBs on any of the other demographic parameters evaluated in the study.

In short, since survival was the only endpoint for which any statistically significant effect was found by EPA, and since the significance of the survival effect depends on which statistical approach and concentration averaging method are used, any PCB-related difference in survival (if any) are marginal and should have no measurable influence on shrew abundance or reproductive success. This is consistent with both with EPA's finding that shrews are the most abundant small mammals on the floodplain (ERA,Vol. 6, p. J-58), and with Boonstra and Bowman's (2003) finding that the short-tailed shrew densities observed in their study are the highest ever reported.

In these circumstances, GE believes that it is reasonable to consider the highest PCB soil concentration involved in the Boonstra and Bowman (2003) study as essentially an unbounded NOAEL. The highest spatially weighted average PCB concentration in floodplain soil in that study was 43.5 mg/kg. Accordingly, GE proposes an alternative RMC of greater than 43.5 mg/kg in floodplain soil for the protection of short-tailed shrews.

3.4.4 Alternative RMCs for Fish Tissue Based on Risks to Fish

As noted in Section 2.4.4, the overall goal for protection of fish is ***to reduce PCB and TEQ concentrations in fish as necessary so that they do not prevent the presence of healthy and self-sustaining populations of fish in the Rest of River, to the extent that such a population can be supported by available habitat***.

Numerical RMCs were presented in Section 2.4.4 for PCBs and TEQs in fish tissue (whole body) based on risks to fish according to the ERA's interpretation of EPA's two-phase site-specific fish reproduction study (Tillitt et al., 2003a, 2003b). GE previously detailed how limitations in the ERA's analysis of these studies led to overly conservative effects thresholds (BBL et al., 2003a). Alternative RMCs are presented in this subsection that GE believes are more consistent with the data. Such alternative RMCs are proposed for both PCBs and TEQs because the ERA established MATCs for both.

The two phases of this fish reproduction study were summarized in Section 2.4.4. A careful review of the data from this study reveals that it did not show consistent relationships between PCB exposure and adverse effects. While the study did find various statistically significant relationships between at least one Housatonic River site and the reference site for a number of adult and offspring endpoints, those differences were not consistent among sites or among developmental phases or between the Phase I and Phase II, and did not show clear exposure-response relationships with PCBs (BBL et al., 2003a, Attachment I).

For the reasons given in GE's prior comments (BBL et al., 2003a, Attachment I), the threshold reported in the ERA for Phase I of the study, as a LOAEL for reduced survival and increased abnormalities in largemouth bass, is not correct because those effects did not occur consistently across Housatonic River sites, did not consistent show exposure-response relationships with PCBs, and were not related to PCB exposure in Phase II. Rather, the Phase I results support an unbounded NOAEL of >149 mg/kg PCB ww, the highest tissue concentration from the study for largemouth bass (Tillitt et al., 2003a).

Phase II provides some limited evidence of effects. The ERA identified a variety of egg-based effect levels (ED50 concentrations in eggs) for the three species evaluated, depending on the location from which the extract was taken, the life stage at which the effect was seen, and the particular trial (ERA, Vol. 5, Table F.3-10). In previous comments (i.e., BBL et al., 2003a, Attachment I), GE identified a number of flaws in these analyses and showed that the ERA's estimates of toxicity thresholds are lower than can be supported by the data. Nonetheless, those thresholds were used here to calculate alternative RMCs, which are highly conservative. As discussed in Section 2.4.4, based on review of the Phase II data presented in the ERA (Vol. 5, Table F.3-10), the species-specific ED50 values for eggs were 185 mg/kg ww PCBs (118 ng/kg ww TEQ) for largemouth bass and means of 144 mg/kg ww PCBs (114 ng/kg ww TEQ) for medaka and 86 mg/kg PCBs (62 ng/kg ww TEQ) for rainbow trout. As shown in GE's prior comments (BBL et al., 2003a, Attachment I), there is no basis for EPA's use of a factor of 0.5 to convert egg concentrations to adult tissue concentrations; no such conversion factor is necessary.

The lack of effects in Phase I of the study and the limited effects in Phase II are consistent with the results of the field surveys conducted by both EPA and GE, which showed no evidence of adverse population-level effects in fish in the PSA (Woodlot, 2002; R2, 2002; Reiser et al.,

2004). In particular, GE's field study demonstrated that there is a healthy self-sustaining population of largemouth bass in the PSA (R2, 2002; Reiser et al., 2004).

Based on the above-referenced data and interpretations, GE proposes a range of alternative RMCs for protection of fish. For fish in the PSA, the proposed alternative range would encompass the thresholds for all of the species evaluated – i.e., 86 to 185 mg/kg ww for PCBs and 62 to 118 ng/kg ww for TEQs. For warmwater fish downstream of the PSA, GE proposes the same range of RMCs identified above, excluding the rainbow trout data. This range is 144 to 185 mg/kg ww for PCBs and 62 to118 ng/kg ww for TEQs. For coldwater species downstream of the PSA, GE proposes the rainbow trout thresholds from the Phase II study – i.e., 86 mg/kg ww for PCBs and 62 ng/kg ww for TEQ – as alternative RMCs.

3.4.5 Alternative RMCs for Fish Tissue Based on Consumption by Mink and Otter

As discussed in Section 2.4.5, the overall goal for protection of mink and otter is, ***in areas of appropriate habitat, to reduce PCB concentrations in Housatonic River fish and other mink and otter prey items from the Rest of River, as necessary, so that they do not prevent the presence of sustainable populations of mink and otter that use the Rest of River as part of their home range***.

Numerical concentration-based RMCs were developed for PCBs in the tissue of prey items consumed by mink and otter in Section 2.4.5 based on the ERA's interpretation of EPA's site-specific mink feeding study (Bursian et al., 2003). GE previously commented on the substantial uncertainties in the ERA's the analysis of that study (BBL et al., 2003a, 2005). An alternative RMC is proposed in this subsection based on GE's interpretation of the same site-specific study. That alternative RMC would apply to the average PCB levels in all prey items (combined) consumed by mink and otter. RMCs were not developed for TEQs in these prey items because the ERA found that risks posed to mink and otter from TEQs were unlikely to exceed risks than from PCBs (see ERA, Vol. 2, p. 9-53; Vol. 6, p. I-114). The ERA did not develop a MATC for TEQs in mink or otter diet (see ERA, Vol. 6, pp. I-113, I-114).

The basis for the alternative RMC for PCBs in the diet of mink and otter is the mink feeding study conducted by EPA contractors (Bursian et al., 2003), which is summarized in Section 2.4.5. As discussed above, for 6-week kit survival, that study reported a LOAEL of 3.7 mg/kg in

diet and a NOAEL of 1.6 mg/kg in diet. A supplemental probit analysis by EPA estimated an LC20 of 0.984 mg/kg for the same endpoint (ERA, Vol. 6, pp. I-52, I-106). However, for several reasons, GE does not believe that this study provided definitive evidence of adverse effects on kit survival. Those reasons include the following:

- GE conducted an independent statistical analysis of the survival data from this study (BBL et al., 2003a, Attachment N), using essentially the same statistical method used by the authors (Bursian et al., 2003) and reported in the July 2003 draft of the ERA – i.e., an independent repeat measures ANOVA – with one key difference. In GE's analysis, percent survival was calculated by litter within treatments – that is, kit survival for a treatment was calculated based on the average survival in individual litters – instead of being calculated across all kits within a treatment regardless of the litter of origin, as was apparently done by the authors. GE's approach is appropriate because it accounts for the effect of litter on survival. GE's analysis showed no significant effect upon survivability due to dietary treatment (BBL et al., 2003a, Attachment N). The resulting unbounded NOAEL for survival for this study is 3.7 mg/kg PCBs in diet.

- While the probit analysis presented in the ERA was found to be significant, it is apparent, based on Figure I.3-4 of the ERA (Vol. 6), that the probit curve and in particular the confidence intervals do not adequately reflect the spread in results across all treatment groups. As shown by BBL et al. (2005), the survival data are highly variable, and no dose-response is evident, especially given that the second highest treatment group had the highest survivability for the 6-week kit survival endpoint. Moreover, the probit analysis provides a modeled or estimated threshold dose, while the NOAEL determined by ANOVA provides a measured threshold dose.

- In its 2005 Responsiveness Summary, EPA suggested that the NOAEL and LOAEL represent test levels that might not necessarily correspond to biologically relevant thresholds (EPA, 2005b, p. 56). It also suggested that problems with experimental design, such as small sample size and improper spacing of treatment doses, may "mistakenly indicate that a substance is less toxic than it really is" (EPA, 2005b, pp.56). These comments were taken from the literature and reflect potential issues in the use of NOAELs and LOAELs in the interpretation of exposure-response data. However, they are not directly relevant to the specific design employed in the mink feeding. That study focused on reproduction, which is a biologically relevant endpoint; and it had a large sample size

and used a tightly bracketed range of five exposures (i.e., 0.34 to 3.7 mg/kg diet) that was based specifically on prior studies evaluating reproductive effects of PCBs on mink.

- In any event, as shown in GE's prior comments (BBL et al., 2003a), kit mortality prior to 6 weeks in this study cannot be attributed to PCB exposure since no necropsy data were reported for those kits, and necropsies on kits that died later showed that their deaths were due to non-PCB-related causes.

For these reasons, GE believes that EPA's mink feeding study did not provide clear evidence of adverse effects on mink, even at the highest dose in the study, which was 3.7 mg/kg PCBs in diet. Based on this conclusion, GE proposes an alternative RMC of greater than 3.7 mg/kg for PCBs in the total diet of mink and otter that is obtained from the Rest of River area.

Moreover, in considering the overall goal of addressing PCB impacts that would prevent the presence of a sustainable population of mink and otter that use the Rest of River as part of their home range, GE believes that the results of its field survey of mink and otter (Bernstein et al., 2003) are relevant. That survey indicated, based on the spatial and temporal distribution of mink and otter tracks and other signs, that even under current conditions, mink and river otter use the PSA as part of their home range in estimated numbers that are within the range of densities that might be expected for such riverine habitat based on the literature (Bernstein et al., 2003; BBL et al., 2003a, Attachments O and P).

3.4.6 Alternative RMCs for Fish Tissue Based on Consumption by Ospreys

As noted in Section 2.4.6, the overall goal for protection of ospreys is, ***in areas of appropriate habitat, to reduce PCB concentrations in Housatonic River fish as necessary so that they do not prevent the presence of a population of ospreys in the Rest of River, taking into account the home range of such osprey***.

In Section 2.4.6, numerical RMCs were presented for PCBs in fish tissue (whole body) based on fish consumption by osprey in the Rest of River, using methods and assumptions consistent with the ERA. However, consistent with prior GE comments (BBL et al., 2003a), we believe that the ERA employed a number of overly conservative assumptions and that more accurate and realistic RMCs can be generated using alternative methods. Such alternative numerical RMCs for PCBs are presented in this subsection. RMCs were not developed for TEQs because the

ERA predicted lower risks to the osprey from TEQs than from PCBs and indeed characterized the TEQ risks as unclear (ERA, Vol. 2, p. 8-42; Vol. 6, pp. H-73, H-74). Separate alternative PCB RMCs have been developed for breeding and transient ospreys in the Rest of River area.

To generate alternative RMCs, the HQ equation was solved for the fish concentration term, as follows:

$$RMC_{fish} = THQ * TRV / (FT * FIR)$$

Where:

RMC_{fish} = Concentration of PCBs in fish that will not cause exceedance of TRV (mg/kg)
THQ = Target hazard quotient (unitless)
TRV = Toxicity reference value (mg/kg bw/d)
FT = Foraging time (unitless)
FIR = Normalized food intake rate (kg/kg bw/d)

In this equation, the target HQ (THQ) was set at 1.0 to ensure that the dose does not exceed the TRV. RMCs were calculated based on three TRVs. To represent the most sensitive species, we used a TRV of 1.4 mg/kg bw/d, which reflects the NOAEL for the most sensitive wild avian species, the mallard, in a study by Custer and Heinz (1980). This study provides a more appropriate basis for the TRV than the dated Lillie et al. (1974) study on white leghorn chickens, which was used in the ERA, because chickens are domesticated and are substantially more sensitive than wild species to PCBs (Bosveld and Van den Berg, 1994). To represent the most tolerant species, we used a TRV of 15.7 mg/kg bw/d, which is the site-specific and stressor-specific dose-based effect metric derived from Custer's (2002) study on tree swallows breeding on the Housatonic River. This site-specific study offers the advantages of temporal and spatial representativeness, as well as consistency in the PCB mixture and habitat variables. Furthermore, because Custer (2002) demonstrated that Housatonic River tree swallows are more tolerant of PCBs than are the American kestrels studied by Fernie et al. (2001) (i.e., the tree swallow TRV is higher than that of kestrels), it is appropriate to use this tree swallow study to represent the most tolerant avian species in defining the range of avian TRVs. The third TRV, 8.55 mg/kg bw/d, is the midpoint of the other two TRVs.

RMCs were initially calculated based on the assumption that 100% of the osprey's foraging time (FT) is within the Rest of River (ERA, Vol. 2, p. 8-11; Vol. 6, pp. H-23, H-24). Fish were assumed to comprise 100% of the osprey's diet (ERA, Vol. 2, p. 8-13; Vol. 6, p. H-26).

The ERA modeled the food intake rate (FIR) of ospreys from a bird algorithm that is not specific to ospreys, but is instead based on Charadriiformes (a taxonomic order that does not include ospreys or any piscivorous birds of prey). Because this algorithm requires inputs for various factors for which limited data are available, the results are highly uncertain. In particular, because Charadriiformes tend to be substantially smaller than ospreys, their metabolism and normalized food intake rate are substantially higher than those of ospreys. Given these limitations, alternative RMCs for ospreys were calculated based on the measured food intake rate of 0.21 kg/kg bw/d for free-living ospreys (Poole, 1983) listed in EPA's (1993) *Wildlife Exposure Factors Handbook.*

Based on the methods and assumptions described above, the resulting range of alternative RMCs for PCBs in fish is 6.7 mg/kg to 75 mg/kg, with a midpoint of 41 mg/kg. These RMCs are applicable only to ospreys breeding in the Rest of River, since they assume that 100% of the osprey's foraging time is within the Rest of River.

For the same reasons given in Section 2.4.6, numerical RMCs have also been calculated for transient ospreys in the Rest of River. These RMCs were based on the assumption that ospreys are present in the Rest of River only 3 days per year (0.8% of the year) as they are migrating. Applying a value of 0.008 for the FT term in the equation above, and using all other exposure assumptions and TRVs described above, yields RMCs for PCBs in fish in the range of 833 mg/kg to 9,345 mg/kg, with a midpoint of 5,089 mg/kg.

In conclusion, the alternative PCB RMCs for ospreys breeding within the Rest of River (if any) range from 6.7 mg/kg to 75 mg/kg in fish tissue, with a midpoint of 41 mg/kg. The alternative RMCs for transient ospreys range from 833 to 9,345 mg/kg, with a midpoint of 5,089 mg/kg.

3.4.7 Alternative RMCs for Fish Tissue Based on Consumption by Bald Eagles

As noted in Section 2.4.7, the overall goal for protection of bald eagles is, ***in areas of appropriate habitat, to reduce PCB concentrations in Housatonic River fish as necessary***

so that they do not have adverse reproductive effects on bald eagles in the Rest of River, taking into account the home range of such eagles.

In Section 2.4.7 of this proposal, numerical risk-based RMCs were presented for PCBs in fish tissue (whole body) based on fish consumption by bald eagles in the Rest of River, using methods and assumptions consistent with the ERA. However, based on prior GE comments (BBL et al., 2003a), we believe that the ERA employed a number of overly conservative assumptions and that more accurate and realistic RMCs can be generated using alternative methods. Such alternative numerical RMCs for PCBs in fish (whole body) based on consumption by bald eagles are presented in this subsection. Separate alternative PCB RMCs have been developed for resident and transient bald eagles. Those developed for resident bald eagles apply to both breeding and wintering eagles, while those developed for transient bald eagles apply to eagles that temporarily forage at the Rest of River during migration. RMCs were not developed for TEQs because the ERA did not predict greater risks to bald eagles from TEQs than from PCBs (both were considered high – see ERA, Vol. 2, p. 11-46; Vol. 6, p. K-88) and did not develop a MATC or other threshold concentrations for TEQs in fish based on consumption by bald eagles (see ERA, Vol. 6, pp. K-68 - K-69).

Like the MATC presented for bald eagles in the ERA (discussed in Section 2.4.7), the alternative RMC reflects the concentration of PCBs in fish that yields a maternal dose that leads to a bald eagle egg concentration equal to the egg-based TRV. To derive that RMC mathematically, the target HQ of 1.0 was first set equal to the ratio of the estimated PCB concentration in eggs ([egg] in mg/kg) to the egg-based TRV (TRV_{egg} in mg/kg). This is equivalent to setting the estimated egg concentration equal to the egg-based TRV – i.e.:

$$[egg] = TRV_{egg}$$

From Bargar et al.'s (2001) work, the estimated egg concentration may also be expressed as a function of the maternal body burden:

$$[egg] = CR_{e:a} * [adult]$$

Where:

$CR_{e:a}$ = Concentration ratio of eggs to adults (unitless)

[egg] = Estimated concentration of PCBs in eggs (mg/kg)

[adult] = Adult body burden of PCBs (mg/kg)

Since the previous two equations both define the estimated concentration of PCBs in eggs [egg], they may be set equal to one another:

$$TRVegg = C\,\mathrm{R}_{e:a} * [adult]$$

Next, the adult body burden [adult] was calculated consistent with the ERA (Vol. 6, pp. K-27 to K-29):

$$[adult] = \sum_{j=2}^{30} CAE * FT * FIR * RMC_{fish} * P_{fish} * 1day$$

Where:

[adult] = Adult body burden of PCBs (mg/kg)

j = Days in pre-laying period (days)

CAE = Chemical absorption efficiency (unitless)

FT = Foraging time (unitless)

FIR = Normalized food intake rate (kg/kg bw/d)

RMC_{fish} = Concentration of PCBs in fish that will not result in exceedance of TRV_{egg} (mg/kg)

P_{fish} = Proportion of fish in diet (unitless)

The preceding two equations were then combined as follows:

$$TRV_{egg} = C\,\mathrm{R}_{e:a} * \sum_{j=2}^{30} CAE * FT * FIR * RMC_{fish} * P_{fish} * 1day$$

Finally, the RMC in fish was calculated by solving the above equation for RMC_{fish}. Microsoft Excel's solver function was used to facilitate solving this equation for RMC_{fish}. The basis for each input value is summarized below.

Consistent with the ERA, (Vol. 6, p. K-29), bald eagles were assumed to arrive at the Rest of River with no PCB load 30 days before initiating egg-laying. Hence, accumulation of PCBs was calculated over days 2 through 30 of the pre-laying period.

Alternative RMCs were calculated based on two egg-based TRVs for bald eagles, as well as the midpoint of those two TRVs. The minimum alternative RMC was calculated using the Stratus (1999) TRV of 20 mg/kg, which was also employed in the ERA. The maximum alternative RMC was calculated using another high-quality field study on bald eagles by Donaldson et al. (1999), which yielded a TRV of 50 mg/kg. The midpoint of those two TRVs, 35 mg/kg, was used to calculate the midpoint alternative RMC for bald eagles.

Consistent with the ERA, (Vol. 6, p. K-28, K-29), the concentration ratio of eggs to adults ($CR_{e:a}$) was set equal to the mean value of 0.22, as reported by Bargar et al. (2001) for white leghorn chickens. It was conservatively assumed that avian species do not metabolize PCBs (ERA, Vol. 6, p. K-27). Consistent with the ERA (Vol. 6, p. K-28), the chemical absorption efficiency (CAE) for fish was assumed to be 0.89. In order to initially focus the analysis on resident bald eagles, foraging time (FT) was assumed to be 1.0. The proportion of fish in the diet (P_{fish}) was assumed to be 0.786, consistent with the ERA (Vol. 2, p. 11-12; Vol. 6, p. K-16, Table K.2-1).

The normalized food intake rate (FIR) was assumed to be 0.12 g/g BW/d, based on the value reported in EPA's (1993) *Wildlife Exposure Factors Handbook* from the Stalmaster and Gessaman (1984) study of free-flying adult bald eagles in Washington and from the Craig et al. (1988) study of free-flying adult bald eagles in Connecticut. This FIR differs from that used in the ERA, which was modeled based on an algorithm for birds in general, rather than bald eagles in particular. The general bird algorithm required inputs for several key factors for which there are limited data, but which are shown in the sensitivity analysis to strongly influence the results (ERA, Vol. 6, Table K.2-7). Although the ERA dismissed the Stalmaster and Gessaman (1984) and Craig et al. (1988) studies on the ground that some eagles apparently did not feed exclusively at the established feeding stations (ERA, Vol. 6, pp. K-14, K-15), the measured rates reported by Stalmaster and Gessaman (1984) and Craig et al. (1988) were employed in this analysis because EPA's (1993) *Wildlife Exposure Factors Handbook* recognizes that measured rates are preferable to modeled rates.

Based on these methods and exposure assumptions, the alternative egg-based RMCs for PCBs in fish that are protective of resident bald eagles range from 37 mg/kg to 93 mg/kg, with a midpoint of 65 mg/kg. These RMCs are applicable only to bald eagles breeding or wintering in the Rest of River, since they assume that 100% of the eagle's foraging time is within the Rest of River.

Alternative RMCs have also been calculated for transient bald eagles, based on the assumption that some bald eagles are present in the Rest of River only 3 days per year (0.8% of the year) as they are migrating. Applying a value of 0.008 for the FT term in the equation above, and using all other exposure assumptions and TRVs described above, yields egg-based RMCs for PCBs in fish ranging from 4,668 mg/kg to 11,670 mg/kg, with a midpoint of 8,169 mg/kg. These values are proposed as alternative RMCs for transient bald eagles.

3.4.8 Alternative RMCs for Aquatic Invertebrates Based on Consumption by Wood Ducks

As noted in Section 2.4.8, the overall goal for protecting wood ducks is, ***in areas of appropriate habitat, to reduce PCB and TEQ concentrations in Housatonic River aquatic invertebrates as necessary so that they do not prevent the presence of a population of wood ducks in the Rest of River***.

In Section 2.4.8, numerical RMCs were presented for PCBs in aquatic invertebrates based on consumption by wood ducks in the Rest of River, using methods and assumptions consistent with the ERA. However, for reasons given in prior GE comments (BBL et al., 2005), we believe that the ERA employed a number of overly conservative assumptions and that more accurate and realistic RMCs can be generated using alternative methods. Such alternative numerical RMCs are presented in this subsection. Such RMCs have been developed for both total PCBs and TEQs, because the ERA concluded that, while the predicted risks from both PCBs and TEQs are similar in magnitude, the certainty of the predicted TEQ risks to wood ducks is slightly higher than that for PCBs (ERA, Vol. 2, pp. 7-67, 7-68; Vol. 5, p. G-130, Tables G.4-22, G.4-23).

To generate alternative RMCs, the HQ equation was solved for the prey concentration term, while holding the HQ value at a target level of 1.0. While the ERA generated HQs for PCBs as the ratio of modeled doses to dose-based TRVs, its HQs for TEQs were egg-based – i.e., expressed as the ratio of modeled concentrations of TEQs in wood duck eggs to egg-based TRVs (ERA, Vol. 2, pp. 7-11, 7-53 – 7-57; Vol. 5, pp. G-86, G-89 – G-91). However, for the alternative RMCs, dose-based TRVs were used to generate RMCs for both PCBs and TEQs due to concerns with the certainty of the egg-based approach and effects metric. In particular, as detailed in Attachment 29 (in Appendix E), the use of the Bargar et al. (2001) study to estimate maternal transfer biases the TEQ RMCs low. Using white leghorn chickens, Bargar et al. (2001) quantified maternal transfer of PCBs to eggs based on ratios of concentrations in

eggs and hens. Due to the considerable differences in the relative masses of hens and eggs between white leghorn chickens and wood ducks, Bargar et al.'s (2001) concentration ratio overestimates maternal transfer in wood ducks. In addition, use of the egg-based TEQ TRVs derived from the field study of wood ducks (White and Seginak, 1994) used in the ERA would introduce a number of confounding factors into the analysis. For example, White and Seginak (1994) employed the International TEQ system (EPA, 1989b), whereas the ERA employed the World Health Organization's TEQ system (Van den Berg et al., 1998) (ERA, Vol. 2, p. 7-41; Vol. 5, p. G-84). In addition, the mixtures of dioxins, furans, and PCBs differ substantially between the Rest of River and the site where that study was conducted, Bayou Meto, Arkansas. Dioxins are the main constituents in Bayou Meto, while PCBs are predominant in the Rest of River. The different mixtures may have different toxicities that are not fully reflected in TEQs. These differences, as well as other potential inter-site differences (e.g., in food sources, bioenergetics, co-contaminants, breeding season duration, etc.), would contribute further uncertainty to egg-based TEQ RMCs. For these reasons, dose-based TRVs were used to generate RMCs.

The following equations and assumptions were employed in deriving the alternative dose-based RMCs:

$$RMC_{prey} = THQ * TRV / (FT * P_i * FIR)$$

Where:

RMC_{prey}	=	Concentration of PCBs in wood duck prey that will not result in exceedance of dose-based TRV (mg/kg)
THQ	=	Target hazard quotient (unitless)
TRV	=	Toxicity reference value (mg/kg bw/d)
FT	=	Foraging time (unitless)
P_i	=	Proportion of invertebrates in diet (unitless)
FIR	=	Normalized food intake rate (kg/kg bw/d)

As previously noted, the THQ was set at 1.0 to ensure that the dose does not exceed the TRV. For PCBs, the same three dose-based TRVs discussed in connection with ospreys in Section 3.4.6 were used – i.e., (a) 1.4 mg/kg bw/d, reflecting the NOAEL for the mallard (Custer and Heinz, 1980), to represent the most sensitive wild avian species; (b) 15.7 mg/kg bw/d, derived

from Custer's (2002) study on tree swallows breeding on the Housatonic River, to represent the most tolerant species; and (c) 8.55 mg/kg bw/d, the midpoint of the other two TRVs.

Similarly, three dose-based TRVs for TEQs were employed. The first, 44 ng/kg bw/d, reflects the geometric mean of the NOAEL and LOAEL for the most sensitive wild avian receptor, the ring-necked pheasant (Nosek et al., 1992). The second, 25,000 ng/kg bw/d, is the threshold at which Hoffman et al. (1996) observed statistically significant effects in American kestrels (although the effects observed did not translate into significant effects on hatchling success or growth). The third, 13,000 ng/kg bw/d, is the midpoint of the other two TRVs. [The TRVs of 44 ng/kg bw/d and 25,000 ng/kg bw/d were also employed in the ERA to evaluate TEQ risks to avian species other than wood ducks (ERA, Vol. 1, pp. 7-40, 8-20; Vol. 5, p. G-83; Vol. 6, p. H-48).]

RMCs were calculated based on an assumed foraging time (FT) of 1.0. The proportion of invertebrates in the diet (P_i) was assumed to be 0.645, based on the average of the diets during the pre-laying and egg-laying periods (Drobney and Fredrickson, 1979; Drobney, 1980).

The normalized food intake rate (FIR) was calculated as:

$$FIR = (FMR * CF) / \sum_{i=1}^{n} (AE_i * G_i * P_i * BW)$$

Where:

FIR	=	Normalized food intake rate (g/g bw/d)
FMR	=	Free metabolic rate (kJ/d)
CF	=	Conversion factor (0.239 kcal/kJ)
i	=	Prey item type (unitless)
AE	=	Assimilation efficiency (unitless)
G	=	Gross energy (kcal/g)
P_i	=	Proportion of prey item i in diet (unitless)
BW	=	Body weight (g)

Inputs for calculating the FIR were all consistent with values employed in the ERA (Vol. 5, pp. G-45, G-46, Table G.2-33). The assimilation efficiencies (AEs) of terrestrial invertebrates and aquatic invertebrates by birds were assumed to be 0.72 and 0.77, respectively, based on

Karasov (1990), Ricklefs (1974), and Bryant and Bryant (1988). Terrestrial and aquatic invertebrates were assumed to have gross energies (G) of 1,600 kcal/kg and 1,100 kcal/kg, respectively, based on Cummins and Wuycheck (1971), Collopy (1975), Bell (1990), Tyler (1973), Jorgensen et al. (1991), Minnich (1982), and Thayer et al. (1973). The proportion of diet comprised of terrestrial invertebrates was assumed to be 0.166, while the proportion of diet comprised of aquatic invertebrates was assumed to be 0.479, based on Drobney and Fredrickson (1979).

The free metabolic rate (FMR) was calculated as:

$$FMR = a * BW^{b}$$

Where:

FMR	=	Free metabolic rate (kJ/d)
a	=	Slope (kJ/g-d)
BW	=	Body weight (g)
b	=	Power (unitless)

Average values reported in the ERA (Vol. 5, pp. G-45, G-46, Table G.2-33) for all three terms were applied, including a slope of 10.5, body weight of 564 g, and power of 0.68.

Using these procedures, the range of alternative RMCs for PCBs in wood duck prey is 6.1 mg/kg to 68 mg/kg, with a midpoint of 37 mg/kg. The range of alternative RMCs for TEQs in wood duck prey is 1.9×10^{-4} mg/kg to 1.1×10^{-1} mg/kg, with a midpoint of 5.5×10^{-2} mg/kg. These TEQ RMCs are equal to a range of 190 ng/kg to 109,000 ng/kg, with a midpoint of 54,500 ng/kg.

4.0 POTENTIAL CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

The Reissued RCRA Permit requires that, in addition to proposing IMPGs, the IMPG Proposal must "take into account" applicable or relevant and appropriate requirements (ARARs) under federal and state laws and regulations. To address this requirement, GE reviewed pertinent federal and state environmental laws and regulations to identify requirements that establish chemical-specific standards or criteria for PCBs or TEQs in particular media present in the Rest of River area and that would meet the definition of ARARs in the NCP (40 CFR § 300.5).

In this regard, GE focused on PCBs and TEQs for the same reasons discussed in Section 1.3 above. Further, GE limited its review to requirements that establish chemical-specific standards or criteria for particular media (i.e., sediments, surface water, floodplain soil, biota, or air), because it is such standards or criteria that are suitable for being taken into account in this IMPG Proposal. While various other federal and state laws and regulations establish substantive requirements that could be applicable or relevant and appropriate to the selection or implementation of a remedy for the Rest of River and thus may ultimately be designated as action-specific or location-specific ARARs, they are not related to goals for constituents in particular media, which is the focus of this IMPG Proposal. Thus, GE focused its review on chemical-specific and media-specific requirements. Finally, GE limited its review to requirements that would qualify as ARARs in that they have been promulgated (after notice-and-comment rulemaking) under federal or state laws, are applicable or relevant and appropriate for the particular medium in question in the Rest of River, and, for state ARARs, are of general applicability, legally enforceable, and more stringent than federal requirements (see 40 CFR § 300.5; EPA, 1989c).

Based on this review, GE has identified certain criteria and standards that could potentially constitute chemical-specific ARARs for the Rest of River remedy. However, as discussed below, those criteria and standards would not constitute or affect the IMPGs because GE has developed site-specific RMCs that address the same receptors and pathways addressed by those criteria and that are fully protective of human health and the environment. A more detailed discussion of ARARs will be included in the CMS Report, along with the basis for a waiver of any ARARs that would not be met.

4.1 Federal Water Quality Criteria and State Water Quality Standards

GE has identified, as potential ARARs, the federal water quality criteria for PCBs and 2,3,7,8-TCDD (which would apply to TEQs), promulgated by EPA under Section 304(a) of the Federal Water Pollution Control Act (FWPCA) (33 USC § 1314), and the state water quality standards based on those criteria. The federal water quality criteria for PCBs are: (a) 0.014 µg/L, the freshwater chronic criterion, based on protection of mink; and (b) 0.000064 µg/L, based on human consumption of water and organisms at a 10^{-6} cancer risk (EPA, 2002). The federal water quality criteria for 2,3,7,8-TCDD are: (a) 5.1×10^{-9} µg/L, based on human consumption of organisms at a 10^{-6} cancer risk; and (b) 5.0×10^{-9} µg/L, based on human consumption of water and organisms at a 10^{-6} cancer risk (EPA, 2002).

The Massachusetts water quality standards provide that, for toxic pollutants such as PCBs and 2,3,7,8-TCDD, the federal water quality criteria published by EPA pursuant to Section 304 of the FWPCA will be used as standards unless a site-specific limit is established (314 CMR 4.05(5)(e)). Site-specific limits have not been adopted for PCBs and 2,3,7,8-TCDD in the Massachusetts portion of the Housatonic River. Thus, the above federal water quality criteria constitute the state water quality standards in Massachusetts.

For Connecticut, the state water quality standards for PCBs and 2,3,7,8-TCDD (as set forth in Connecticut Water Quality Standards, Appendix D) are as follows. For PCBs, the standards are: (a) 0.014 µg/L, the freshwater chronic criterion; and (b) 0.00017 µg/L, based on human consumption of water and organisms. For 2,3,7,8-TCDD, the standards are: (a) 1.4×10^{-8} µg/L, based on human consumption of organisms; and (b) 1.3×10^{-8} µg/L, based on human consumption of water and organisms. These values are the same as those in the prior version of the federal water quality criteria, which was in effect before EPA's adoption of revised criteria for human consumption of organisms or water and organisms in 2002.

GE has "taken into account" (i.e., considered) the federal water quality criteria and state water quality standards for PCBs and 2,3,7,8-TCDD. While these criteria and standards may ultimately be identified as ARARs for the Rest of River remedy, GE does not believe that they should be identified as IMPGs at this point for several reasons. First, GE has developed ranges of site-specific RMCs to address the same receptors and pathways addressed by the water quality criteria and standards, to the extent that the EPA risk assessments found significant risks for those receptors and pathways. Thus, as described above, GE has developed RMCs based

on protection of mink (Sections 2.4.6 & 3.4.6) and based on human consumption of organisms from the Housatonic River (Sections 2.4 and 3.4). (The Housatonic River is not used for human consumption of water; and as discussed in Section 1.3, a highly conservative screening-level evaluation performed by EPA of potential risks due to direct contact with the surface water of the river demonstrated that current levels of PCBs in the river are well below any levels that could present such risks.) Moreover, if the water quality criteria and standards are identified as ARARs, they are subject to waiver under the NCP if achievement of them is not technically practicable or would result in greater risks to human health or the environment than other alternatives or for other reasons specified in the NCP (40 CFR 300.430(f)(1)(ii)(C)). That evaluation has not yet been made; under the Reissued RCRA Permit (Special Condition II.G.1.c), it is part of the CMS Report. As a result, it is unknown at this point whether the federal water quality criteria and state water quality standards would serve as goals for the Rest of River remedy.

4.2 Connecticut Remediation Standards for Soil

GE has also considered the Connecticut Remediation Standard regulations (RSRs), which include specific numerical criteria for soil remediation based on direct human contact with the soil, and also allow for the development of alternative soil remediation criteria based on direct contact (Conn. Agencies Regs. 22a-133k-1 through -3). These criteria apply only to soil, which is defined as "unconsolidated geological material overlying bedrock, but *not including sediment*" (Conn. Agencies Regs 22a-133k-1, emphasis added). The RSRs establish separate direct exposure criteria for soil in residential areas and soil in industrial/commercial areas. The criteria for PCBs are 1 mg/kg for residential soil and 10 mg/kg for industrial/commercial soil (Appendix A to Conn. Agencies Regs. 22a-133k-1 through -3). (There are no such numerical criteria for TEQs or 2,3,7,8-TCDD.) However, the RSRs also allow the Commissioner of the Connecticut Department of Environmental Protection (CDEP) to approve alternative direct exposure criteria for PCBs if it can be shown that such alternative criteria will protect human health and the environment from risks associated with direct exposure to PCB-containing soil and are consistent with EPA's regulations under the Toxic Substances Control Act (40 CFR Part 761) and with EPA's 1990 "Guide on Remedial Actions at Superfund Sites with PCB Contamination" (Conn. Agencies Regs. 22a-133k-2(d)(7)).

GE does not believe that the RSRs' numerical direct exposure criteria for PCBs would constitute ARARs for the Rest of River in Connecticut. First, as noted above, these criteria are limited to soils and, by their terms, clearly do not apply to sediments. Second, the residential soil criterion is not an ARAR even for residential areas in the Rest of River floodplain because: (a) the RSRs allow for CDEP approval of an alternative direct exposure criterion; and (b) the Consent Decree, to which the CDEP is a party, establishes a PCB Performance Standard of 2 mg/kg, based on direct human exposure, for Actual/Potential Lawns in the Rest of River area (see Section 2.1.1 above), which the CDEP determined is protective of human health and the environment (CD, ¶ 8.b). That determination, in effect, constitutes the approval of an alternative criterion for a residential exposure scenario. Third, the RSRs' residential direct exposure criterion is not applicable or relevant to other (e.g., recreational) exposure scenarios in the Rest of River floodplain, since it was based on residential exposure assumptions (e.g., an assumed exposure frequency of 365 days per year) that do not apply to such other scenarios. Finally, in any case, the existing floodplain soil PCB data from Connecticut show no concentrations even close to 1 mg/kg, with a maximum concentration of 0.037 mg/kg (estimated).

In any event, regardless of whether the RSRs' direct exposure criteria are ultimately identified as ARARs for soil in residential areas and industrial/commercial areas in the Rest of River floodplain in Connecticut, GE does not believe that they should be considered IMPGs, because, as discussed above, GE has developed site-specific RMCs based on direct human contact for all the relevant exposure scenarios, and has shown that those site-specific RMCs are protective of human health from risks via that pathway.

5.0 REFERENCES

AMEC. 2001. *Development of a Revised Chronic Reference Dose for Polychlorinated Biphenyls (Aroclor 1254) Based on Empirical Data*. AMEC Earth & Environmental, Inc. May 31. Submitted to EPA Region 1 on June 6, 2001.

AMEC. 2002. *Comments of General Electric on EPA's Proposed Procedures and Assumptions for the Fish and Waterfowl Consumption Assessments for the Rest of River*. Prepared by AMEC Earth and Environmental, Inc. July 30.

AMEC and BBL. 2003. *Comments of the General Electric Company on the U.S. Environmental Protection Agency's Human Health Risk Assessment for the Housatonic River Site - Rest of River.* Prepared by AMEC Earth and Environmental, Inc. and BBL Sciences, Inc. July 28.

AMEC and BBL. 2005. *Comments of the General Electric Company on the Human Health Risk Assessment for the General Electric/Housatonic River Site, Rest of River (February 2005).* Prepared by AMEC Earth and Environmental, Inc. and BBL Sciences, Inc. April.

Amundson, D.S. 1984. *Organochlorine Pesticides and PCBs in Edible Tissues of Giant Canada Geese from the Chicago Area*. M.S. Thesis, University of Illinois at Chicago.

Bailer, A.J. and J.T. Oris. 1997. Estimating inhibition concentrations for different response scales using generalized linear models. *Environmental Toxicology and Chemistry* 16(7):1554-1559.

Bargar, T.A., G.I. Scott, and G.P. Cobb. 2001. Maternal transfer of contaminants: Case study of the excretion of three polychlorinated biphenyl congeners and technical-grade endosulfan into eggs by white leghorn chickens (*Gallus domesticus*). *Environmental Toxicology and Chemistry* 20:61-67.

BBL Sciences, ARCADIS G&M, Branton Environmental Consulting and LWB Environmental Services. 2003a. *Comments of General Electric Company on the Ecological Risk Assessment for the General Electric/Housatonic River Site, Rest of River (July 2003 Draft)*. September.

BBL Sciences, Branton Environmental Consulting, and W.J. Resetartis. 2003b. *Comments on the Final Report - Frog Reproduction and Development Study: 2000 Rana sylvatica Vernal Pool Study.* Prepared for General Electric Company. February.

BBL Sciences, Arcadis G&M, Branton Environmental Consulting, and LWB Environmental Services. 2005. *Comments of General Electric Company on the Ecological Risk Assessment for the General Electric/Housatonic River Site. Rest of River (November 2004 Draft).* January.

Bell, G.P. 1990. Birds and mammals on an insect diet: A primer on diet composition analysis in relation to ecological energetics. *Studies in Avian Biology* 12:391-415.

Bernier, J.E., J. Borak, D. Palumbo, R.C. James, R.E. Keenan, and J. Silkworth (contributors or reviewers). 2001. *Non-Cancer Effects of PCBs – A Comprehensive Literature Review*. January 4. Submitted to EPA Headquarters by the PCB Panel of the American Chemistry Council, the National Electrical Manufacturers Associated, and the Utility Solid Waste Activities Group. January 4, 2001.

Bernstein P., M. Chamberlain, ARCADIS G&M, Inc., BBL Sciences and Branton Environmental Consulting. 2003. *Evaluation of Piscivorous Mammals - Presence/Absence, Distribution and Abundance in the Housatonic River Floodplain*. Prepared for GE, Pittsfield, Massachusetts. June. Attachment O to BBL et al., 2003a (cited above).

Boonstra, R., and L. Bowman. 2003. Demography of short-tailed shrew populations living on polychlorinated biphenyl-contaminated sites. *Environmental Toxicology and Chemistry.* 22:1394-1403.

Bosveld, A.T.C., and M. Van den Berg. 1994. Effects of polychlorinated biphenyls, dibenzo-p-dioxins, and dibenzofurans on fish-eating birds. *Environmental Review* 2:147-166.

Bursian, S.J., R.J. Aulerich, B. Yamini, and D.E. Tillitt. 2003. Dietary Exposure of Mink to Fish from the Housatonic River: Effects on Reproduction and Survival. Revised Final Report. Michigan State

Bryant, D.M., and V.M. Bryant. 1988. Assimilation efficiency and growth of nestling insectivores. *Ibis* 130:268-274. University, Department of Animal Science. June 10.

Calabrese, E. 2003. Letter to Kevin W. Holtzclaw, GE, Re: Soil Ingestion Rates. July 23. Exhibit E.1 to AMEC and BBL, 2003 (cited above).

Castro, G., N. Stoyan, and J.P. Myers. 1989. Assimilation efficiency in birds: A function of taxon or food type? *Comparative Biochemistry Physiology A. Comparative Physiology* 92:272-278.

ChemRisk. 1991. *Consumption of Freshwater Fish from Maine Lakes and Ponds.* ChemRisk Division of McLaren/Hart, Portland, ME. September 6.

Cook, R.R. 1982. The role of epidemiology in risk assessment. *Drug Metab. Rev.* 13:913-923.

Collopy, M.W. 1975. Behavioral and predatory dynamics of kestrels wintering in the Arcata Bottoms. Master's Thesis. Arcata, California: Humboldt State University.

Craig, R.J., E.S. Mitchell, and J.E. Mitchell. 1988. Time and energy budgets of bald eagles wintering along the Connecticut River. *Journal of Field Ornithology* 59:22-32.

Cummins, K.W., and J.C. Wuycheck. 1971. Caloric equivalents for investigations in ecological energetics. Stuttgart, West Germany: International Association of Theoretical and Applied Limnology.

Custer, C.M. 2002. *Final Report to U.S. Environmental Protection Agency – Exposure and Effects of Chemical Contaminants on Tree Swallows Nesting Along the Housatonic River, Berkshire Co., Massachusetts, 1998-2000*. U.S. Geologic Survey, Biological Resources Division, LaCrosse, Wisconsin. July 8.

Custer, T.W., and G.H. Heinz. 1980. Reproductive success and nest attentiveness of mallard ducks fed Aroclor 1254. E*nvironmental Pollution* 21:313-318.

Dinman, B.D. and N.B. Sussman. 1983. Uncertainty, risk and the role of epidemiology in public policy development. *Journal of Occupational Medicine* 25:511-516.

Donaldson, G.M., J.L. Shutt, and P. Hunter. 1999. Organochlorine contamination in bald eagle eggs and nestlings from the Canadian Great Lakes. *Archives of Environmental Contamination and Toxicology* 36:70-80.

Drobney, R.D., and L.H. Fredrickson. 1979. Food selection by wood ducks in relation to breeding status. *Journal of Wildlife Management* 43:109-120.

Drobney, R.D. 1980. Reproductive bioenergetics of wood ducks. *Auk* 97:480-490.

Ebert, E.S., N.W. Harrington, K.J. Boyle, J.W. Knight, and R.E. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers. *N. Am. J. Fish. Mgt.* 13:737-745.

EPA. 1989a. *Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A) – Interim Final.* U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89-002. July.

EPA. 1989b. *Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and dibenzofurans (CDDs and CDFs) and 1989 Update.* U.S. Environmental Protection Agency. EPA/625/3-89/016. March.

EPA. 1989c. *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements*. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA/540/G-89/009. OSWER Directive 9234.1-02. August.

EPA. 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187a. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

EPA. 1997a. *Exposure Factors Handbook.* U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. Washington, DC. EPA/600/P-95/002. August.

EPA. 1997b. *Health Effects Assessment Summary Tables, FY 1997* Update. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA-540-R-97-036. July.

EPA. 1998. *Guidelines for Neurotoxicity Risk Assessment*. *Federal Register* 63(93):26926-26954.

EPA. 1999a. *Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund.* OSWER Directive 9285.7-28 P. October 7.

EPA. 1999b Memorandum from Ann-Marie Burke, Toxicologist, to Richard Cavagnero, GE Project Leader, Re: *Protectiveness of Cleanup Levels for Removal Actions Outside the River – Protection of Human Health*. Attachment A to Appendix D to Consent Decree in *United States et al. v. General Electric Company* (No. 99-30225-MAP, U.S. Dist. Court for Dist. of Mass.). August 4.

EPA. 1999c. *Report on FIFRA Scientific Advisory Panel Meeting, February 23-24, 1999.* Session III: Consultation on development of draft aggregate exposure assessment guidance document for combining exposure from multiple sources and routes. SAP Report No. 99-02. March 25.

EPA. 2001 *Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance, Dermal Risk Assessment Interim Guidance*. *Public Review Draft.* U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R/99/005. September.

EPA. 2002. *National Recommended Water Quality Criteria: 2002.* EPA-822-R-02-047. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology. November.

EPA. 2004a. *Ecological Risk Assessment for General Electric (GE)/Housatonic River Site, Rest of River.* Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. November 12.

EPA. 2004b. *Responsiveness Summary to the Peer Review of the Human Health Risk Assessment, GE/Housatonic River Site, Rest of River.* Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. March.

EPA. 2004c. *Responsiveness Summary to the Peer Review of the Ecological Risk Assessment, GE/Housatonic River Site, Rest of River.* Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. June.

EPA. 2005a. *Human Health Risk Assessment - GE/Housatonic River Site - Rest of River.* Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. February 11.

EPA. 2005b. *Responsiveness Summary to Public Comments on New Information - Ecological Risk Assessment for the GE/Housatonic River Site, Rest of River.* Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. March.

EPA. 2005c. *Responsiveness Summary to Public Comments on New Information - Human Health Risk Assessment for the GE/Housatonic River Site, Rest of River*. Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. June.

EPA. 2005d. *Guidelines for Carcinogen Risk Assessment (Final Guidelines)*. EPA/630/P-03/001B. Risk Assessment Forum, Washington, D.C. NCEA-F-0644. March.

EPA 2005e. Glossary of IRIS Terms, Revised 2005. Integrated Risk Information System, Cincinnati, OH http://www.epa.gov/iris/gloss8.htm

FEL (Fort Environmental Laboratories, Inc.). 2002. *Final Report – Frog Reproduction and Development Study: 2000 Rana sylvatica Vernal Pool Study.* Prepared by Fort Environmental Laboratories, Inc., Stillwater, Oklahoma.

Fernie, K.J., J.E. Smits, G.R. Bortolotti, and D.M. Bird. 2001. Reproductive success of American kestrels exposed to dietary polychlorinated biphenyls. *Environmental Toxicology and Chemistry* 20:776-781.

GE (General Electric Co.). 2003. *Comments of the General Electric Company on EPA's Human Health Risk Assessment for the GE - Housatonic River Site - Rest of River.* Presentation to the Peer Review Panel. General Electric Company, Pittsfield, MA. November 18.

GE (General Electric Co.). 2004. *Comments of the General Electric Company on the U.S. Environmental Protection Agency's Ecological Risk Assessment for the Housatonic River Site - Rest of River.* Presentation to the Peer Review Panel. General Electric Company, Pittsfield, MA. January 13.

Gilbert, M., R. LeClair, and R. Fortin. 1994. Reproduction of the northern leopard frog in floodplain of the Richelieu River, Quebec, Canada. *Journal of Herpetology* 28:465-470.

Golden, R. and P. G. Shields, 2001. Technical Report: A Weight-of-Evidence Review of the Human Studies of the Potential Cancer Effects of PCBs. Lombardi Cancer Center, Washington D.C. April 10.

Hake, M., N. Kjellen, and T. Alerstan. 2001. Satellite tracking of Swedish Ospreys *Pandion haliaetus*: autumn migration routes and orientation. *Journal of Avian Biology* 32: 47-56.

Hawley, J.K. 1985. Assessment of health risk from exposure to contaminated soil. *Risk Analysis* 5:289-302.

Hoffman, D.J., M.J. Melancon, P.N. Klein, C.P. Rice, J.D. Eisemann, R.K. Hines, J.W. Spann, and G.W. Pendleton. 1996. Developmental toxicity of PCB 126 (3,3,4,45-pentachlorobiphenyl) in nestling American kestrels (*Falco sparverius*). *Fundamental and Applied Toxicology* 34:188-200.

Jorgensen, S.E., S.N. Nielsen, and L.A. Jorgensen. 1991. *Handbook of Ecological Parameters and Ecotoxicoloty.* Elsevier Science Publishers, Amsterdam, The Netherlands.

Karasov, W.H. 1990. Digestion in birds: Chemical and physiological determinants and ecological implications. *Studies in Avian Biology* 13:391-415.

Kjellen, N., M. Hake, and T. Alerstan. 2001. Timing and speed of migration in male, female and juvenile Ospreys *Pandion haliaetus* between Sweden and Africa as revealed by field observations, radar and satellite tracking. *Journal of Avian Biology* 32:57-67.

Knuth, B.A., N.A. Connelly, and B.E. Matthews. 1998. *Children's Fishing and Fish Consumption Patterns.* Cornell University Human Dimensions Research Unit. HDRU Series No. 98-3. May.

Layard, M.W., and A. Silvers. 1989. Epidemiology in environmental risk assessment. In: *The Risk Assessment of Environmental and Human Health Hazards: A Textbook of Case Studies*. (D.J. Paustenbach, Ed.), pp. 157-173. John Wiley & Sons, New York.

Lillie, R.J., H.C. Cecil, J. Bitman, and G.F. Fries. 1974. Differences in response of caged white leghorn layers to various polychlorinated biphenyls (PCBs) in the diet. *Poultry Science* 53:726-732.

Martell, M., C. Henny, P. Nye, and M. Solensky. 2003. Fall migration routes, timing, and wintering sites of North American Ospreys as determined by Satellite telemetry. *The Condor* 103:715-724.

Merrell, D.J. 1977. *Life History of the Leopard Frog in Minnesota.* Occasional Papers 15. Bell Museum of Natural History, University of Minnesota. 23 pp.

Minnich, J.E. 1982. The use of water. In: Gans, C.; Pough, F.H. eds. *Biology of the Reptilia, Physiology C; Physiological Ecology*. V. 12. Academic Press, New York, New York.

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles and birds. *Annual Reviews in Nutrition* 19:247-277.

Nosek, J.A., S.R. Craven, J.R. Sullivan, S.S. Hurley, and R.E. Peterson. 1992. Toxicity and reproductive effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin in ring-necked pheasant. *Journal of Toxicology and Environmental Health* 35:187-198.

Poole, A.F. 1983. Courtship feeding, clutch size, and egg size in ospreys: A preliminary report. In: D.M. Bird, N.R. Seymour, J.M. Gerrard, eds. *Biology and Management of Bald Eagles and Ospreys.* Harpell Press, St. Anne de Bellevue, Quebec. pp. 243-256.

R2 (R2 Resource Consultants Inc.). 2002. *Evaluation of Largemouth Bass Habitat, Population Structure and Reproduction in the Upper Housatonic River, Massachusetts*. Prepared by R2 Resource Consultants Inc., Redmond, WA. Prepared for GE, Pittsfield, Massachusetts. July 23.

Reeder, A.L., G.L. Foley, D.K. Nichols, L.G. Hansen, B. Wikoff, S. Faeh, J. Eisold, M.G. Wheeler, R. Warner, J.E. Murphy, and V.R. Beasley. 1998. Forms and prevalence of intersexuality and effects of environmental contaminants on sexuality in cricket frogs (*Acris crepitans*). *Environmental Health Perspectives* 106:261-266.

Reiser, D.W., E.S. Greenberg, T.E. Helser, M. Branton, and K.D. Jenkins. 2004. In situ reproduction, abundance, and growth of young-of-year and adult largemouth bass in a population exposed to polychlorinated biphenyls. *Environmental Toxicology and Chemistry* 23:1762-1773.

Ricklefs, R.E. 1974. Energetics of reproduction in birds. In: Paynter, R.A. ed. *Avian Energetics*. Nuttall Ornithological Club, Cambridge, Massachusetts.

Silkworth, J.B., A. Koganti, K. Illouz, A. Possolo, M. Zhao, and S.B. Hamilton. 2005. Comparison of TCDD and PCB CYP1A induction sensitivities in fresh hepatocytes from human donors, Sprague-Dawley rats, and rhesus monkeys, and HepG2 cells. *Toxicol. Sci.* (Advance Access), July 27.

Stalmaster, M.V., and J.A. Gessaman. 1982. Food consumption and energy requirements of captive bald eagles. *Journal of Wildlife Management* 46:646-654.

Stalmaster, M.V., and J.A. Gessaman. 1984. Ecological energetics and foraging behavior of overwintering bald eagles. *Ecological Monographs* 54:407-428.

Stanek, E.J. and E.J. Calabrese. 1992. Soil ingestion in children: Outdoor soil or indoor dust? *J. Soil Contam*. 1(1):1-28.

Stanek, E.J., E.J. Calabrese, R. Barnes, and P. Pekaow. 1997. Soil ingestion in adults – results of a second pilot study. *Ecotoxicology and Environmental Safety* 36:249-257.

Stebbins, R.C. and N.W. Cohen. 1995. *A Natural History of Amphibians.* Princeton University Press, Princeton, NJ.

Stratus (Stratus Consulting, Inc.). 1999. Injuries to Avian Resources, Lower Fox River/Green Bay Natural Resource Damage Assessment. Final Report. Prepared for U.S. Fish & Wildlife Service, U.S. Department of the Interior and U.S. Department of Justice. May 7.

Swartout, J.C., P.S. Price, M.L. Dourson, H.L. Carlson-Lynch, R.E. Keenan. 1998. A probabilistic framework for the reference dose (probabilistic RfD). *Risk Analysis* 18(3):271-281.

Thayer, G.W., W.E. Schaaf, J.W. Angelovic, and M.W. LaCroix. 1973. Caloric measurements of some estuarine organisms. *Fishery Bulletin* 71:289-296.

Tillitt, D., D. Papoulias, and D. Buckler. 2003a. *Fish Reproductive Health Assessment in PCB Contaminated Regions of the Housatonic River, Massachusetts, USA: Investigations of Causal Linkages Between PCBs and Fish Health. Final Report of Phase I Studies*. Prepared for U.S. Fish and Wildlife Service, Concord, New Hampshire, and U.S. Environmental Protection Agency, Boston, Massachusetts.

Tillitt, D., D. Papoulias, and D. Buckler. 2003b. *Fish Reproductive Health Assessment in PCB Contaminated Regions of the Housatonic River, Massachusetts, USA: Investigations of Causal Linkages Between PCBs and Fish Health. Final Report of Phase II Studies.* Prepared for U.S. Fish and Wildlife Service, Concord, New Hampshire, and U.S. Environmental Protection Agency, Boston, Massachusetts.

Tyler, A.V. 1973. Caloric values of some North Atlantic invertebrates. *Marine Biology* 19:258-261.

Van den Berg, M., L. Birnbaum, A.T.C. Bosveld, B. Brunstrom, P. Cook, M. Feeley, J.P. Giesy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X. R. van Leeuwen, A.K. Djien Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs, for humans and wildlife. *Environmental Health Perspectives* 106(12):775-792.

Veit, R.R., and W.R. Petersen. 1993. *Birds of Massachusetts*. Natural History of New England Series, Lincoln, Massachusetts: Massachusetts Audubon Society.

White, D. H. and J.T. Seginak. 1994. Dioxin and furans linked to reproductive impairment in wood ducks. *Journal of Wildlife Management* 58(1):100-106.

Woodlot Alternatives. 2002. *Fish Biomass Estimate for Housatonic River Primary Study Area*. Prepared for U.S. Army Corps of Engineers. DCN: GE-061202-ABBF.

Zabik, M.E. 1974. Polychlorinated biphenyl levels in raw and cooked chicken and chicken broth. *Poultry Science* 53:1785-1790.

Zabik, M.E. 1990. Effect of roasting, hot-holding or microwave heating on polychlorinated biphenyl levels in turkey. *School Food Ser. Res. Review* 14:98-102.

APPENDIX A

USE OF RANGES OF INTERIM MEDIA PROTECTION GOALS

APPENDIX A

USE OF RANGES OF INTERIM MEDIA PROTECTION GOALS

As discussed in the text, this IMPG Proposal presents ranges of numerical risk-based concentration values (referred to as "Risk-based Media Concentrations" or RMCs), based on varying inputs and assumptions. For the health-based values, the range of RMCs includes values based on use of both Reasonable Maximum Exposure (RME) assumptions and Central Tendency Exposure (CTE) assumptions; and for each set of assumptions, it includes cancer-based values based on three excess lifetime cancer risk levels within EPA's acceptable cancer risk range – namely, $1x10^{-6}$, $1x10^{-5}$, and $1x10^{-4}$ – as well as non-cancer-based values using a Hazard Index (HI) of 1. For the ecologically based values, the range of RMCs includes various effect thresholds from the site-specific studies used in EPA's Ecological Risk Assessment (ERA) or, for species for which there are no site-specific studies, values based on ranges of toxicity reference values from the literature. As further discussed in the text, this IMPG Proposal presents two sets of such ranges – one set (presented in Section 2) using the exposure assumptions, toxicity values, and data interpretations set forth in EPA's Human Health Risk Assessment (HHRA) and ERA, and the other set (presented in Section 3) using some alternate assumptions, values, and data interpretations that GE believes are more scientifically supportable. In either case, as shown below, the use of ranges of RMCs allows for consideration of relevant site-specific factors in the CMS in selecting the goals to be used for evaluating potential corrective measures, and in evaluating an appropriate array of such measures.

Health-Based Goals

For health-based values, the National Contingency Plan (NCP) provides that, "[f]or known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of being between 10^{-4} and 10^{-6} using information on the relationship between dose and response" (40 CFR § 300.430(e)(2)(i)(A)(*2*)). While that provision states further that "[t]he 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective," EPA's guidance makes clear, as shown below, that that risk level need not be the target or preliminary goal in all situations.

For actions under RCRA corrective action permits, such as the Reissued RCRA Permit governing the IMPG Proposal here, EPA treats as guidance its proposed rulemaking in 1990 (55 Fed. Reg. 30793-30884, July 27, 1990) and its Advance Notice of Proposed Rulemaking (ANPR) in 1996 (61 Fed. Reg. 19432-19464, May 1, 1996). The preamble to EPA's 1990 proposed rule, like the NCP, notes that the 10^{-6} risk level is the "point of departure" for establishing "media cleanup standards" (55 Fed. Reg. at 30826). However, it also explains that, as part of the Corrective Measures Study (CMS) process, "the Agency will typically provide the owner/operator with target cleanup levels for significant hazardous constituents in each medium of concern when he/she is required to perform a CMS. For carcinogens, *these targets will be established within the protective risk range of 1 x 10^{-4} to 1 x 10^{-6}, based on site-specific factors*, unless another level is deemed necessary to protect environmental receptors" (55 Red. Reg. at 30826, emphasis added). These target cleanup levels for use in the CMS are comparable to the IMPGs under the Reissued RCRA Permit.

Similarly, EPA's 1996 ANPR reiterates that EPA's risk reduction goal is to ensure that excess lifetime cancer risks fall within a range from 10^{-6} to 10^{-4} and that the non-cancer HI should generally not exceed 1 (61 Fed. Reg. at 19449-50). It then states that "[a]vailable risk-based media cleanup standards are considered protective if they achieve a level of risk which falls within the 10^{-6} to 10^{-4} risk range" (61 Fed. Reg. at 19450). The ANPR explains further that the 10^{-6} risk level should be used as a "point of departure when developing site-specific media cleanup standards," but that, "[g]iven the diversity of the corrective action universe and the emphasis on consideration of site-specific conditions such as exposure, uncertainty, or technical limitations, the Agency expects that *other risk reduction goals may be appropriate at many corrective action facilities*" (*ibid*., emphasis added).

The same conclusion is supported by EPA's guidance under Superfund. EPA's guidance entitled *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (OSWER Directive 9355.0-30, April 22, 1991) explains: "EPA uses the general 10(-4) to 10(-6) risk range as a 'target range' within which the Agency strives to manage risks as part of a Superfund cleanup. Once a decision has been made to make an action, the Agency has expressed a reference [probably should read preference] for cleanups achieving the more protective end of the range (i.e., 10(-6)), although *waste management strategies achieving reductions in site risks anywhere within the risk range may be deemed acceptable by the EPA risk manager*." (Emphasis added.) That guidance states further that while "preliminary goals

are developed based on ARARs and the 10(-6) cancer risk point of departure" pursuant to the NCP, "the results of the baseline risk assessment may be used to modify preliminary remediation goals." Thus, although concentrations based on a 10^{-6} cancer risk are the "point of departure for determining remediation goals" under the NCP, the preliminary goals based on that risk level may be modified based on the baseline risk assessment, so as to establish other goals within the target risk range. This is further demonstrated by the fact that the same guidance notes that, "[f]or sites where the cumulative site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10(-4), *action generally is not warranted*, but may be warranted if a chemical specific standard that defines acceptable risk is violated or unless there are noncarcinogenic effects or an adverse environmental impact that warrants action" (emphasis added). EPA's statement that action is generally not warranted where the cancer risk is less than 10^{-4} (even if above 10^{-6}) demonstrates that remediation goals anywhere within that range may be appropriate, so long as non-cancer impacts and environmental impacts are also considered.

As these guidance documents demonstrate, the NCP requirement that the 10^{-6} cancer risk level be used as the "point of departure *for determining remediation goals*" (emphasis added) does not mean that that level must be the goal or the only goal at every site, or that it is equivalent to the Reissued RCRA Permit's definition of IMPGs as goals "that will serve as points of departure *in evaluating potential corrective measures*" in the CMS (emphasis added). Rather, from a health standpoint, any of the RMCs within EPA's cancer risk range – or, if lower, the non-cancer-based RMCs – may be identified as remediation goals and thus as IMPGs, depending on site-specific conditions and other relevant factors.

Moreover, even for non-cancer effects, an HI of 1 should not be regarded as a bright line marking the level of adverse effects. The HI is the ratio of the predicted dose to the Reference Dose (RfD), which represents a daily intake level (or dose) that will ***not*** result in non-cancer health effects. That level is typically calculated by applying multiple uncertainty factors to the no-effect or lowest-effect level in the underlying study. Thus, if the HI is less than 1, then the dose is less than the RfD and no risk is predicted. However, given the uncertainty factors and conservatism inherent in the derivation of the RfD, the converse is not true: a calculated HI greater than 1 does not necessarily mean that significant hazards are predicted. Accordingly, remediation goals may, in appropriate cases, include non-cancer-based values that reflect HIs greater than 1. Indeed, there are precedents from other sites in EPA Region 1 indicating that

EPA views the non-cancer risk threshold as an HI range from 1 to 10. For example, EPA's Records of Decision for the Fletcher's Paint Works and Storage Facility Superfund Site in New Hampshire and for the Charles George Reclamation Trust Landfill in Massachusetts state that EPA's non-cancer risk range is "usually a hazard index between 1 and 10."[1]

Ecological Goals

For ecologically based values, there is no comparable EPA regulation or guidance on numerical levels of risk reduction. While EPA's 1990 proposed rule and 1996 ANPR on RCRA corrective action discuss the need to address ecological receptors if they are subject to adverse effects at lower levels than humans, they do not provide any further quantitative guidance on risk levels or risk ranges (see 55 Fed. Reg. at 30827; 61 Fed. Reg. at 19451).

In fact, EPA's guidance on *Ecological Risk Assessment and Risk Management Principles for Superfund* (OSWER Directive 9285.7-28 P, October 7, 1999, p. 2) explains:

> "Establishing remediation goals for ecological receptors is considerably more difficult than establishing such goals for the protection of human health due to the paucity of broadly applicable and quantifiable toxicological data. Further, owing to the large variation in the kinds and numbers of receptor species present at sites, to their differences in their susceptibility to contaminants, to their recuperative potential following exposure, and to the tremendous variation in environmental bioavailability of many contaminants in different media, *protective exposure levels are best established on a site-specific basis*." (Emphasis added.)

That guidance notes further (pp. 7 & 8) that while cleanup levels should provide "adequate protection of the ecological receptors," "[t]he difficulty is in determining the acceptable level of adverse effects for the receptors to be protected; e.g., what percent reduction in fish survival or in benthic species diversity is no longer protective? *There is no magic number that can be used*; it is dependent on the assessment endpoints selected and the risk assessment measures used including chemical and biological data gathered from the range of contaminated locations and compared to the reference locations." (Emphasis added.) That guidance does, however, make clear (p. 3) that the overall goal "is to reduce ecological risks to levels that will result in the recovery and maintenance of *healthy local populations and communities of biota*" (emphasis added). It further states (p. 4) that "site-specific ecological risk data" should be used, wherever

[1] See *EPA Superfund Record of Decision: Fletcher's Paint Works and Storage*, EPA ID: NHD001079649, OU 1, Milford, NH, EPA/ROD/R01-98/124 (September 30, 1998); *EPA Superfund Record of Decision: Charles George Reclamation Trust Landfill*, EPA ID: MAD003809266, OU 03, 04, Tyngsborough, MA, EPA/ROD/R01-88/029, (September 29, 1988).

practical, “to develop quantitative cleanup goals that are protective.” Thus, the selection of specific goals for the protection of ecological receptors should be based on an evaluation of the assessment endpoints and the site-specific risk assessment measures used, considering the overall goal of protecting ecological receptors at the local population or community level.

In the present case, the ERA identifies Maximum Acceptable Tissue Concentrations (MATCs) for several receptors, based on a conservative evaluation of various effects thresholds from the site-specific studies considered. However, review of both the ERA and the underlying data also reveals other effects thresholds from those studies, which vary depending on the particular study, the endpoint, and the size of the effect (e.g., EC20 representing a 20% effect or EC50 representing a 50% effect). For example, for benthic invertebrates, the ERA lists 20% and 50% effect thresholds for various endpoints, both from EPA’s toxicity tests and from its benthic community study and for both fine-grained and coarse-grained sediments. Consistent with EPA’s 1999 guidance (cited above), various values with these ranges may be selected as cleanup goals, depending the type and size of effect to be prevented, the relevance of the endpoints to the protection of local populations or communities, and the type of sediments present.

Additionally, for a number of receptors for which there are no such site-specific effect data and no literature-based toxicity data, the ERA utilizes an approach in which a range of effect thresholds is identified based on use of toxicity reference values (TRVs) reported in the literature for other species, ranging from the most sensitive species to the most tolerant species. Given the uncertainty about which of those other species best represents the species in question, it may be appropriate to select a value or values within the specified range (e.g., the midpoint of the range) as the cleanup goal.

Use of Other Values

Finally, it is important to note that, whichever values are ultimately identified as IMPGs for the CMS, the remaining RMCs in the ranges may also be considered in evaluating potential corrective measures in the CMS. As the Reissued RCRA Permit states, the IMPGs “are not necessarily equivalent to cleanup standards or Performance Standards and may be modified or revised in the selection of Performance Standards and associated corrective measures.” Hence, the CMS may evaluate potential remedial alternatives based on the extent to which they would achieve various RMCs within the ranges. As shown in the text of this IMPG Proposal,

based on the assumptions used, all of the RMCs in the ranges are protective of human health or the environment *for the particular scenarios, receptors, and risk or effect levels to which they apply*. As such, those RMCs can provide useful benchmarks for evaluating the level of protection provided by particular remedial alternatives. Thus, if a given remedial alternative would not achieve a more stringent RMC, it may be evaluated based on the extent to which it would achieve a less stringent RMC.

APPENDIX B

ATTACHMENTS 1 THROUGH 13

Attachment 1
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
In High-Use Recreational Areas (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil in high-use recreational areas. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of young children, older children, and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left((AF_1 * SA_1 * AD_1) + (AF_2 * SA_2 * AD_2)\right)/(AD_1 + AD_2)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 1a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA. For young children in high-use recreational areas, the HHRA evaluated some areas using the same exposure frequency as adults and older children and other areas using a lower, alternate exposure frequency. The same approach has been followed in developing the RMCs.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group (adults, older children, young children with high exposure frequency, and young children with lower exposure frequency). The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 1b), older children (Table 1c), young children under high frequency conditions (Table 1d), and young children under lower, alternate frequency conditions (Table 1e). For each of these receptors, the calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	1.4	14	143	38	63	630	6,305	234
Older Child	3.9	39	388	27	51	514	5,143	176
Young Child								
High frequency	1.3	13	134	4.6	18	184	1,842	32
Alt. frequency	8.0	80	802	27	37	368	3,684	63

Table 1a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the High Use Recreational Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Young child (high frequency)			90	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Older child			90	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Adult			90	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Young child (alternative frequency)			15	15	HHRA, Vol. IIIA; Section 4.5.3.2.1; Page 4-54; Lower usage for areas without well defined trails.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol. IIIA; Table 4-23; From age 1 to 6 years. EPA, 1991.
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			47	13	HHRA, Vol. IIIA; Table 4-23; Aged 19 to 65 years (RME); 19 to 31 years (CTE). Based on MDPH, 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			17,155	4,745	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Young child			200	100	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Older child			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Young child			0.2	0.2	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Children playing in wet soil weighted by exposed body area.
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Young child			0.35	0.35	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Children playing in wet soil weighted by exposed body area.
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Young child			2,800	2,800	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and head.
Older child			4,400	4,400	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Adult			5,700	5,700	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.

Table 1a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the High Use Recreational Scenario (EPA Assumptions

Skin surface area (cooler months)	cm^2/day	SA_2			
Young child			684	684	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 1b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Recreational Areas
Adults (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	47	47	47	13	13	13
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
RAF-oral (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.4E-07	2.4E-07	2.4E-07	5.5E-09	5.5E-09	5.5E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	3.5E-07	3.5E-07	3.5E-07	2.9E-08	2.9E-08	2.9E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)						
Adult Warmer months	5700	5700	5700	5700	5700	5700
Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.1E-07	1.1E-07	1.1E-07	1.0E-08	1.0E-08	1.0E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.7E-07	1.7E-07	1.7E-07	5.6E-08	5.6E-08	5.6E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.1E-07	1.1E-07	1.1E-07	1.0E-08	1.0E-08	1.0E-08
Total Exposure, soil ingestion $(days)^{-1}$	2.4E-07	2.4E-07	2.4E-07	5.5E-09	5.5E-09	5.5E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**143**	**14**	**1.4**	**6305**	**630**	**63**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.7E-07			5.6E-08		
Total Exposure, soil ingestion $(days)^{-1}$	3.5E-07			2.9E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**38**			**234**		

Table 1c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Recreational Areas
Older Child (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
RAF-oral (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	9.4E-08	9.4E-08	9.4E-08	7.8E-09	7.8E-09	7.8E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	5.5E-07	5.5E-07	5.5E-07	4.6E-08	4.6E-08	4.6E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)						
Older child Warmer months	4400	4400	4400	4400	4400	4400
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	3.5E-08	3.5E-08	3.5E-08	1.2E-08	1.2E-08	1.2E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.0E-07	2.0E-07	2.0E-07	6.8E-08	6.8E-08	6.8E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	3.5E-08	3.5E-08	3.5E-08	1.2E-08	1.2E-08	1.2E-08
Total Exposure, soil ingestion $(days)^{-1}$	9.4E-08	9.4E-08	9.4E-08	7.8E-09	7.8E-09	7.8E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**388**	**39**	**3.9**	**5143**	**514**	**51**
NONCARCINOGENIC	**Older Child**			**Older Child**		
Total Exposure, dermal contact $(days)^{-1}$	2.0E-07			6.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$	5.5E-07			4.6E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**27**			**176**		

Table 1d. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Recreational Areas
Young Child - High Frequency (EPA Assumptions)

Parameter	**EPA RME Analysis**			**EPA CTE Analysis**		
Common Parameters						
Exposure duration (yrs)						
Young child	6	6	6	6	6	6
Body weight (kg)						
Young child	15	15	15	15	15	15
Averaging time - noncarcinogenic (days)						
Young child	2,190	2,190	2,190	2,190	2,190	2,190
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Young child	200	200	200	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
RAF-oral (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.8E-07	2.8E-07	2.8E-07	2.3E-08	2.3E-08	2.3E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	3.3E-06	3.3E-06	3.3E-06	2.7E-07	2.7E-07	2.7E-07
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Young child Warmer months	0.2	0.2	0.2	0.2	0.2	0.2
Cooler months	0.35	0.35	0.35	0.35	0.35	0.35
Skin surface area exposed (cm^2/day)						
Young child Warmer months	2800	2800	2800	2800	2800	2800
Cooler months	684	684	684	684	684	684
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	9.2E-08	9.2E-08	9.2E-08	3.1E-08	3.1E-08	3.1E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.1E-06	1.1E-06	1.1E-06	3.6E-07	3.6E-07	3.6E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	9.2E-08	9.2E-08	9.2E-08	3.1E-08	3.1E-08	3.1E-08
Total Exposure, soil ingestion $(days)^{-1}$	2.8E-07	2.8E-07	2.8E-07	2.3E-08	2.3E-08	2.3E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**134**	**13**	**1.3**	**1842**	**184**	**18**
NONCARCINOGENIC	**Young Child**			**Young Child**		
Total Exposure, dermal contact $(days)^{-1}$	1.1E-06			3.6E-07		
Total Exposure, soil ingestion $(days)^{-1}$	3.3E-06			2.7E-07		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**4.6**			**32**		

Table 1e. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Recreational Areas
Young Child - Alternative Frequency (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Young child	6	6	6	6	6	6
Body weight (kg)						
Young child	15	15	15	15	15	15
Averaging time - noncarcinogenic (days)						
Young child	2,190	2,190	2,190	2,190	2,190	2,190
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Young child	200	200	200	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
RAF-oral (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	15	15	15	15	15	15
Exposure (soil ing)-carcinogenic $(days)^{-1}$	4.7E-08	4.7E-08	4.7E-08	1.2E-08	1.2E-08	1.2E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	5.5E-07	5.5E-07	5.5E-07	1.4E-07	1.4E-07	1.4E-07
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Young child Warmer months	0.2	0.2	0.2	0.2	0.2	0.2
Cooler months	0.35	0.35	0.35	0.35	0.35	0.35
Skin surface area exposed (cm^2/day)						
Young child Warmer months	2800	2800	2800	2800	2800	2800
Cooler months	684	684	684	684	684	684
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	15	15	15	15	15	15
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08
Total Exposure, soil ingestion $(days)^{-1}$	4.7E-08	4.7E-08	4.7E-08	1.2E-08	1.2E-08	1.2E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**802**	**80**	**8.0**	**3684**	**368**	**37**
NONCARCINOGENIC	**Young Child**			**Young Child**		
Total Exposure, dermal contact $(days)^{-1}$	1.8E-07			1.8E-07		
Total Exposure, soil ingestion $(days)^{-1}$	5.5E-07			1.4E-07		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**27**			**63**		

Attachment 2
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
In Medium-Use Recreational Areas (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil in medium-use recreational areas. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 2a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target hazard index (HI) of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 2b) and older children (Table 2c). For each of these receptors, the calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	2.1	21	215	58	63	630	6,305	234
Older Child	5.8	58	582	40	51	514	5,143	176

Table 2a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Medium-Use Recreational Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Older child			60	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Adult			60	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			47	13	HHRA, Vol. IIIA; Table 4-23; Aged 19-65 years (RME); 19-31 years (CTE). Based on MDPH, 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			17,155	4,745	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,400	4,400	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Adult			5,700	5,700	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 2b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Medium-Use Recreational Areas
Adults (EPA Assumptions)

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Adult		47	47	47	13	13	13
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$		1.6E-07	1.6E-07	1.6E-07	5.5E-09	5.5E-09	5.5E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		2.3E-07	2.3E-07	2.3E-07	2.9E-08	2.9E-08	2.9E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	5700	5700	5700	5700	5700	5700
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$		7.5E-08	7.5E-08	7.5E-08	1.0E-08	1.0E-08	1.0E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		1.1E-07	1.1E-07	1.1E-07	5.6E-08	5.6E-08	5.6E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		7.5E-08	7.5E-08	7.5E-08	1.0E-08	1.0E-08	1.0E-08
Total Exposure, soil ingestion $(days)^{-1}$		1.6E-07	1.6E-07	1.6E-07	5.5E-09	5.5E-09	5.5E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)		**215**	**21**	**2.1**	**6305**	**630**	**63**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$		1.1E-07			5.6E-08		
Total Exposure, soil ingestion $(days)^{-1}$		2.3E-07			2.9E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentrations (mg/kg)		**58**			**234**		

Table 2c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Medium-Use Recreational Areas
Older Child (EPA Assumptions)

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Older child		12	12	12	12	12	12
Body weight (kg)							
Older child		45	45	45	45	45	45
Averaging time - noncarcinogenic (days)							
Older child		4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Older child		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (soil ing)-carcinogenic (days)$^{-1}$		6.3E-08	6.3E-08	6.3E-08	7.8E-09	7.8E-09	7.8E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$		3.7E-07	3.7E-07	3.7E-07	4.6E-08	4.6E-08	4.6E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Older child	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)							
Older child	Warmer months	4400	4400	4400	4400	4400	4400
	Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (dermal con)-carcinogenic (days)$^{-1}$		2.3E-08	2.3E-08	2.3E-08	1.2E-08	1.2E-08	1.2E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$		1.4E-07	1.4E-07	1.4E-07	6.8E-08	6.8E-08	6.8E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		2.3E-08	2.3E-08	2.3E-08	1.2E-08	1.2E-08	1.2E-08
Total Exposure, soil ingestion (days)$^{-1}$		6.3E-08	6.3E-08	6.3E-08	7.8E-09	7.8E-09	7.8E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)		**582**	**58**	**5.8**	**5143**	**514**	**51**
NONCARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		1.4E-07			6.8E-08		
Total Exposure, soil ingestion (days)$^{-1}$		3.7E-07			4.6E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentrations (mg/kg)		**40**			**176**		

Attachment 3
Risk-based Media Concentrations for Direct Contact With Floodplain Soil In Low-Use Recreational Areas

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil in low-use recreational areas. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left((AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 2a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 3b) and older children (Table 3c). For each of these receptors, the calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	4.3	43	429	115	126	1,261	12,610	468
Older Child	12	116	1,165	80	103	1,029	10286	353

Table 3a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Low-Use Recreational Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Older child			30	15	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment
Adult			30	15	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			47	13	HHRA, Vol. IIIA; Table 4-23; Aged 19 to 65 years (RME); 19 to 31 years (CTE). Based on MDPH, 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			17,155	4,745	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,400	4,400	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head
Adult			5,700	5,700	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 3b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Low-Use Recreational Areas
Adults (EPA Assumptions)

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Adult		47	47	47	13	13	13
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (soil ing)-carcinogenic $(days)^{-1}$		7.9E-08	7.9E-08	7.9E-08	2.7E-09	2.7E-09	2.7E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		1.2E-07	1.2E-07	1.2E-07	1.5E-08	1.5E-08	1.5E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	5700	5700	5700	5700	5700	5700
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (dermal con)-carcinogenic $(days)^{-1}$		3.8E-08	3.8E-08	3.8E-08	5.2E-09	5.2E-09	5.2E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		5.6E-08	5.6E-08	5.6E-08	2.8E-08	2.8E-08	2.8E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		3.8E-08	3.8E-08	3.8E-08	5.2E-09	5.2E-09	5.2E-09
Total Exposure, soil ingestion $(days)^{-1}$		7.9E-08	7.9E-08	7.9E-08	2.7E-09	2.7E-09	2.7E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**429**	**43**	**4.3**	**12610**	**1261**	**126**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$		5.6E-08			2.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$		1.2E-07			1.5E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**115**			**468**		

Table 3c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Low-Use Recreational Areas
Older Child (EPA Assumptions)

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Older child		12	12	12	12	12	12
Body weight (kg)							
Older child		45	45	45	45	45	45
Averaging time - noncarcinogenic (days)							
Older child		4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Older child		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (soil ing)-carcinogenic (days)$^{-1}$		3.1E-08	3.1E-08	3.1E-08	3.9E-09	3.9E-09	3.9E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$		1.8E-07	1.8E-07	1.8E-07	2.3E-08	2.3E-08	2.3E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Older child	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)							
Older child	Warmer months	4400	4400	4400	4400	4400	4400
	Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (dermal con)-carcinogenic (days)$^{-1}$		1.2E-08	1.2E-08	1.2E-08	5.8E-09	5.8E-09	5.8E-09
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$		6.8E-08	6.8E-08	6.8E-08	3.4E-08	3.4E-08	3.4E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		1.2E-08	1.2E-08	1.2E-08	5.8E-09	5.8E-09	5.8E-09
Total Exposure, soil ingestion (days)$^{-1}$		3.1E-08	3.1E-08	3.1E-08	3.9E-09	3.9E-09	3.9E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**1165**	**116**	**12**	**10286**	**1029**	**103**
NONCARCINOGENIC		**Older Child**			**Older Child**		
Total Exposure, dermal contact (days)$^{-1}$		6.8E-08			3.4E-08		
Total Exposure, soil ingestion (days)$^{-1}$		1.8E-07			2.3E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**80**			**353**		

Attachment 4
Risk-based Media Concentrations for Direct Contact With Floodplain Soil
In the Bank Fishing Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the bank fishing (angler) scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 4a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 4b) and older children (Table 4c). For each of these receptors, the calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	2.6	26	256	56	70	702	7,015	220
Older Child	6.2	62	619	42	52	524	5,237	180

Table 4a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Bank Fishing Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Older child			30	10	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.6.1. EPA's professional judgment based on numerous studies.
Adult			30	10	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.6.1. EPA's professional judgment based on numerous studies.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			38	11	HHRA, Vol. IIIA; Table 4-23; Based on MDPH, 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			13,870	4,015	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.31	0.31	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Adult			0.3	0.3	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.43	0.43	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Adult			0.47	0.47	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,471	4,471	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Adult			6,074	6,074	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 4b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Bank Fishing Scenario
Adults (EPA Assumptions)

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Adult		38	38	38	11	11	11
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		13,870	13,870	13,870	4,015	4,015	4,015
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	10	10	10
Exposure (soil ing)-carcinogenic (days)$^{-1}$		6.4E-08	6.4E-08	6.4E-08	1.5E-09	1.5E-09	1.5E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$		1.2E-07	1.2E-07	1.2E-07	9.8E-09	9.8E-09	9.8E-09
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.3	0.3	0.3	0.3	0.3	0.3
	Cooler months	0.47	0.47	0.47	0.47	0.47	0.47
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	6074	6074	6074	6074	6074	6074
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	10	10	10
Exposure (dermal con)-carcinogenic (days)$^{-1}$		1.3E-07	1.3E-07	1.3E-07	1.3E-08	1.3E-08	1.3E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$		2.4E-07	2.4E-07	2.4E-07	8.1E-08	8.1E-08	8.1E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		1.3E-07	1.3E-07	1.3E-07	1.3E-08	1.3E-08	1.3E-08
Total Exposure, soil ingestion (days)$^{-1}$		6.4E-08	6.4E-08	6.4E-08	1.5E-09	1.5E-09	1.5E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**256**	**26**	**2.6**	**7015**	**702**	**70**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact (days)$^{-1}$		2.4E-07			8.1E-08		
Total Exposure, soil ingestion (days)$^{-1}$		1.2E-07			9.8E-09		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**56**			**220**		

Table 4c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Bank Fishing Scenario
Older Child (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	30	30	30	10	10	10
Exposure (soil ing)-carcinogenic $(days)^{-1}$	3.1E-08	3.1E-08	3.1E-08	2.6E-09	2.6E-09	2.6E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	1.8E-07	1.8E-07	1.8E-07	1.5E-08	1.5E-08	1.5E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child Warmer months	0.31	0.31	0.31	0.31	0.31	0.31
Cooler months	0.43	0.43	0.43	0.43	0.43	0.43
Skin surface area exposed (cm^2/day)						
Older child Warmer months	4471	4471	4471	4471	4471	4471
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	30	30	30	10	10	10
Exposure (dermal con)-carcinogenic $(days)^{-1}$	4.9E-08	4.9E-08	4.9E-08	1.6E-08	1.6E-08	1.6E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.9E-07	2.9E-07	2.9E-07	9.6E-08	9.6E-08	9.6E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	4.9E-08	4.9E-08	4.9E-08	1.6E-08	1.6E-08	1.6E-08
Total Exposure, soil ingestion $(days)^{-1}$	3.1E-08	3.1E-08	3.1E-08	2.6E-09	2.6E-09	2.6E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**619**	**62**	**6.2**	**5237**	**524**	**52**
NONCARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.9E-07			9.6E-08		
Total Exposure, soil ingestion $(days)^{-1}$	1.8E-07			1.5E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**42**			**180**		

Attachment 5
Risk-based Media Concentrations for Direct Contact With Floodplain Soil
In Dirt Biking/ATVing Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the dirt biking/ATVing scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. The RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{(((AF_1 * SA_1 * AD_1) + (AF_2 * SA_2 * AD_2))/(AD_1 + AD_2)) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 5a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for older children who participate in dirt biking or ATVing are presented below and in Table 5b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Older Child	2.0	20	205	14	29	290	2,901	99

Table 5a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Dirt Biking/ATV Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-13.
Exposure frequency	days/year	EF	90	30	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.3.1. EPA's professional judgment.
Exposure duration	years	ED	12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Calculated by EPA.
Body weight	kg/mg	BW	45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint	days	ATnc	4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	200	100	HHRA, Vol. IIIA; Tables 4-13 and 4-24; Section 4.5.3.3.3. Based on EPA 1997 and Stanek et al., 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-13. EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1	0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.3.4. Heavy equipment operators and construction workers.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2	0.24	0.24	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.3.4. Heavy equipment operators and construction workers.
Skin surface area (warmer months)	cm^2/day	SA_1	3,522	3,522	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Section 4.5.3.3.4. Hands, forearms, lower legs, and face.
Skin surface area (cooler months)	cm^2/day	SA_2	1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Section 4.5.3.3.4. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-13; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-13; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-13, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Stanek, E.J., E.J. Calabrese, R. Barnes, P. Pekow. 1997. Soil ingestion in adults - Results of a second pilot study. *Ecotoxicology and Environmental Safety* 36:249-257
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 5b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Dirt Bike/ATV Scenario
Older Child (EPA Assumptions)

Parameter	**EPA RME Analysis**			**EPA CTE Analysis**		
Common Parameters						
Exposure duration (yrs)	12	12	12	12	12	12
Body weight (kg)	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	200	200	200	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.9E-07	1.9E-07	1.9E-07	1.6E-08	1.6E-08	1.6E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	1.1E-06	1.1E-06	1.1E-06	9.1E-08	9.1E-08	9.1E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Warmer months	0.14	0.14	0.14	0.14	0.14	0.14
Cooler months	0.24	0.24	0.24	0.24	0.24	0.24
Skin surface area exposed (cm^2/day)						
Warmer months	3522	3522	3522	3522	3522	3522
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	5.6E-08	5.6E-08	5.6E-08	1.9E-08	1.9E-08	1.9E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	3.3E-07	3.3E-07	3.3E-07	1.1E-07	1.1E-07	1.1E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	5.6E-08	5.6E-08	5.6E-08	1.9E-08	1.9E-08	1.9E-08
Total Exposure, soil ingestion $(days)^{-1}$	1.9E-07	1.9E-07	1.9E-07	1.6E-08	1.6E-08	1.6E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**205**	**20**	**2.0**	**2901**	**290**	**29**
NONCARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	3.3E-07			1.1E-07		
Total Exposure, soil ingestion $(days)^{-1}$	1.1E-06			9.1E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**14**			**99**		

Attachment 6
Risk-based Media Concentrations for Direct Contact With Floodplain Soil In Marathon Canoeing Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the marathon canoeing scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{(((AF_1 * SA_1 * AD_1) + (AF_2 * SA_2 * AD_2))/(AD_1 + AD_2)) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 6a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for noncancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adults who participate in marathon canoeing are presented below and in Table 6b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	0.78	7.8	78	13	5.8	58	575	25

Table 6a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Marathon Canoeist Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-14.
Exposure frequency	days/year	EF	150	90	HHRA, Vol. IIIA; Table 4-22; Weston 2001.
Exposure duration	years	ED	30	15	HHRA, Vol. IIIA; Table 4-23; RME based on Weston 2001. CTE based on EPA's professional judgment.
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	10,950	5,475	HHRA, Vol. IIIA. Table 4-14; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	50	50	HHRA, Vol. IIIA; Tables 4-14 and 4-24; Section 4.5.3.4.5. Based on EPA 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-14; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1	0.32	0.32	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.4.4. Reed gatherers.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2	0.658	0.658	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.4.4. Reed gatherers.
Skin surface area (warmer months)	cm^2/day	SA_1	5,672	5,672	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Section 4.5.3.4.4. Hands, forearms, lower legs, and feet.
Skin surface area (cooler months)	cm^2/day	SA_2	904	904	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.3.4.4. Hands.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-14; Professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-14; Professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-14, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environ. Toxicology and Environ. Health* 39:375-382.
Weston 2001. Email memorandum from M. Isabel Zapisek (Weston Pittsfield, MA Office) to Robert Warwick (West Chester, PA office). October 9.

Table 6b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Marathon Canoeist Scenario
Adults (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)	30	30	30	15	15	15
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	10,950	10,950	10,950	5,475	5,475	5,475
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	50	50	50	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	150	150	150	90	90	90
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.3E-07	1.3E-07	1.3E-07	1.9E-08	1.9E-08	1.9E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	2.9E-07	2.9E-07	2.9E-07	8.8E-08	8.8E-08	8.8E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Warmer months	0.32	0.32	0.32	0.32	0.32	0.32
Cooler months	0.658	0.658	0.658	0.658	0.658	0.658
Skin surface area exposed (cm^2/day)						
Warmer months	5672	5672	5672	5672	5672	5672
Cooler months	904	904	904	904	904	904
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	150	150	150	90	90	90
Exposure (dermal con)-carcinogenic $(days)^{-1}$	5.2E-07	5.2E-07	5.2E-07	1.5E-07	1.5E-07	1.5E-07
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.2E-06	1.2E-06	1.2E-06	7.2E-07	7.2E-07	7.2E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	5.2E-07	5.2E-07	5.2E-07	1.5E-07	1.5E-07	1.5E-07
Total Exposure, soil ingestion $(days)^{-1}$	1.3E-07	1.3E-07	1.3E-07	1.9E-08	1.9E-08	1.9E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**78**	**7.8**	**0.78**	**575**	**58**	**5.8**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.2E-06			7.2E-07		
Total Exposure, soil ingestion $(days)^{-1}$	2.9E-07			8.8E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**13**			**25**		

Attachment 7
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Recreational Canoeing Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the recreational canoeing scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

Specific exposure assumptions used in this analysis and the basis of each are summarized in Table 7a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adults and older children who participate in recreational canoeing are presented below and in Tables 7b and 7c, respectively. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	1.2	12	121	28	13	129	1,286	73
Older child	6.2	62	619	42	35	349	3,491	120

Table 7a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Recreational Canoeing Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-15.
Exposure frequency	days/year	EF			
Older child			30	15	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Adult			60	30	HHRA, Vol. IIIA; Table 4-22; Weston 2001.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Calculated by EPA.
Adult			40	20	HHRA, Vol. IIIA; Table 4-23; RME based on Weston 2001; CTE based on EPA's professional judgment.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			14,600	7,300	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-15 and 4-24; Section 4.5.3.5.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-15 and 4-24; Section 4.5.3.5.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-15; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,471	4,471	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Adult			6,074	6,074	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-15; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-15; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-15, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Weston 2001. Email memorandum from M. Isabel Zapisek (Weston Pittsfield, MA Office) to Robert Warwick (West Chester, PA office). October 9.

Table 7b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Recreational Canoeing
Adults (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	40	40	40	20	20	20
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	14,600	14,600	14,600	7,300	7,300	7,300
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	60	60	60	30	30	30
Exposure (soil ing)-carcinogenic (days)$^{-1}$	1.3E-07	1.3E-07	1.3E-07	8.4E-09	8.4E-09	8.4E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$	2.3E-07	2.3E-07	2.3E-07	2.9E-08	2.9E-08	2.9E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult Warmer months	0.3	0.3	0.3	0.3	0.3	0.3
Cooler months	0.47	0.47	0.47	0.47	0.47	0.47
Skin surface area exposed (cm^2/day)						
Adult Warmer months	6074	6074	6074	6074	6074	6074
Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	60	60	60	30	30	30
Exposure (dermal con)-carcinogenic (days)$^{-1}$	2.8E-07	2.8E-07	2.8E-07	6.9E-08	6.9E-08	6.9E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$	4.9E-07	4.9E-07	4.9E-07	2.4E-07	2.4E-07	2.4E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$	2.8E-07	2.8E-07	2.8E-07	6.9E-08	6.9E-08	6.9E-08
Total Exposure, soil ingestion (days)$^{-1}$	1.3E-07	1.3E-07	1.3E-07	8.4E-09	8.4E-09	8.4E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**121**	**12**	**1.2**	**1286**	**129**	**13**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact (days)$^{-1}$	4.9E-07			2.4E-07		
Total Exposure, soil ingestion (days)$^{-1}$	2.3E-07			2.9E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**28**			**73**		

Table 7c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Recreational Canoeing Scenario
Older Child (EPA Assumptions)

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Older child		12	12	12	12	12	12
Body weight (kg)							
Older child		45	45	45	45	45	45
Averaging time - noncarcinogenic (days)							
Older child		4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Older child		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (soil ing)-carcinogenic (days)$^{-1}$		3.1E-08	3.1E-08	3.1E-08	3.9E-09	3.9E-09	3.9E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$		1.8E-07	1.8E-07	1.8E-07	2.3E-08	2.3E-08	2.3E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Older child	Warmer months	0.31	0.31	0.31	0.31	0.31	0.31
	Cooler months	0.43	0.43	0.43	0.43	0.43	0.43
Skin surface area exposed (cm^2/day)							
Older child	Warmer months	4471	4471	4471	4471	4471	4471
	Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (dermal con)-carcinogenic (days)$^{-1}$		4.9E-08	4.9E-08	4.9E-08	2.5E-08	2.5E-08	2.5E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$		2.9E-07	2.9E-07	2.9E-07	1.4E-07	1.4E-07	1.4E-07
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		4.9E-08	4.9E-08	4.9E-08	2.5E-08	2.5E-08	2.5E-08
Total Exposure, soil ingestion (days)$^{-1}$		3.1E-08	3.1E-08	3.1E-08	3.9E-09	3.9E-09	3.9E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)		**619**	**62**	**6.2**	**3491**	**349**	**35**
NONCARCINOGENIC		**Older Child**			**Older Child**		
Total Exposure, dermal contact (days)$^{-1}$		2.9E-07			1.4E-07		
Total Exposure, soil ingestion (days)$^{-1}$		1.8E-07			2.3E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentrations (mg/kg)		**42**			**120**		

Attachment 8
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Waterfowl Hunting Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the waterfowl hunting scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults and older children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 8a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adults and older children who engage in waterfowl hunting are presented below and in Tables 8b and 8c, respectively. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	9	90	904	196	75	752	7,518	537
Older child	41	408	4080	140	233	2,325	23,253	399

Table 8a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Waterfowl Hunting Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-17.
Exposure frequency	days/year	EF			
Older child			14	7	HHRA, Vol. IIIA; Table 4-22; Based on USFWS 2001 and EOEA 2000.
Adult			14	7	HHRA, Vol. IIIA; Table 4-22; Based on USFWS 2001 and EOEA 2000.
Exposure duration	years	ED			
Older child			6	6	HHRA, Vol. IIIA; Table 4-23; Age 12 -18 years. Section 4.5.3.7.2. Based on MassWildlife 2001.
Adult			38	38	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.7.2. Based on MDPH 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			2,190	2,190	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			13,870	13,870	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	100	HHRA, Vol. IIIA; Tables 4-17 and 4-24; Section 4.5.3.7.3. Based on EPA 1991 and 1997.
Adult			100	100	HHRA, Vol. IIIA; Tables 4-17 and 4-24; Section 4.5.3.7.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-17; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF			
Older child			0.43	0.43	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.7.4. Reed gatherers (hands), gardeners (face).
Adult			0.47	0.47	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.7.4. Reed gatherers (hands), gardeners (face).
Skin surface area	cm^2/day	SA			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands and face.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-17, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EOEA 2000. Masschusetts Executive Office of Environmental Affairs. Massachusetts Outdoors 2000! Statewide Comprehensive Outdoor Recreational Plan (SCORP).
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.
USFWS 2001. U.S. Fish and Wildlife Service. *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation - Massachusetts.* FHW/01-MA-Rev.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 8b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Waterfowl Hunting
Adults (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	38	38	38	25	25	25
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	13,870	13,870	13,871	9,125	9,125	9,125
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	100	100	100	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (soil ing)-carcinogenic $(days)^{-1}$	3.0E-08	3.0E-08	3.0E-08	4.9E-09	4.9E-09	4.9E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	5.5E-08	5.5E-08	5.5E-08	1.4E-08	1.4E-08	1.4E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult	0.47	0.47	0.47	0.47	0.47	0.47
Skin surface area exposed (cm^2/day)						
Adult	1306	1306	1306	1306	1306	1306
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (dermal con)-carcinogenic $(days)^{-1}$	2.6E-08	2.6E-08	2.6E-08	8.4E-09	8.4E-09	8.4E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	4.7E-08	4.7E-08	4.7E-08	2.4E-08	2.4E-08	2.4E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.6E-08	2.6E-08	2.6E-08	8.4E-09	8.4E-09	8.4E-09
Total Exposure, soil ingestion $(days)^{-1}$	3.0E-08	3.0E-08	3.0E-08	4.9E-09	4.9E-09	4.9E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**904**	**90**	**9.0**	**7518**	**752**	**75**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	4.7E-08			2.4E-08		
Total Exposure, soil ingestion $(days)^{-1}$	5.5E-08			1.4E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**196**			**537**		

Table 8c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Waterfowl Hunting
Older Child (EPA Assumptions)

Parameter	**EPA RME Analysis**			**EPA CTE Analysis**		
Common Parameters						
Exposure duration (yrs)						
Older child	6	6	6	6	6	6
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	2,190	2,190	2,190	2,190	2,190	2,190
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	100	100	100	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (soil ing)-carcinogenic (days)$^{-1}$	7.3E-09	7.3E-09	7.3E-09	1.8E-09	1.8E-09	1.8E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$	8.5E-08	8.5E-08	8.5E-08	2.1E-08	2.1E-08	2.1E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child	0.43	0.43	0.43	0.43	0.43	0.43
Skin surface area exposed (cm^2/day)						
Older child	1125	1125	1125	1125	1125	1125
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (dermal con)-carcinogenic (days)$^{-1}$	4.9E-09	4.9E-09	4.9E-09	2.5E-09	2.5E-09	2.5E-09
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$	5.8E-08	5.8E-08	5.8E-08	2.9E-08	2.9E-08	2.9E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$	4.9E-09	4.9E-09	4.9E-09	2.5E-09	2.5E-09	2.5E-09
Total Exposure, soil ingestion (days)$^{-1}$	7.3E-09	7.3E-09	7.3E-09	1.8E-09	1.8E-09	1.8E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**4080**	**408**	**41**	**23253**	**2325**	**233**
NONCARCINOGENIC	**Older Child**			**Older Child**		
Total Exposure, dermal contact (days)$^{-1}$	5.8E-08			2.9E-08		
Total Exposure, soil ingestion (days)$^{-1}$	8.5E-08			2.1E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**140**			**399**		

Attachment 9
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Farmer Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the farmer scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 9a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adult farmers are presented below and in Table 9b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	1.2	12	118	43	42	419	4,195	348

Table 9a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Farmer Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-19.
Exposure frequency	days/year	EF	40	10	HHRA, Vol. IIIA; Table 4-22; Based on Fries 2002.
Exposure duration	years	ED	64	29	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.9.2. Based on MDPH 2001.
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	23,360	10,585	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	200	100	HHRA, Vol. IIIA; Tables 4-19 and 4-24; Section 4.5.3.9.3. Based on EPA 1997 and Stanek et al. 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-19; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.21	0.21	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.9.4. Based on farmers.
Skin surface area	cm^2/day	SA	3,300	3,300	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and head.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-19, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Fries 2002. USDA (retired). Personal communication.
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.*
Stanek, E., E. Calabrese, R. Barnes, P. Pekow. 1997. Soil ingestion adults - results of a second pilot study. *Ecotoxicology and Environmental Safety 36:249:257.*
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 9b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Farmer Scenario
Adult (EPA Assumptions)

Parameter	**EPA RME Analysis**			**EPA CTE Analysis**		
Common Parameters						
Exposure duration (yrs)	64	64	64	29	29	29
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	200	200	200	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	40	40	40	10	10	10
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.9E-07	2.9E-07	2.9E-07	8.1E-09	8.1E-09	8.1E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	3.1E-07	3.1E-07	3.1E-07	2.0E-08	2.0E-08	2.0E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.21	0.21	0.21	0.21	0.21	0.21
Skin surface area exposed (cm^2/day)	3300	3300	3300	3300	3300	3300
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	40	40	40	10	10	10
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	1.6E-08	1.6E-08	1.6E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.5E-07	1.5E-07	1.5E-07	3.8E-08	3.8E-08	3.8E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	1.6E-08	1.6E-08	1.6E-08
Total Exposure, soil ingestion $(days)^{-1}$	2.9E-07	2.9E-07	2.9E-07	8.1E-09	8.1E-09	8.1E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**118**	**12**	**1.2**	**4195**	**419**	**42**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.5E-07			3.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$	3.1E-07			2.0E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**43**			**348**		

Attachment 10
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
High Use Commercial Groundskeeper Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the high-use commercial groundskeeper scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 10a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adult groundskeepers in high-use commercial areas are presented below and in Table 10b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	1.8	18	177	25	17	166	1,664	57

Table 10a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the High-use Commercial Groundskeeper Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-20.
Exposure frequency	days/year	EF	150	150	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.10.1. Based on EPA's professional judgment.
Exposure duration	years	ED	25	12	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.10.2. EPA 1991 (RME) and EPA's professional judgment (CTE).
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	9,125	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	100	50	HHRA, Vol. IIIA; Tables 4-20 and 4-24; Section 4.5.3.10.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-20; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.1	0.1	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.10.4. Based on gardeners.
Skin surface area	cm^2/day	SA	2,479	2,479	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and face.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-20, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 10b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Commercial Groundskeeper Scenario
Adults (EPA Assumptions)

Parameter	**EPA RME Analysis**			**EPA CTE Analysis**		
Common Parameters						
Exposure duration (yrs)	25	25	25	12	12	12
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	9,125	9,125	9,125	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	150	150	150	150	150	150
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.1E-07	2.1E-07	2.1E-07	2.5E-08	2.5E-08	2.5E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	5.9E-07	5.9E-07	5.9E-07	1.5E-07	1.5E-07	1.5E-07
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.1	0.1	0.1	0.1	0.1	0.1
Skin surface area exposed (cm^2/day)	2479	2479	2479	2479	2479	2479
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	150	150	150	150	150	150
Exposure (dermal con)-carcinogenic $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	3.5E-08	3.5E-08	3.5E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.0E-07	2.0E-07	2.0E-07	2.0E-07	2.0E-07	2.0E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	3.5E-08	3.5E-08	3.5E-08
Total Exposure, soil ingestion $(days)^{-1}$	2.1E-07	2.1E-07	2.1E-07	2.5E-08	2.5E-08	2.5E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**177**	**18**	**1.8**	**1664**	**166**	**17**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	2.0E-07			2.0E-07		
Total Exposure, soil ingestion $(days)^{-1}$	5.9E-07			1.5E-07		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**25**			**57**		

Attachment 11
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Low-Use Commercial Groundskeeper Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the low-use commercial groundskeeper scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 11a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adult groundskeepers in high-use commercial areas are presented below and in Table 11b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	8.9	89	885	126	166	1,664	16,642	571

Table 11a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Low-Use Commercial Groundskeeper Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-20.
Exposure frequency	days/year	EF	30	15	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.10.1. Based on EPA's professional judgment.
Exposure duration	years	ED	25	12	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.10.2. EPA 1991 (RME) and EPA's professional judgment (CTE).
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	9,125	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	100	50	HHRA, Vol. IIIA; Tables 4-20 and 4-24; Section 4.5.3.10.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-20; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.1	0.1	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.10.4. Based on gardeners.
Skin surface area	cm^2/day	SA	2,479	2,479	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and face.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-20, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 11b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Low-Use Commercial Groundskeeper Scenario
Adults (EPA Assumptions)

Parameter	**EPA RME Analysis**			**EPA CTE Analysis**		
Common Parameters						
Exposure duration (yrs)	25	25	25	12	12	12
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	9,125	9,125	9,125	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	30	30	30	15	15	15
Exposure (soil ing)-carcinogenic $(days)^{-1}$	4.2E-08	4.2E-08	4.2E-08	2.5E-09	2.5E-09	2.5E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	1.2E-07	1.2E-07	1.2E-07	1.5E-08	1.5E-08	1.5E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.1	0.1	0.1	0.1	0.1	0.1
Skin surface area exposed (cm^2/day)	2479	2479	2479	2479	2479	2479
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	30	30	30	15	15	15
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	3.5E-09	3.5E-09	3.5E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	4.1E-08	4.1E-08	4.1E-08	2.0E-08	2.0E-08	2.0E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	3.5E-09	3.5E-09	3.5E-09
Total Exposure, soil ingestion $(days)^{-1}$	4.2E-08	4.2E-08	4.2E-08	2.5E-09	2.5E-09	2.5E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**885**	**89**	**8.9**	**16642**	**1664**	**166**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	4.1E-08			2.0E-08		
Total Exposure, soil ingestion $(days)^{-1}$	1.2E-07			1.5E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**126**			**571**		

Attachment 12
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Utility Worker Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the utility worker scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 12a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adult utility workers are presented below and in Table 12b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	17	169	1,694	242	209	2,093	20,933	718

Table 12a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Utility Worker Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-21.
Exposure frequency	days/year	EF	5	5	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.11.1. Based on EPA's professional judgment.
Exposure duration	years	ED	25	12	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.11.2. EPA 1991 (RME) and EPA's professional judgment (CTE).
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	9,125	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	330	100	HHRA, Vol. IIIA; Tables 4-21 and 4-24; Section 4.5.3.11.3. Based on EPA 1997 and Stanek et al. 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-21; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.2	0.2	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.11.4. Based on utility workers.
Skin surface area	cm^2/day	SA	3,300	3,300	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and head.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-21, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Stanek, E., E. Calabrese, R. Barnes, P. Pekow. 1997. Soil ingestion adults - results of a second pilot study. *Ecotoxicology and Environmental Safety* 36:249:257.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 12b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Utility Worker Scenario
Adults

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)	25	25	25	12	12	12
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	9,125	9,125	9,125	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	330	330	330	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	5	5	5	5	5	5
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.3E-08	2.3E-08	2.3E-08	1.7E-09	1.7E-09	1.7E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	6.5E-08	6.5E-08	6.5E-08	9.8E-09	9.8E-09	9.8E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.2	0.2	0.2	0.2	0.2	0.2
Skin surface area exposed (cm^2/day)	3300	3300	3300	3300	3300	3300
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	5	5	5	5	5	5
Exposure (dermal con)-carcinogenic $(days)^{-1}$	6.5E-09	6.5E-09	6.5E-09	3.1E-09	3.1E-09	3.1E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.8E-08	1.8E-08	1.8E-08	1.8E-08	1.8E-08	1.8E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	6.5E-09	6.5E-09	6.5E-09	3.1E-09	3.1E-09	3.1E-09
Total Exposure, soil ingestion $(days)^{-1}$	2.3E-08	2.3E-08	2.3E-08	1.7E-09	1.7E-09	1.7E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**1694**	**169**	**17**	**20933**	**2093**	**209**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.8E-08			1.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$	6.5E-08			9.8E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**242**			**718**		

Attachment 13
Risk-based Media Concentrations for Direct Contact with Sediment
Sediment Exposure Scenario (EPA Assumptions)

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with sediments under the sediment exposure scenario. Consistent with the approach used in EPA's HHRA, potential sediment ingestion and dermal contact exposures of adults and older children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the sediment ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with sediment (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the sediment ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with sediment (day^{-1})

In both of the above equations, the exposures due to sediment ingestion ($Exp_{ingestion}$) and dermal contact with sediment (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Sediment ingestion rate (mg/day)
FI	=	Fraction of sediment ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 13a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adults and older children who engage in sediment contact activities are presented below and in Tables 13b and 13c, respectively. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	1.3	13	135	40	28	280	2,800	152
Older child	4.5	45	453	31	36	365	3,645	125

Table 13a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Sediment Exposure Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-18.
Exposure frequency	days/year	EF			
Older child			36	12	HHRA, Vol. IIIA; Table 4-22; Based on EPA's professional judgment.
Adult			36	12	HHRA, Vol. IIIA; Table 4-22; Based on EPA's professional judgment.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Age 7 -18 years. Section 4.5.3.8.2. Calculated by EPA.
Adult			52	19	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.8.2. Based on MDPH 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			18,980	6,935	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-18 and 4-24; Section 4.5.3.8.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-18 and 4-24; Section 4.5.3.8.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-18; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF			
Older child			0.31	0.31	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.8.4. Gardeners (face) and Reed gatherers (other body parts).
Adult			0.3	0.3	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.8.4. Gardeners (face) and Reed gatherers (other body parts).
Skin surface area	cm^2/day	SA			
Older child			4,471	4,471	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Adult			6,074	6,074	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-18, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 13b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Sediment Exposure Scenario
Adults (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	52	52	52	19	19	19
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	18,980	18,980	18,980	6,935	6,935	6,935
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	36	36	36	12	12	12
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.0E-07	1.0E-07	1.0E-07	3.2E-09	3.2E-09	3.2E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	1.2E-08	1.2E-08	1.2E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult	0.3	0.3	0.3	0.3	0.3	0.3
Skin surface area exposed (cm^2/day)						
Adult	6074	6074	6074	6074	6074	6074
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	36	36	36	12	12	12
Exposure (dermal con)-carcinogenic $(days)^{-1}$	2.7E-07	2.7E-07	2.7E-07	3.3E-08	3.3E-08	3.3E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	3.6E-07	3.6E-07	3.6E-07	1.2E-07	1.2E-07	1.2E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.7E-07	2.7E-07	2.7E-07	3.3E-08	3.3E-08	3.3E-08
Total Exposure, soil ingestion $(days)^{-1}$	1.0E-07	1.0E-07	1.0E-07	3.2E-09	3.2E-09	3.2E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**135**	**13**	**1.3**	**2800**	**280**	**28**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	3.6E-07			1.2E-07		
Total Exposure, soil ingestion $(days)^{-1}$	1.4E-07			1.2E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**40**			**152**		

Table 13c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Sediment Exposure Scenario
Older Child (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	36	36	36	12	12	12
Exposure (soil ing)-carcinogenic $(days)^{-1}$	3.8E-08	3.8E-08	3.8E-08	3.1E-09	3.1E-09	3.1E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	2.2E-07	2.2E-07	2.2E-07	1.8E-08	1.8E-08	1.8E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child	0.31	0.31	0.31	0.31	0.31	0.31
Skin surface area exposed (cm^2/day)						
Older child	4471	4471	4471	4471	4471	4471
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	36	36	36	12	12	12
Exposure (dermal con)-carcinogenic $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	2.4E-08	2.4E-08	2.4E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	4.3E-07	4.3E-07	4.3E-07	1.4E-07	1.4E-07	1.4E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	2.4E-08	2.4E-08	2.4E-08
Total Exposure, soil ingestion $(days)^{-1}$	3.8E-08	3.8E-08	3.8E-08	3.1E-09	3.1E-09	3.1E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**453**	**45**	**4.5**	**3645**	**365**	**36**
NONCARCINOGENIC	**Older Child**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	4.3E-07			1.4E-07		
Total Exposure, soil ingestion $(days)^{-1}$	2.2E-07			1.8E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**31**			**125**		

APPENDIX C

ATTACHMENTS 14 THROUGH 19

Attachment 14
Risk-based Media Concentrations for PCBs in
Massachusetts and Connecticut Bass Tissue
Fish Consumption Scenario (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for exposure, via human consumption, to PCBs in the edible tissue of bass obtained from the Massachusetts and Connecticut portions of the river. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic approach and a probabilistic 1-dimensional Monte Carlo approach (1-D Monte Carlo). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

The RMCs for the non-cancer endpoint (RMC_{nc}) for this scenario have been calculated using the following equation. Non-cancer RMCs have been calculated separately for young children and adults.

Young Child

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_a * ED_a}{BW_a}}$$

In the above equations:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
RMC_{nc}	=	RMC based on the non-cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
HI	=	Target hazard index (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)

LOSS	=	Cooking loss (unitless)
IR_c	=	Bass ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Bass ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
RfD	=	Reference dose (mg/kg-day)

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 14a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the probabilistic analysis, the input distributions were developed from the information provided in Table 6-2 of Vol. IV of the HHRA (p. 6-15). Descriptions of these distributions are provided in Table 14b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer hazard index of 1 (evaluating adults and children separately).

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA. For the probabilistic analysis, a point estimate CSF of 2 $(mg/kg\text{-}day)^{-1}$ was used for both the RME and CTE scenarios.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

For the probabilistic analysis, the same risk range and Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution values exceed the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints based on the deterministic analysis are presented in Table 14c. A summary of the distribution of RMCs calculated using the 1-D Monte Carlo is provided in Table 14d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (mg/kg)				CTE (mg/kg)			
	Cancer Risk			Non-cancer	Cancer Risk			Non-cancer
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Young child/Adult	0.0019	0.019	0.19	NC	0.049	0.49	4.9	NC
Adult	NC	NC	NC	0.062	NC	NC	NC	0.43
Young child	NC	NC	NC	0.026	NC	NC	NC	0.19
1-D Monte Carlo								
Young child/Adult	0.0026	0.026	0.26	NC	0.031	0.31	3.1	NC
Adult	NC	NC	NC	0.047	NC	NC	NC	0.53
Young child	NC	NC	NC	0.040	NC	NC	NC	0.49

NC = Not calculated

Table 14a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption Scenario for Bass (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			16	4.3	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.6. EPA's calculation based on EPA 2002.
Adult			31	8.7	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.4. Based on EPA's evaluation of the Ebert et al. data.
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.3. EPA's evaluation based on multiple studies.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA, Section 4.5.2.6.
Adult			44	17	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			16,060	6,205	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers.*North American Journal of Fisheries Management* 13:737-745.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 14b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Bass Consumption Scenario[1] (EPA Assumptions)

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/day	IR					
Adult			0.27	80.22	8.5	13.6	Empirical Distribution Function
Young child			0.135	40.11	4.25	6.8	Empirical Distribution Function[2]
Fraction ingested from site	unitless	FI	-	-	1	-	Point Estimate
Oral absorption factor	unitless	ABS_o	-	-	1	-	Point Estimate
Fraction PCBs lost during cooking	unitless	LOSS	0.16	1	0.26	0.18	Stochastic mixture of distributions
Exposure frequency	days/yr	EF	-	-	365	-	Point Estimate
Exposure duration	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg/mg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate
Averaging time (noncancer endpoint)	days	ATnc					
Young child					Variable		Dependent on Exposure Duration
Adult					Variable		Dependent on Exposure Duration

[1]All distribution statistics are presented in Table 6-2, page 6-15, of the HHRA Volume IV.
[1]Based on one-half the adult distribution of rates.

Table 14c. Deterministic RMCs for PCBs (mg/kg) in Bass Tissue for Target Risk Range and Hazard Index of 1
Fish Consumption - Massachusetts and Connecticut Bass (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	16,060	16,060	16,060	6,205	6,205	6,205
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Bass ingestion rate (g/day)						
Child	16	16	16	4.3	4.3	4.3
Adult	31	31	31	8.7	8.7	8.7
Fraction attributable to site	0.97	0.97	0.97	0.5	0.5	0.5
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic $(days)^{-1}$	2.7E-04	2.7E-04	2.7E-04	2.1E-05	2.1E-05	2.1E-05
Exposure - noncarcinogenic $(days)^{-1}$ - Child	7.8E-04	7.8E-04	7.8E-04	1.1E-04	1.1E-04	1.1E-04
Exposure - noncarcinogenic $(days)^{-1}$ - Adult	3.22E-04	3.22E-04	3.22E-04	4.66E-05	4.66E-05	4.66E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, fish ingestion $(days)^{-1}$	2.7E-04	2.7E-04	2.7E-04	2.1E-05	2.1E-05	2.1E-05
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.19**	**0.019**	**0.0019**	**4.9**	**0.49**	**0.049**
NONCARCINOGENIC	**Child 1-6 years**			**Child 1-6 years**		
Total Exposure, fish ingestion $(days)^{-1}$	7.8E-04			1.1E-04		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.026**			**0.19**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, fish ingestion $(days)^{-1}$	3.2E-04			4.7E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.062**			**0.43**		

Table 14d. Summary of PCB RMC (mg/kg) Output of 1-D Monte Carlo for Consumption of Bass (EPA Assumptions)

	RMC (mg/kg)				
	Cancer			Non-cancer	
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk	Adult	Child
Minimum	0.00038	0.0038	0.038	0.012	0.0077
5	0.0026	0.026	0.26	0.047	0.040
10	0.0045	0.045	0.45	0.082	0.068
15	0.0065	0.065	0.65	0.12	0.10
20	0.0086	0.086	0.86	0.16	0.13
25	0.011	0.11	1.1	0.20	0.17
30	0.014	0.14	1.4	0.24	0.21
35	0.017	0.17	1.7	0.28	0.25
40	0.020	0.20	2.0	0.34	0.32
45	0.025	0.25	2.5	0.41	0.40
50	0.031	0.31	3.1	0.53	0.49
55	0.040	0.40	4.0	0.68	0.63
60	0.051	0.51	5.1	0.87	0.80
65	0.067	0.67	6.7	1.1	1.0
70	0.087	0.87	8.7	1.5	1.4
75	0.11	1.1	11	2.0	1.8
80	0.15	1.5	15	2.5	2.3
85	0.19	1.9	19	3.3	3.1
90	0.27	2.7	27	4.4	4.2
95	0.40	4.0	40	6.1	6.8
Maximum	159	1589	15889	1972	576

Attachment 15
Risk-based Media Concentrations for PCBs in Connecticut Trout Tissue
Fish Consumption Scenario (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for exposure, via human consumption, to PCBs in the edible tissue of trout obtained from the Connecticut portions of the river. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic and a probabilistic 1-dimensional Monte Carlo approach (1-D Monte Carlo). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * ABS_o * FI * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

The RMCs for the non-cancer endpoint (RMC_{nc}) for this scenario have been calculated using the following equation. Non-cancer RMCs have been calculated separately for young children and adults.

Young Child

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_a * ED_a}{BW_a}}$$

In the above equations:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
RMC_{nc}	=	RMC based on the non-cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
HI	=	Target hazard index (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
EF	=	Exposure frequency (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Trout ingestion rate for children aged 1-6 years (g/day)

IR_a	=	Trout ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
RfD	=	Reference dose (mg/kg-day)

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 15a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the probabilistic analysis, the input distributions were developed from the information provided in Table 6-2 of Vol. IV of the HHRA (p. 6-15). Descriptions of these distributions are provided in Table 15b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer hazard index of 1 (evaluating adults and children separately).

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA. For the probabilistic analysis, a point estimate CSF of 2 $(mg/kg\text{-}day)^{-1}$ was used for both the RME and CTE scenarios.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for noncancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

For the 1-D Monte Carlo analysis, the same risk range and target Hazard Index have been used. Once the analysis was completed, the 5^{th} percentile (95% of the calculated RMC output distribution values exceed the 5^{th} percentile) and the 50^{th} percentile values from the output distribution of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints based on the deterministic analysis are presented in Table 15c. A summary of the distribution of RMCs calculated using the 1-D Monte Carlo is provided in Table 15d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5^{th} and 50^{th} percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (mg/kg)				CTE (mg/kg)			
	Cancer Risk			Non-cancer	Cancer Risk			Non-cancer
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Young child/Adult	0.0048	0.048	0.48	NC	0.11	1.1	11	NC
Adult	NC	NC	NC	0.16	NC	NC	NC	0.93
Young child	NC	NC	NC	0.069	NC	NC	NC	0.40
1-D Monte Carlo								
Young child/Adult	0.0070	0.070	0.70	NC	0.067	0.67	6.7	NC
Adult	NC	NC	NC	0.14	NC	NC	NC	1.1
Young child	NC	NC	NC	0.11	NC	NC	NC	1.0

NC = Not calculated

Table 15a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption Scenario for Trout (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			6	2	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.6. EPA's calculation based on EPA 2002.
Adult			12	4	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.4. Based on EPA's evaluation of the Ebert et al. data.
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.3. EPA's evaluation based on multiple studies.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA, Section 4.5.2.6.
Adult			44	17	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			16,060	6,205	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers.*North American Journal of Fisheries Management* 13:737-745.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 15b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Trout Consumption Scenario[1] (EPA Assumptions)

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Fraction ingested from site	unitless	FI	-	-	1	-	Point Estimate
Oral absorption factor	unitless	ABS_o	-	-	1	-	Point Estimate
Fraction PCBs lost during cooking	unitless	LOSS	0.16	1	0.26	0.18	Stochastic mixture of distributions
Ingestion rate	g/day	IR					
Young child			0.14	23.31	2.1	3.65	Empirical Distribution Function[2]
Adult			0.27	46.62	4.2	7.3	Empirical Distribution Function
Exposure frequency	days	EF	-	-	365	-	Point Estimate
Exposure duration	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg/mg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate
Averaging time (noncancer endpoint)	days	ATnc					
Young child					Variable		Dependent on exposure duration
Adult					Variable		Dependent on exposure duration

[1]All distribution statistics are presented in Table 6-2, page 6-15, of the HHRA Volume IV.

[2]Developed by using half the adult rate distribution.

Table 15c. Deterministic RMCs for PCBs (mg/kg) in Trout Tissue for Target Risk Range and Hazard Index of 1
Fish Consumption - Connecticut Trout (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	16,060	16,060	16,060	6,205	6,205	6,205
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	6	6	6	2	2	2
Adult	12	12	12	4	4	4
Fraction attributable to site	0.97	0.97	0.97	0.5	0.5	0.5
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic (days)$^{-1}$	1.0E-04	1.0E-04	1.0E-04	9.5E-06	9.5E-06	9.5E-06
Exposure - noncarcinogenic (days)$^{-1}$ - Child	2.9E-04	2.9E-04	2.9E-04	5.0E-05	5.0E-05	5.0E-05
Exposure - noncarcinogenic (days)$^{-1}$ - Adult	1.25E-04	1.25E-04	1.25E-04	2.14E-05	2.14E-05	2.14E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, fish ingestion (days)$^{-1}$	1.0E-04	1.0E-04	1.0E-04	9.5E-06	9.5E-06	9.5E-06
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.48**	**0.048**	**0.0048**	**11**	**1.1**	**0.11**
NONCARCINOGENIC	**Child 1-6 years**			**Child 1-6 years**		
Total Exposure, fish ingestion (days)$^{-1}$	2.9E-04			5.0E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.069**			**0.40**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, fish ingestion (days)$^{-1}$	1.2E-04			2.1E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.16**			**0.93**		

Table 15d. Summary of PCB RMC (mg/kg) Output of 1-D Monte Carlo for Consumption of Trout (EPA Assumptions)

	RMC (mg/kg)				
	Cancer			Non-cancer	
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk	Adult	Child
Minimum	0.00065	0.0065	0.065	0.022	0.015
5	0.0070	0.070	0.70	0.14	0.11
10	0.011	0.11	1.1	0.21	0.17
15	0.015	0.15	1.5	0.28	0.24
20	0.020	0.20	2.0	0.36	0.30
25	0.025	0.25	2.5	0.44	0.38
30	0.030	0.30	3.0	0.53	0.47
35	0.037	0.37	3.7	0.65	0.57
40	0.045	0.45	4.5	0.78	0.70
45	0.055	0.55	5.5	0.94	0.86
50	0.067	0.67	6.7	1.1	1.0
55	0.082	0.82	8.2	1.4	1.3
60	0.10	1.0	10	1.7	1.6
65	0.12	1.2	12	2.2	1.9
70	0.15	1.5	15	2.6	2.4
75	0.18	1.8	18	3.2	2.9
80	0.23	2.3	23	3.9	3.5
85	0.28	2.8	28	4.7	4.4
90	0.36	3.6	36	5.8	5.7
95	0.51	5.1	51	7.4	8.5
Maximum	6553	65530	655299	8517	75373

Attachment 16
Risk-based Media Concentrations for PCBs in Waterfowl Tissue
Waterfowl Consumption Scenario (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for exposure, via human consumption, to PCBs in waterfowl tissues obtained in the edible tissue of waterfowl from the river. Consistent with the approach used in EPA's HHRA, potential waterfowl consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic and a probabilistic 1-dimentional Monte Carlo approach (1-D Monte Carlo). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

The RMCs for the non-cancer endpoint (RMC_{nc}) for this scenario have been calculated using the following equation. Non-cancer RMCs have been calculated separately for young children and adults.

Young Child

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{hc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_a * ED_a}{BW_a}}$$

In the above equations:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
RMC_{nc}	=	RMC based on the non-cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
HI	=	Target hazard index (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
EF	=	Exposure frequency (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Waterfowl ingestion rate for children aged 1-6 years (g/day)

IR_a	=	Waterfowl ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
RfD	=	Reference dose (mg/kg-day)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 16a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA. (It should be noted that the approach used in the deterministic analysis differs slightly from that used in the 1-D Monte Carlo. For the deterministic analysis, the IRWF is reported in g/day and is multiplied by an EF of 365 days/year to derive the g/year estimate. In the 1-D Monte Carlo analysis, the g/year estimate is derived by multiplying the IRWF in units of g/meal by an EF of meals/year.)

For the 1-D Monte Carlo analysis, the input distributions were developed from the information provided in Table 6-4 of Vol. IV of the HHRA (p. 6-58). Descriptions of these distributions are provided in Table 16b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer Hazard Index of 1 (evaluating adults and children separately).

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA. For the probabilistic analysis, a point estimate CSF of 2 $(mg/kg\text{-}day)^{-1}$ was used for both the RME and CTE scenarios.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for noncancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

For the 1-D Monte Carlo analysis, the same risk range and target Hazard Index have been used. Once the analysis was completed, the 5^{th} percentile (95% of the calculated RMC output distribution values exceed the 5^{th} percentile) and the 50^{th} percentile values from the output distribution of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints based on the deterministic analysis are presented in Table 16c. A summary of the distribution of RMCs calculated using the 1-D Monte Carlo is provided in Table 16d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5^{th} and 50^{th} percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (mg/kg)				CTE (mg/kg)			
	Cancer Risk			Non-cancer	Cancer Risk			Non-cancer
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Young child/Adult	0.0084	0.084	0.84	NC	0.066	0.66	6.6	NC
Adult	NC	NC	NC	0.28	NC	NC	NC	0.58
Young child	NC	NC	NC	0.12	NC	NC	NC	0.25
1-D Monte Carlo								
Young child/adult	0.0075	0.075	0.75	NC	0.072	0.72	7.2	NC
Adult	NC	NC	NC	0.12	NC	NC	NC	0.87
Young child	NC	NC	NC	0.12	NC	NC	NC	1.2

NC = Not calculated

Table 16a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Waterfowl Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-38 and 4-40.
Ingestion rate	g/day	IR			
Young child			2.5	1.2	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Calculated by EPA based on one-half adult rate.
Adult			5	2.4	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Meal size based on poultry meal sizes from Pao et al. 1982; meal frequency based on 90th percentile from MDPH 2001 survey.
Fraction ingested from site	unitless	FI	1	1	HHRA, Vol IV; Tables 4-38 and 4-40. Section 4.6.2.3. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-38 and 4-40. Waterfowl consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0	0	HHRA, Vol IV; Tables 4-38 and 4-40. Section 4.6.2.2. EPA's professional judgment.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-39 and 4-40. Ages 1 to 6 years. Calculated by EPA based on EPA 1989.
Adult			44	17	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.5. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-38; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IV. Table 4-40; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			16,060	6,205	HHRA, Vol. IV. Table 4-40; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Pao, E., K. Fleming, P. Guenther, S. Mickle. 1982. *Foods Commonly Esten by Individuals: Amount Per Day and Per Eating Occasion.* Consumer Nutrition Center, Human Nutrition Information Service, U.S. Department of Agriculture. Hyattsville, MD. Home Economics Reserach Report Number 44.

Table 16b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Waterfowl Consumption Scenario[1] (EPA Assumptions)

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/meal	IR					
Young child			19	338	94	57	Lognormal
Adult			38	675	188	113	Lognormal
Exposure frequency	meals/year	EF	1	52	5.4	10.6	Empirical Distribution Function
Fraction ingested from site	unitless	FI	-	-	1	-	Point Estimate
Oral absorption factor	unitless	ABS_o	-	-	1	-	Point Estimate
Fraction PCBs lost during cooking	unitless	LOSS	-	-	0	-	Point Estimate
Exposure duration	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg/mg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate
Averaging time (noncancer endpoint)	days	ATnc					
Young child					Variable		Dependent on exposure duration
Adult					Variable		Dependent on exposure duration

[1]All distribution statistics are presented in Table 6-4, page 6-58, of the HHRA Volume IV.

Table 16c. Deterministic RMCs for PCBs (mg/kg) in Waterfowl Tissue at Target Risk Range and Hazard Index of 1
Waterfowl Consumption Scenario (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	16,060	16,060	16,060	6,205	6,205	6,205
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	2.5	2.5	2.5	1.2	1.2	1.2
Adult	5	5	5	2.4	2.4	2.4
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0	0	0	0	0	0
Conversion factor, waterfowl ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic $(days)^{-1}$	5.9E-05	5.9E-05	5.9E-05	1.5E-05	1.5E-05	1.5E-05
Exposure - noncarcinogenic $(days)^{-1}$ - Child	1.7E-04	1.7E-04	1.7E-04	8.0E-05	8.0E-05	8.0E-05
Exposure - noncarcinogenic $(days)^{-1}$ - Adult	7.14E-05	7.14E-05	7.14E-05	3.43E-05	3.43E-05	3.43E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, waterfowl ingestion $(days)^{-1}$	5.9E-05	5.9E-05	5.9E-05	1.5E-05	1.5E-05	1.5E-05
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.84**	**0.084**	**0.0084**	**6.6**	**0.66**	**0.066**
NONCARCINOGENIC	**Child 1-6 years**			**Child 1-6 years**		
Total Exposure, waterfowl ingestion $(days)^{-1}$	1.7E-04			8.0E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.12**			**0.25**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, waterfowl ingestion $(days)^{-1}$	7.1E-05			3.4E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.28**			**0.58**		

Table 16d. Summary of PCB RMC (mg/kg) Output of 1-D Monte Carlo for Consumption of Waterfowl (EPA Assumptions)

	RMC (mg/kg)				
	Cancer			Non-cancer	
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk	Adult	Child
Minimum	0.00057	0.0057	0.057	0.014	0.010
5	0.0075	0.075	0.75	0.12	0.12
10	0.012	0.12	1.2	0.19	0.19
15	0.017	0.17	1.7	0.26	0.27
20	0.022	0.22	2.2	0.33	0.36
25	0.028	0.28	2.8	0.40	0.45
30	0.035	0.35	3.5	0.48	0.56
35	0.042	0.42	4.2	0.56	0.68
40	0.050	0.50	5.0	0.66	0.82
45	0.060	0.60	6.0	0.76	0.99
50	0.072	0.72	7.2	0.87	1.2
55	0.085	0.85	8.5	1.0	1.4
60	0.10	1.0	10	1.1	1.7
65	0.12	1.2	12	1.3	2.1
70	0.15	1.5	15	1.5	2.5
75	0.18	1.8	18	1.7	3.1
80	0.23	2.3	23	2.0	4.0
85	0.30	3.0	30	2.4	5.3
90	0.42	4.2	42	3.0	7.4
95	0.68	6.8	68	4.0	12
Maximum	9.1	91	906	17	233

Attachment 17
Risk-based Media Concentrations for TEQ in
Massachusetts and Connecticut Bass Tissue
Fish Consumption Scenario (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for dioxin toxicity equivalency quotients (TEQs) based on the potential for humans to be exposed, via consumption, to dioxins, furans, and dioxin-like PCBs in the edible tissue of bass obtained from the Massachusetts and Connecticut portions of the river. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic and a probabilistic 1-dimensional Monte Carlo approach (1-D Monte Carlo). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated for TEQs based on potential cancer risks for children and adults combined, using the exposure assumptions and TEQ toxicity value used in the HHRA. Consistent with the HHRA, since EPA has not developed a non-cancer reference dose for dioxin TEQs, RMCs based on non-cancer impacts have not been developed for TEQs.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c * CF}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (ng/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CF	=	Unit conversion factor (1,000,000 ng/mg)
EF	=	Exposure frequency (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Bass ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Bass ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 17a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the 1-D Monte Carlo analysis, the input distributions were developed from the information provided in Table 6-2 of Vol. IV of the HHRA (p. 6-15). Descriptions of these distributions are provided in Table 17b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure).

Currently EPA's IRIS database does not publish a cancer slope factor (CSF) for dioxin. Consistent with the approach used in the HHRA, a CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of 150,000 $(mg/kg\text{-}day)^{-1}$, which was the CSF published in EPA's 1997 *Health Effects Assessment Summary Tables*, has been used to calculate the RMCs for dioxin TEQs.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range.

For the 1-D Monte Carlo analysis, the same risk range and Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution exceeds the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs (in ng/kg or ppt) for the cancer endpoint based on the deterministic analysis are presented in Table 17c. A summary of the distribution of RMCs calculated using the 1-D Monte Carlo is provided in Table 17d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (ng/kg)			**CTE (ng/kg)**		
	Cancer Risk			**Cancer Risk**		
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**
Young child/Adult	0.025	0.25	2.5	0.32	3.2	32
Probabilistic						
Young child/Adult	0.034	0.34	3.4	0.42	4.2	42

Table 17a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption Scenario for Bass (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			16	4.3	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.6. EPA's calculation based on EPA 2002.
Adult			31	8.7	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.4. Based on EPA's evaluation of the Ebert et al. 1993.
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.3. EPA's evaluation based on multiple studies.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA, Section 4.5.2.6.
Adult			44	17	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers. *North American Journal of Fisheries Management* 13:737-745.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 17b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Bass Consumption Scenario[1] (EPA Assumptions)

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/day	IR					
Adult			0.27	80.22	8.5	13.6	Empirical Distribution Function
Young child			0.135	40.11	4.25	6.8	Empirical Distribution Function[2]
Fraction ingested from site	unitless	FI	-	-	1	-	Empirical Distribution Function
Oral absorption factor	unitless	ABS_o	-	-	1	-	Point Estimate
Fraction PCBs lost during cooking	unitless	LOSS	0.16	1	0.26	0.18	Stochastic mixture of distributions
Exposure frequency			-	-	365	-	Point Estimate
Exposure duration	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg/mg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate

[1]All distribution statistics are presented in Table 6-2, page 6-15, of the HHRA Volume IV.
[2]Distribution is half of the adult empirical distribution.

Table 17c. Deterministic RMCs for TEQ (ng/kg) in Bass Tissue at Target Risk Range and Hazard Index of 1
Fish Consumption - Massachusetts and Connecticut Bass (EPA Assumptions)

Parameter	**EPA RME Analysis**			**EPA CTE Analysis**		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	16	16	16	4.3	4.3	4.3
Adult	31	31	31	8.7	8.7	8.7
Fraction attributable to site	0.97	0.97	0.97	0.5	0.5	0.5
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic (days)$^{-1}$	2.7E-04	2.7E-04	2.7E-04	2.1E-05	2.1E-05	2.1E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, fish ingestion (days)$^{-1}$	2.7E-04	2.7E-04	2.7E-04	2.1E-05	2.1E-05	2.1E-05
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	150,000	150,000	150,000	150,000	150,000	150,000
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Unit conversion factor (ng/mg)	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
Risk-based Media Concentration (ng/kg)	**2.5**	**0.25**	**0.025**	**32**	**3.2**	**0.32**

Table 17d. Summary of TEQ RMC (ng/kg) Output of 1-D Monte Carlo for Consumption of Bass (EPA Assumptions)

	RMC (ng/kg)		
	Cancer		
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk
Minimum	0.0054	0.054	0.54
5	0.034	0.34	3.4
10	0.059	0.59	5.9
15	0.087	0.87	8.7
20	0.11	1.1	11
25	0.15	1.5	15
30	0.18	1.8	18
35	0.22	2.2	22
40	0.27	2.7	27
45	0.33	3.3	33
50	0.42	4.2	42
55	0.53	5.3	53
60	0.69	6.9	69
65	0.89	8.9	89
70	1.2	12	116
75	1.5	15	152
80	2.0	20	197
85	2.6	26	260
90	3.5	35	352
95	5.3	53	530
Maximum	733	7329	73285

Attachment 18
Risk-based Media Concentrations for TEQ in Connecticut Trout Tissue
Fish Consumption Scenario (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for dioxin toxicity equivalency quotients (TEQs) based on the potential for humans to be exposed, via consumption, to dioxins, furans, and dioxin-like PCBs in the edible tissue of trout obtained from the Connecticut portion of the river. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic approach and a probabilistic 1-dimensional Monte Carlo approach (1-D Monte Carlo). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated for TEQs based on potential cancer risks for children and adults combined, using the exposure assumptions and TEQ toxicity value used in the HHRA. Consistent with the HHRA, since EPA has not developed a non-cancer reference dose for dioxin TEQs, RMCs based on non-cancer impacts have not been developed for TEQs.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c * CF}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (ng/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CF	=	Unit conversion factor (1,000,000 ng/mg)
EF	=	Exposure frequency (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Trout ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Trout ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 18a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the 1-D Monte Carlo analysis, the input distributions were developed from information provided in Table 6-2 of Vol. IV of the HHRA (p. 6-15). Descriptions of these distributions are provided in Table 18b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure).

Currently EPA's IRIS database does not publish a cancer slope factor (CSF) for dioxin. Consistent with the approach used in the HHRA, a CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of 150,000 $(mg/kg\text{-}day)^{-1}$, which was the CSF published in EPA's 1997 *Health Effects Assessment Summary Tables*, has been used to calculate the RMCs for dioxin TEQs.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range.

For the 1-D Monte Carlo analysis, the same risk range and Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution values exceed the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs (in ng/kg or ppt) for the cancer endpoint based on the deterministic analysis are presented in Table 18c. A summary of the distribution of RMCs calculated using the 1-D Monte Carlo is provided in Table 18d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (ng/kg)			**CTE (ng/kg)**		
	Cancer Risk			**Cancer Risk**		
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**
Young child/Adult	0.065	0.65	6.5	0.70	7.0	70
1-D Monte Carlo						
Young child/Adult	0.094	0.94	9.4	0.90	9.0	90

Table 18a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption Scenario for Trout (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF1	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			6	2	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.6. EPA's calculation based on EPA 2002.
Adult			12	4	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.4. Based on EPA's evaluation of the Ebert et al. 1993.
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.3. EPA's evaluation based on multiple studies.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA, Section 4.5.2.6.
Adult			44	17	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers. *North American Journal of Fisheries Management* 13:737-745.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 18b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Trout Consumption Scenario[1] (EPA Assumptions)

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/day	IR					
Adult			0.27	46.62	4.2	7.3	Empirical Distribution Function
Young child			0.135	23.31	2.1	3.65	Empirical Distribution Function[2]
Fraction ingested from site	unitless	FI	-	-	1	-	Point Estimate
Oral absorption factor	unitless	ABS_o	-	-	1	-	Point Estimate
Fraction PCBs lost during cooking	unitless	LOSS	0.16	1	0.26	0.18	Stochastic mixture of distributions
Exposure frequency	days/yr		-	-	365	-	Point Estimate
Exposure duration	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg/mg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate

[1]All distribution statistics are presented in Table 6-2, page 6-15, of the HHRA Volume IV.
[2]Distribution is half the adult distribution.

Table 18c. Deterministic RMCs for TEQ (ng/kg) in Trout Tissue at Target Risk Range and Hazard Index of 1
Fish Consumption - Connecticut Trout (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	6	6	6	2	2	2
Adult	12	12	12	4	4	4
Fraction attributable to site	0.97	0.97	0.97	0.5	0.5	0.5
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic (days)$^{-1}$	1.0E-04	1.0E-04	1.0E-04	9.5E-06	9.5E-06	9.5E-06
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, fish ingestion (days)$^{-1}$	1.0E-04	1.0E-04	1.0E-04	9.5E-06	9.5E-06	9.5E-06
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	150,000	150,000	150,000	150,000	150,000	150,000
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Unit conversion factor (ng/mg)	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
Risk-based Media Concentration (ng/kg)	**6.5**	**0.65**	**0.065**	**70**	**7.0**	**0.70**

Table 18d. Summary of TEQ RMC (ng/kg) Output of 1-D Monte Carlo for Consumption of Trout (EPA Assumptions)

	RMC (ng/kg)		
	Cancer		
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk
Minimum	0.0084	0.084	0.84
5	0.094	0.94	9.4
10	0.15	1.5	15
15	0.20	2.0	20
20	0.26	2.6	26
25	0.33	3.3	33
30	0.40	4.0	40
35	0.50	5.0	50
40	0.60	6.0	60
45	0.73	7.3	73
50	0.90	9.0	90
55	1.1	11	109
60	1.3	13	133
65	1.6	16	163
70	2.0	20	200
75	2.4	24	245
80	3.0	30	301
85	3.8	38	377
90	4.8	48	483
95	6.9	69	687
Maximum	4134	41341	413412

Attachment 19
Risk-based Media Concentrations for TEQ in Waterfowl Tissue
Waterfowl Consumption Scenario (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for dioxin toxic equivalents (TEQ) based on the potential for humans to be exposed, via consumption, to dioxins, furans, and dioxin-like PCBs in the edible tissue of waterfowl obtained from the study area. Consistent with the approach used in EPA's HHRA, potential waterfowl consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic and a probabilistic 1-dimensional Monte Carlo approach (1-D Monte Carlo). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated for TEQs based on potential cancer risks for children and adults combined, using the exposure assumptions and TEQ toxicity value used in the HHRA. Consistent with the HHRA, since EPA has not developed a non-cancer reference dose for dioxin TEQs, RMCs based on non-cancer impacts have not been developed for TEQs.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c * CF}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (ng/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CF	=	Unit conversion factor (1,000,000 ng/mg)
EF	=	Exposure frequency (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Waterfowl ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Waterfowl ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 19a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the 1-D Monte Carlo analysis, the input distributions were developed from the information provided in Table 6-4 of Vol. IV of the HHRA (p. 6-58). Descriptions of these distributions are provided in Table 16b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure).

Currently EPA's IRIS database does not publish a cancer slope factor (CSF) for dioxin. Consistent with the approach used in the HHRA, a CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of 150,000 $(mg/kg\text{-}day)^{-1}$, which was the CSF published in EPA's 1997 *Health Effects Assessment Summary Tables*, has been used to calculate the RMCs for dioxin TEQs.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range.

For the 1-D Monte Carlo analysis, the same risk range and target Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution values exceed the 5th percentile) and 50th percentile values from the output distribution of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs (in ng/kg or ppt) for the cancer endpoint based on the deterministic analysis are presented in Table 19b. A summary of the distribution of RMCs calculated using the 1-D Monte Carlo is provided in Table 19d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (ng/kg)			**CTE (ng/kg)**		
	Cancer Risk			**Cancer Risk**		
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**
Young child/Adult	0.11	1.1	11	0.44	4.4	44
1-D Monte Carlo						
Young child/Adult	0.10	1.0	10	0.96	9.6	96

Table 19a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Waterfowl Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-38 and 4-40.
Ingestion rate	g/day	IR			
Young child			2.5	1.2	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Calculated by EPA based on one-half adult rate.
Adult			5	2.4	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Meal size based on poultry meal sizes from Pao et al. 1982; meal frequency based on 90th percentile from MDPH 2001 survey.
Fraction ingested from site	unitless	FI	1	1	HHRA, Vol IV; Tables 4-38 and 4-40. Section 4.6.2.3. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-38 and 4-40. Waterfowl consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0	0	HHRA, Vol IV; Tables 4-38 and 4-40. Section 4.6.2.2. EPA's professional judgment.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-39 and 4-40. Ages 1 to 6 years. Calculated by EPA based on EPA 1989.
Adult			44	17	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.5. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-38; based on EPA 1989. Lifetime of 70 years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Pao, E., K. Fleming, P. Guenther, S. Mickle. 1982. *Foods Commonly Esten by Individuals: Amount Per Day and Per Eating Occasion.* Consumer Nutrition Center, Human Nutrition Information Service, U.S. Department of Agriculture. Hyattsville, MD. Home Economics Reserach Report Number 44.

Table 19b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Waterfowl Consumption Scenario[1] (EPA Assumptions)

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/meal	IR					
Young child			19	338	94	57	Lognormal
Adult			38	675	188	113	Lognormal
Exposure frequency	meals/year	EF	1	52	5.4	10.6	Empirical Distribution Function
Fraction ingested from site	unitless	FI	-	-	1	-	Point Estimate
Oral absorption factor	unitless	ABS_o	-	-	1	-	Point Estimate
Fraction PCBs lost during cooking	unitless	LOSS	-	-	0	-	Point Estimate
Exposure duration	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg/mg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate

[1]All distribution statistics are presented in Table 6-4, page 6-58, of the HHRA Volume IV.

Table 19c. Deterministic RMCs for TEQ (ng/kg) in Waterfowl Tissue at Target Risk Range and Hazard Index of 1
Waterfowl Consumption Scenario (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	2.5	2.5	2.5	1.2	1.2	1.2
Adult	5	5	5	2.4	2.4	2.4
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0	0	0	0	0	0
Conversion factor, waterfowl ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic $(days)^{-1}$	5.9E-05	5.9E-05	5.9E-05	1.5E-05	1.5E-05	1.5E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, waterfowl ingestion $(days)^{-1}$	5.9E-05	5.9E-05	5.9E-05	1.5E-05	1.5E-05	1.5E-05
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	150,000	150,000	150,000	150,000	150,000	150,000
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Unit conversion factor (ng/mg)	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
Risk-based Media Concentration (ng/kg)	**11**	**1.1**	**0.11**	**44**	**4.4**	**0.44**

Table 19d. Summary of TEQ RMC (ng/kg) Output of 1-D Monte Carlo for Consumption of Waterfowl (EPA Assumptions)

Percentile	RMC (ng/kg) Cancer 10^{-6} Risk	10^{-5} Risk	10^{-4} Risk
Minimum	0.0082	0.082	0.82
5	0.10	1.0	10
10	0.16	1.6	16
15	0.23	2.3	23
20	0.30	3.0	30
25	0.37	3.7	37
30	0.46	4.6	46
35	0.56	5.6	56
40	0.68	6.8	68
45	0.80	8.0	80
50	0.96	9.6	96
55	1.1	11	114
60	1.4	14	135
65	1.6	16	163
70	2.0	20	199
75	2.4	24	244
80	3.1	31	306
85	4.0	40	399
90	5.6	56	559
95	8.9	89	894
Maximum	181	1809	18085

APPENDIX D

ATTACHMENTS 20 THROUGH 28

Attachment 20
Risk-based Media Concentrations for Ingestion of Dairy Products (Cow Milk) from Commercial Farms (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of dairy products from commercial farms by adult farmers and children. Consistent with the approach used in EPA's HHRA, potential ingestion of dairy products by adult farmers and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting cow milk from commercial farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * FI * ABS_o * EF}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting cow milk from commercial farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * FI * ABS_o * EF * ED}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

FI	=	Fraction ingested that is attributable to the Site (unitless)
ABS_o	=	Relative oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 20a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$, for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 20b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.000026	0.00026	0.0026	NC	0.00012	0.0012	0.012	NC
Child	NC	NC	NC	0.00030	NC	NC	NC	0.00047
Adult	NC	NC	NC	0.0014	NC	NC	NC	0.0017

Table 20a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Commercial Farm Dairy Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Farmer			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Farmer			64	29	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Farmer			23,360	10,585	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Dairy Ingestion Rate	kg/kg-day	IR			
Adult Farmer			0.01511	0.0124	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-28 & Table 11-2
Child			0.0703	0.0441	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-28 & Table 11-2
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	1.3882	0.6242	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Fraction absorbed in GI tract	unitless	FI	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 20b. RMCs for PCBs (mg/kg) in Dairy Products for Target Risk Range and HI of 1
Commmercial Farm (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	64	64	64	29	29	29
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Dairy Consumption						
Ingestion rate (kg/kg-day)						
Child	0.0703	0.0703	0.0703	0.0441	0.0441	0.0041
Adult	0.0151	0.0151	0.0151	0.0124	0.0124	0.0124
Age-Adjusted (kg-year/kg-day)	1.3882	1.3882	1.3882	0.6242	0.6242	0.6242
Fraction attributable to site (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Relative oral absorption factor (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
Exposure (dairy ing)-carcinogenic (kg/kg-day)	0.01902	0.01902	0.01902	0.00855	0.00855	0.00855
Exposure (dairy ing)-noncarcinogenic (kg/kg-day) - child	0.06741	0.06741	0.06741	0.04229	0.04229	0.00393
Exposure (dairy ing)-noncarcinogenic (kg/kg-day) - adult	0.01448	0.01448	0.01448	0.01189	0.01189	0.01189
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dairy ingestion (kg/kg-day)	0.01902	0.01902	0.01902	8.6E-03	8.6E-03	8.6E-03
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.0026**	**0.00026**	**0.000026**	**0.012**	**0.0012**	**0.00012**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, dairy ingestion (kg/kg-day)	6.7E-02			4.2E-02		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.00030**			**0.00047**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dairy ingestion (kg/kg-day)	1.4E-02			1.2E-02		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.0014**			**0.0017**		

Attachment 21
Risk-based Media Concentrations for Ingestion of Dairy Products (Cow Milk) from Backyard Farms (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of dairy products from backyard farms by adult residents and children. Consistent with the approach used in EPA's HHRA, potential ingestion of dairy products by adult residents and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting cow milk from backyard farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * FI * ABS_o * EF}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting cow milk from backyard farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * FI * ABS_o * EF * ED}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

FI	=	Fraction ingested that is attributable to the Site (unitless)
ABS_o	=	Relative oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 21a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adult and young children separately, based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the Table 21b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.000030	0.00030	0.0030	NC	0.00017	0.0017	0.017	NC
Child	NC	NC	NC	0.00030	NC	NC	NC	0.00047
Adult	NC	NC	NC	0.0010	NC	NC	NC	0.0012

Table 21a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Backyard Farm Dairy Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Resident			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Resident			39	9	HHRA, Vol. V; Appendix D; Table 4-10. Based on MADPH 2001a
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Resident			14,235	3,285	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Dairy Ingestion Rate	kg/kg-day	IR			
Adult Resident			0.0209	0.0181	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-28 & Table 11-2
Child			0.0703	0.0441	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-28 & Table 11-2
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	1.2369	0.4275	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Fraction absorbed in GI tract	unitless	FI	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 21b. RMCs for PCBs (mg/kg) in Dairy Products for Target Risk Range and HI of 1
Backyard Farm (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	39	39	39	9	9	9
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	14,235	14,235	14,235	3,285	3,285	3,285
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Dairy Consumption						
Ingestion rate (kg/kg-day)						
Child	0.0703	0.0703	0.0703	0.0441	0.0441	0.0441
Adult	0.0209	0.0209	0.0209	0.0181	0.0181	0.0181
Age-Adjusted (kg-year/kg-day)	1.2369	1.2369	1.2369	0.4275	0.4275	0.4275
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative oral absorption factor (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (dairy ing)-carcinogenic (kg/kg-day)	0.01694	0.01694	0.01694	0.00586	0.00586	0.00586
*Exposure (dairy ing)-noncarcinogenic (kg/kg-day) - child	0.06741	0.06741	0.06741	0.04229	0.04229	0.04229
*Exposure (dairy ing)-noncarcinogenic (kg/kg-day)-adult	0.02004	0.02004	0.02004	0.01736	0.01736	0.01736
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dairy ingestion (kg/kg-day)	0.01694	0.01694	0.01694	5.9E-03	5.9E-03	5.9E-03
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.0030**	**0.00030**	**0.000030**	**0.017**	**0.0017**	**0.00017**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, dairy ingestion (kg/kg-day)	6.7E-02			4.2E-02		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.00030**			**0.00047**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dairy ingestion (kg/kg-day)	2.0E-02			1.7E-02		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.0010**			**0.0012**		

Attachment 22
Risk-based Media Concentrations for Ingestion of Beef Cow Tissue from Commercial Farms (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of beef cow tissue from commercial farms by adult farmers and children. Consistent with the approach used in EPA's HHRA, potential ingestion of beef cow tissue by adult farmers and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting beef tissue from commercial farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * FI * ABS_o * EF}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting beef tissue from commercial farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * FI * ABS_o * EF * ED}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)
FI	=	Fraction ingested that is attributable to the Site (unitless)
ABS_o	=	Relative oral absorption factor (unitless)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

EF = Exposure frequency (days/year)
ED = Exposure duration (years)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 22a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and children based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 22b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00018	0.0018	0.018	NC	0.00083	0.0083	0.083	NC
Child	NC	NC	NC	0.0043	NC	NC	NC	0.0056
Adult	NC	NC	NC	0.0079	NC	NC	NC	0.0092

Table 22a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Commercial Farm Beef Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Farmer			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Farmer			64	29	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Farmer			23,360	10,585	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Beef Ingestion Rate	kg/kg-day	IR			
Adult Farmer			0.00265	0.00226	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-36 & Table 11-3
Child			0.00486	0.00372	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-36 & Table 11-3
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.19876	0.08786	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Fraction absorbed in GI tract	unitless	FI	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 22b. RMCs for PCBs (mg/kg) in Beef Tissue for Target Risk Range and HI of 1
Commercial Farm (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	64	64	64	29	29	29
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Beef Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00486	0.00486	0.00486	0.00372	0.00372	0.00372
Adult	0.00265	0.00265	0.00265	0.00226	0.00226	0.00226
Age-Adjusted (kg-year/kg-day)	0.19876	0.19876	0.19876	0.0876	0.0876	0.0876
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative oral absorption factor (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (beef ing)-carcinogenic (kg/kg-day)	0.00272	0.00272	0.00272	0.00120	0.00120	0.00120
*Exposure (beef ing)-noncarcinogenic (kg/kg-day) - child	0.00466	0.00466	0.00466	0.00357	0.00357	0.00357
*Exposure (beef ing)-noncarcinogenic (kg/kg-day) - adult	0.00254	0.00254	0.00254	0.00217	0.00217	0.00217
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, beef ingestion (kg/kg-day)	0.00272	0.00272	0.00272	1.2E-03	1.2E-03	1.2E-03
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.018**	**0.0018**	**0.00018**	**0.083**	**0.0083**	**0.00083**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, beef ingestion (kg/kg-day)	4.7E-03			3.6E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.0043**			**0.0056**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, beef ingestion (kg/kg-day)	2.5E-03			2.2E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.0079**			**0.0092**		

Attachment 23
Risk-based Media Concentrations for Ingestion of Beef Cow Tissue from Backyard Beef Farms (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of beef cow tissue from backyard farms by adult residents and children. Consistent with the approach used in EPA's HHRA, potential ingestion of beef cow tissue by adult residents and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting beef tissue from backyard farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * FI * ABS_o * EF}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting beef tissue from backyard farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * FI * ABS_o * EF * ED}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)
FI	=	Fraction ingested that is attributable to the Site (unitless)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

ABS_o = Relative oral absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 23a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 23b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00026	0.0026	0.026	NC	0.0015	0.015	0.15	NC
Child	NC	NC	NC	0.0043	NC	NC	NC	0.0056
Adult	NC	NC	NC	0.0073	NC	NC	NC	0.0074

Table 23a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Backyard Farm Beef Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Resident			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Resident			39	9	HHRA, Vol. V; Appendix D; Table 4-10. Based on MADPH 2001a
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Resident			14,235	3,285	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Beef Ingestion Rate	kg/kg-day	IR			
Adult Resident			0.00286	0.00283	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-36 & Table 11-3
Child			0.00486	0.00372	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-36 & Table 11-3
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.1407	0.04779	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Fraction absorbed in GI tract	unitless	FI	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 23b. RMCs for PCBs (mg/kg) in Beef Tissue for Target Risk Range and HI of 1
Backyard Farm (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	39	39	39	9	9	9
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	14,235	14,235	14,235	3,285	3,285	3,285
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Beef Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00486	0.00486	0.00486	0.00372	0.00372	0.00372
Adult	0.00286	0.00286	0.00286	0.00283	0.00283	0.00283
Age-Adjusted (kg-year/kg-day)	0.1407	0.1407	0.1407	0.04779	0.04779	0.04779
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative oral absorption factor (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (beef ing)-carcinogenic (kg/kg-day)	0.00193	0.00193	0.00193	0.00065	0.00065	0.00065
*Exposure (beef ing)-noncarcinogenic (kg/kg-day) - child	0.00466	0.00466	0.00466	0.00357	0.00357	0.00357
*Exposure (beef ing)-noncarcinogenic (kg/kg-day) -adult	0.00274	0.00274	0.00274	0.00271	0.00271	0.00271
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, beef ingestion (kg/kg-day)	0.00193	0.00193	0.00193	6.5E-04	6.5E-04	6.5E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.026**	**0.0026**	**0.00026**	**0.15**	**0.015**	**0.0015**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, beef ingestion (kg/kg-day)	4.7E-03			3.6E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.0043**			**0.0056**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, beef ingestion (kg/kg-day)	2.7E-03			2.7E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.0073**			**0.0074**		

Attachment 24
Risk-based Media Concentrations for Ingestion of Poultry Meat from Commercial Farms (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of poultry meat from commercial farms by adult farmers and children. Consistent with the approach used in EPA's HHRA, potential ingestion of poultry meat by adult farmers and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting poultry meat from commercial farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * FI * ABS_o * EF}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting poultry meat from commercial farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * FI * ABS_o * EF * ED}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

FI	=	Fraction ingested that is attributable to the Site (unitless)
ABS_o	=	Relative oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 24a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 24b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00024	0.0024	0.024	NC	0.0014	0.014	0.14	NC
Child	NC	NC	NC	0.0072	NC	NC	NC	0.0089
Adult	NC	NC	NC	0.010	NC	NC	NC	0.016

Table 24a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Commercial Farm Poultry Meat Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Farmer			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Farmer			64	29	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Farmer			23,360	10,585	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Poultry Ingestion Rate	kg/kg-day	IR			
Adult Farmer			0.00208	0.00132	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-55 & Table 11-5
Child			0.00288	0.00235	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-55 & Table 11-5
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.1504	0.05238	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Fraction absorbed in GI tract	unitless	FI	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 24b. RMCs for PCBs (mg/kg) in Poultry Meet for Target Risk Range and HI of 1
Commercial Farm (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	64	64	64	29	29	29
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Poultry Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00288	0.00288	0.00288	0.00235	0.00235	0.00235
Adult	0.00208	0.00208	0.00208	0.00132	0.00132	0.00132
Age-Adjusted (kg-year/kg-day)	0.1504	0.1504	0.1504	0.05238	0.05238	0.05238
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative oral absorption factor (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (poultry ing)-carcinogenic (kg/kg-day)	0.00206	0.00206	0.00206	0.00072	0.00072	0.00072
*Exposure (poultry ing)-noncarcinogenic (kg/kg-day) - child	0.00276	0.00276	0.00276	0.00225	0.00225	0.00225
*Exposure (poultry ing)-noncarcinogenic (kg/kg-day) - adult	0.00199	0.00199	0.00199	0.00127	0.00127	0.00127
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, poultry ingestion (kg/kg-day)	0.00206	0.00206	0.00206	7.2E-04	7.2E-04	7.2E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.024**	**0.0024**	**0.00024**	**0.14**	**0.014**	**0.0014**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, soil poultry (kg/kg-day)	2.8E-03			2.3E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.0072**			**0.0089**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, soil poultry (kg/kg-day)	2.0E-03			1.3E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.010**			**0.016**		

Attachment 25
Risk-based Media Concentrations for Ingestion of Poultry Meat from Backyard Farms (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of poultry meat from backyard farms by adult residents and children. Consistent with the approach used in EPA's HHRA, potential ingestion of poultry meat by adult residents and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting poultry meat from backyard farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * FI * ABS_o * EF}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting poultry meat from backyard farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * FI * ABS_o * EF * ED}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

FI	=	Fraction ingested that is attributable to the Site (unitless)
ABS_o	=	Relative oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 25a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 25b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00043	0.0043	0.043	NC	0.0025	0.025	0.25	NC
Child	NC	NC	NC	0.0072	NC	NC	NC	0.0089
Adult	NC	NC	NC	0.012	NC	NC	NC	0.013

Table 25a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Backyard Farm Poultry Meat Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Resident			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Resident			39	9	HHRA, Vol. V; Appendix D; Table 4-10. Based on MADPH 2001a
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Resident			14,235	3,285	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Poultry Ingestion Rate	kg/kg-day	IR			
Adult Resident			0.00173	0.00162	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-55 & Table 11-5
Child			0.00288	0.00235	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-55 & Table 11-5
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.08475	0.02868	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Fraction absorbed in GI tract	unitless	FI	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 25b. RMCs for PCBs (mg/kg) in Poultry Meat for Target Risk Range and HI of 1
Backyard Farm (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	39	39	39	9	9	9
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	14,235	14,235	14,235	3,285	3,285	3,285
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Poultry Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00288	0.00288	0.00288	0.00235	0.00235	0.00235
Adult	0.00173	0.00173	0.00173	0.00162	0.00162	0.00162
Age-Adjusted (kg-year/kg-day)	0.08475	0.08475	0.08475	0.02868	0.02868	0.02868
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative oral absorption factor (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (poultry ing)-carcinogenic (kg/kg-day))	0.00116	0.00116	0.00116	0.00039	0.00039	0.00039
*Exposure (poultry ing)-noncarcinogenic (kg/kg-day) - child	0.00276	0.00276	0.00276	0.00225	0.00225	0.00225
*Exposure (poultry ing)-noncarcinogenic (kg/kg-day) -adult	0.00166	0.00166	0.00166	0.00155	0.00155	0.00155
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, poultry ingestion (kg/kg-day)	0.00116	0.00116	0.00116	3.9E-04	3.9E-04	3.9E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.043**	**0.0043**	**0.00043**	**0.25**	**0.025**	**0.0025**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, poultry ingestion (kg/kg-day)	2.8E-03			2.3E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.0072**			**0.0089**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, poultry ingestion (kg/kg-day)	1.7E-03			1.6E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.012**			**0.013**		

Attachment 26
Risk-based Media Concentrations for Ingestion of Poultry Eggs from Commercial Farms (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of eggs from commercial farms by adult farmers and children. Consistent with the approach used in EPA's HHRA, potential ingestion of eggs by adult farmers and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting poultry eggs from commercial farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * FI * ABS_o * EF}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting poultry eggs from commercial farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * FI * ABS_o * EF * ED}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)
FI	=	Fraction ingested that is attributable to the Site (unitless)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

ABS_o = Relative oral absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 26a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 26b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00055	0.0055	0.055	NC	0.0025	0.025	0.25	NC
Child	NC	NC	NC	0.011	NC	NC	NC	0.013
Adult	NC	NC	NC	0.025	NC	NC	NC	0.031

Table 26a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Commercial Farm Egg Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Farmer			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Farmer			64	29	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Farmer			23,360	10,585	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Egg Ingestion Rate	kg/kg-day	IR			
Adult Farmer			0.00085	0.00067	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-43 & Table 11-7
Child			0.00191	0.00159	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-43 & Table 11-7
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.06586	0.02897	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Fraction absorbed in GI tract	unitless	FI	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 26b. RMCs for PCBs (mg/kg) in Eggs for Target Risk Range and HI of 1
Commercial Farm (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	64	64	64	29	29	29
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Egg Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00191	0.00191	0.00191	0.00159	0.00159	0.00159
Adult	0.00085	0.00085	0.00085	0.00067	0.00067	0.00067
Age-Adjusted (kg-year/kg-day)	0.06586	0.06586	0.06586	0.02897	0.02897	0.02897
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative oral absorption factor (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (egg ing)-carcinogenic (kg/kg-day)	0.00090	0.00090	0.00090	0.00040	0.00040	0.00040
*Exposure (egg ing)-noncarcinogenic (kg/kg-day) -child	0.00183	0.00183	0.00183	0.00152	0.00152	0.00152
*Exposure (egg ing)-noncarcinogenic (kg/kg-day) -adult	0.00082	0.00082	0.00082	0.00064	0.00064	0.00064
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, egg ingestion (kg/kg-day)	0.00090	0.00090	0.00090	4.0E-04	4.0E-04	4.0E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.055**	**0.0055**	**0.00055**	**0.25**	**0.025**	**0.0025**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, egg ingestion (kg/kg-day)	1.8E-03			1.5E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.011**			**0.013**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, egg ingestion (kg/kg-day)	8.2E-04			6.4E-04		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.025**			**0.031**		

Attachment 27
Risk-based Media Concentrations for Ingestion of Poultry Eggs from Backyard Farms (EPA Assumptions)

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of eggs from backyard farms by adult residents and children. Consistent with the approach used in EPA's HHRA, potential ingestion of eggs by adult residents and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting poultry eggs from backyard farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * FI * ABS_o * EF}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
EF	=	Exposure frequency (days/year)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting poultry eggs from backyard farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * FI * ABS_o * EF * ED}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)
FI	=	Fraction ingested that is attributable to the Site (unitless)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

ABS_o = Relative oral absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 27a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the Table 27b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00082	0.0082	0.082	NC	0.0044	0.044	0.44	NC
Child	NC	NC	NC	0.011	NC	NC	NC	0.013
Adult	NC	NC	NC	0.025	NC	NC	NC	0.026

Table 27a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Backyard Farm Egg Consumption Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Resident			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Resident			39	9	HHRA, Vol. V; Appendix D; Table 4-10. Based on MADPH 2001a
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Resident			14,235	3,285	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Egg Ingestion Rate	kg/kg-day	IR			
Adult Resident			0.00085	0.00079	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-43 & Table 11-7
Child			0.00191	0.00159	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-43 & Table 11-7
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.04461	0.01665	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Fraction absorbed in GI tract	unitless	FI	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 27b. RMCs for PCBs (mg/kg) in Eggs for Target Risk Range and HI of 1
Backyard Farm (EPA Assumptions)

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	39	39	39	9	9	9
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	14,235	14,235	14,235	3,285	3,285	3,285
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Egg Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00191	0.00191	0.00191	0.00159	0.00159	0.00159
Adult	0.00085	0.00085	0.00085	0.00079	0.00079	0.00079
Age-Adjusted (kg-year/kg-day)	0.04461	0.04461	0.04461	0.01665	0.01665	0.01665
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative oral absorption factor (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (egg ing)-carcinogenic (kg/kg-day)	0.00061	0.00061	0.00061	0.00023	0.00023	0.00023
*Exposure (egg ing)-noncarcinogenic (kg/kg-day) - child	0.00183	0.00183	0.00183	0.00152	0.00152	0.00152
*Exposure (egg ing)-noncarcinogenic (kg/kg-day) -adult	0.00082	0.00082	0.00082	0.00076	0.00076	0.00076
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, egg ingestion (kg/kg-day)	0.00061	0.00061	0.00061	2.3E-04	2.3E-04	2.3E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.082**	**0.0082**	**0.00082**	**0.44**	**0.044**	**0.0044**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, egg ingestion (kg/kg-day)	1.8E-03			1.5E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.011**			**0.013**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, egg ingestion (kg/kg-day)	8.2E-04			7.6E-04		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.025**			**0.026**		

Attachment 28
Risk-based Media Concentrations for Ingestion of Fruit and Vegetables from Commercial or Backyard Farms (EPA Assumptions)

Risk-based Media Concentrations (RMCs) have been developed for PCBs based on potential consumption of produce (exposed fruit, exposed vegetables and root vegetables) from commercial or backyard farms in the floodplain. As discussed in the text of this IMPG Proposal, RMCs for these types of produce have been calculated based solely on potential non-cancer impacts to children. Separate RMCs have been calculated for each of the individual produce categories (i.e., exposed fruit, exposed vegetables and root vegetables), as well as for total produce based on the assumption that a child would consume all three types of produce grown in the floodplain at the consumption rates specified in the HHRA.

Consistent with the approach used in EPA's HHRA, potential ingestion of fruits and vegetables by children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential non-cancer impacts to children, using the exposure assumptions and toxicity values used in the HHRA. Because the exposure assumptions for a child do not differ between the commercial and backyard farm scenarios, the calculated RMCs apply to both commercial and backyard farms.

The RMCs for each individual produce category have been calculated using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to fruit and vegetable ingestion pathway (kg/kg-day)

In the above equation, the exposure due to ingestion of fruits and vegetables ($Exp_{ingestion}$) has been calculated using the following equation:

$$Exp_{ingestion} = \frac{IR * AF * FI * ABS_o * EF * ED}{AT}$$

Where:

IR	=	Individual produce ingestion rate (kg/kg-day)
AF	=	Regional consumption adjustment factor (unitless)
FI	=	Fraction ingested that is attributable to the Site (unitless)
ABS	=	Relative oral absorption factor (unitless)

EF = Exposure frequency (days/year)
ED = Exposure duration (years)
AT = Averaging time (days)

For total produce, the RMC has been calculated as follows:

$$RMC(Total)_{noncancer} = \frac{HI}{((Exp_{ing\_exposedfruit} \div RfD) + (Exp_{ing\_exposedvegetable} \div RfD) + (Exp_{ing\_rootvegetable} \div RfD))}$$

Where:

$RMC(Total)_{noncancer}$ = RMC (total produce) based on the non-cancer endpoint (mg/kg)
HI = Target hazard index (unitless)
RfD = Reference dose (mg/kg-day)
$Exp_{ing\_exposedfruit}$ = Exposure due to exposed fruit consumption (kg/kg-day)
$Exp_{ing\_exposedvegetable}$ = Exposure due to exposed vegetable consumption (kg/kg-day)
$Exp_{ing\_rootvegetables}$ = Exposure due to root vegetable consumption (kg/kg-day)

In the above equation, exposure due to ingestion of individual fruits and vegetables (e.g., $Exp_{ing\_exposedfruit)}$ has been calculated using the previously listed $Exp_{ingestion}$ equation.

The specific exposure assumptions used for children in this analysis, and the basis of each, are summarized in Table 28a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

A chronic reference dose of 2E-05 was used for both the RME and CTE scenario. This value is published in EPA's IRIS database and was used in EPA's HHRA. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios for children based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for non-cancer endpoints are presented in Table 28b and are summarized as follows.

	RME (mg/kg)	**CTE (mg/kg)**
Child (Commercial and Backyard Farm)	**Noncancer**	**Non-cancer**
Exposed Fruit	0.11	0.12
Exposed Vegetable	0.024	0.031
Root Vegetable	0.030	0.041
Total Produce	0.012	0.015

Table 28a. Summary of Pathway Exposure Assumptions Used in the Fruit (Exposed) and Vegetable (Exposed and Root) Consumption by Child Scenario (EPA Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency Child	days/year	EF	350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration Child	years	ED	6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (noncancer endpoint) Child	days	ATnc	2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Exposed Fruit Ingestion Rate	kg/kg-day	IR	0.00269	0.00259	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-61
AF Exposed Fruit	unitless	AF	0.07	0.07	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-33,13-61 and 13-62.
Exposed Vegetable Ingestion Rate	kg/kg-day	IR	0.00294	0.00226	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-63
AF Exposed Vegetable	unitless	AF	0.3	0.3	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-33,13-63, 13-64 and 13-65.
Root Vegetable Ingestion Rate	kg/kg-day	IR	0.00234	0.0017	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-65
AF Root Vegetable	unitless	AF	0.3	0.3	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-33,13-63, 13-64 and 13-65.
Fraction absorbed in GI tract	unitless	FI	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. H*uman Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 28b. RMCs for PCBs (mg/kg) in Fruit and Vegetables for Target Risk Range and HI of 1
Commercial and Backyard Farm (EPA Assumptions)

Parameter	EPA RME Analysis	EPA CTE Analysis
Common Parameters		
Exposure duration (yrs) Child	6	6
Averaging time - noncarcinogenic (days) Child	2,190	2,190
Fruit and Vegetable Consumption Child		
Exposed Fruit Ingestion rate (kg/kg-day)	0.00269	0.00259
AF Exposed Fruit	0.07	0.07
Exposed Vegetable Ingestion rate (kg/kg-day)	0.00294	0.00226
AF Exposed Fruit	0.3	0.3
Root Vegetable Ingestion rate (kg/kg-day)	0.00234	0.0017
AF Exposed Fruit	0.3	0.3
Fraction attributable to site	1.0	1.0
Relative oral absorption factor (unitless)	1.0	1.0
Exposure frequency (days/year)	350	350
*Exposure (Exposed Fruit ing)-noncarcinogenic (kg/kg-day)	0.00018	0.00017
*Exposure (Exposed Vegetable ing)-noncarcinogenic (kg/kg-day)	0.00085	0.00065
*Exposure (Root Vegetable ing)-noncarcinogenic (kg/kg-day)	0.00067	0.00049
NONCARCINOGENIC	**Child**	**Child**
Total Exposure, Fruit ingestion (kg/kg-day)	0.00018	0.00017
Total Exposure, Exposed Vegetable ingestion (kg/kg-day)	0.00085	0.00065
Total Exposure, Root Vegetable ingestion (kg/kg-day)	0.00067	0.00049
Reference Dose (RfD) (mg/kg-day)	2.00E-05	2.00E-05
Target Hazard Index	1	1
Risk-based Media Concentration (mg/kg) - Exposed Fruit	0.11	0.12
Risk-based Media Concentration (mg/kg) - Exposed Vegetables	0.024	0.031
Risk-based Media Concentration (mg/kg) - Root Vegetables	0.030	0.041
Risk-based Media Concentration (mg/kg) - Total Produce	0.012	0.015

APPENDIX E

ATTACHMENT 29

Attachment 29
Proposed Risk-based Media Concentrations for Aquatic Invertebrates Based on Consumption by Wood Ducks

Numerical risk-based media concentrations (RMCs) for aquatic insects based on consumption by wood ducks have been developed for both total PCBs and dioxin toxicity equivalents (TEQs). The general methodology used to generate these RMCs reflects the ERA's evaluation of potential risks to wood ducks based on modeled exposures and effects. Such endpoints can be expressed as ratios of modeled exposure to toxicity reference values (TRVs) and are hereafter referred to as hazard quotients (HQs). The HQs for PCBs were "dose-based," in that they were calculated as the ratio of modeled doses to dose-based TRVs. The HQs for TEQs, in contrast, were "egg-based," in that they were calculated as the ratio of modeled concentrations of TEQs in wood duck eggs to egg-based TRVs. To generate RMCs, the HQ equations were solved for the prey concentration term, while holding the HQ value at a target level of 1.0. Specific methodologies used to generate PCB RMCs and TEQ RMCs are detailed below, followed by a brief discussion of the uncertainties in the proposed RMCs.

PCB RMCs for Aquatic Invertebrates

The equation employed to calculate PCB RMCs was as follows:

$$RMC_{prey} = THQ * TRV / (FT * P_i * FIR) \qquad \text{Equation 1}$$

Where:

RMC_{prey}	=	Concentration of PCBs in wood duck prey that will not result in exceedance of dose-based TRV (mg/kg)
THQ	=	Target hazard quotient (unitless)
TRV	=	Toxicity reference value (mg/kg bw/d)
FT	=	Foraging time (unitless)
P_i	=	Proportion of invertebrates in diet (unitless)
FIR	=	Normalized food intake rate (kg/kg bw/d)

As previously noted, the THQ was set at 1.0 to ensure that the dose does not exceed the TRV. Three dose-based TRVs for PCBs were employed. The first, 0.12 mg/kg bw/d, reflects the ERA's interpretation (Vol. 2, p. 7-40; Vol. 5, p. G-82) of the effects metric for the most sensitive avian receptor, the white leghorn chicken (Lillie et al., 1974). The second, 7.0 mg/kg bw/d, reflects the ERA's interpretation (Vol. 2, p. 7-40; Vol. 5, p. G-82) of the effects metric for the most tolerant avian receptor, the American kestrel (Fernie et al., 2001). The third, 3.6 mg/kg bw/d, is the midpoint of the other two TRVs.

Consistent with the ERA (Vol. 2, p. 7-18; Vol. 6, Table G.2-33), RMCs were calculated based on an assumed foraging time (FT) of 1.0. The proportion of invertebrates in the diet (P_i) was assumed to be 0.76, consistent with the ERA (Vol. 5, Table G.2-33) and based on the diet during the pre-laying period (Drobney and Fredrickson, 1979; Drobney, 1980).

The ERA (Vol. 2, p. 6-8; Vol. 5, p. G-46) indicates that the food intake rate (FIR) was calculated as:

$$FIR = FMR / \sum_{i=1}^{n} (AE_i * G_i)$$ Equation 2

Where:

FIR	=	Normalized food intake rate (kg/kg bw/d)
FMR	=	Free metabolic rate (kJ/d)
i	=	Prey item type (unitless)
AE	=	Assimilation efficiency (unitless)
G	=	Gross energy (kcal/g)

Equation 2 does not include a factor for the proportion of diet composed of litter invertebrates and aquatic invertebrates because dietary preference was considered implicitly in the ERA's probabilistic analysis of FIR. That is, for each iteration of the probabilistic analysis, the ERA selected a prey type based on a pre-defined dietary composition, and then assigned values for assimilation efficiency (AE) and gross energy (G) according to the prey type selected. In addition, the units used in Equation 2 do not cancel out correctly. Therefore, for purposes of calculating deterministic RMCs, the following modification was made to Equation 2:

$$FIR = (FMR * CF) / \sum_{i=1}^{n} (AE_i * G_i * P_i * BW)$$ Equation 3

Where:

FIR	=	Normalized food intake rate (kg/kg bw/d)
FMR	=	Free metabolic rate (kJ/d)
CF	=	Conversion factor (0.239 kcal/kJ)
i	=	Prey item type (unitless)
AE	=	Assimilation efficiency (unitless)
G	=	Gross energy (kcal/kg)
P_i	=	Proportion of prey item i in diet (unitless)
BW	=	Body weight (kg)

Consistent with the ERA (Vol. 5, p. G-47, Table G.2-33), the AEs of terrestrial invertebrates and aquatic invertebrates by birds were assumed to be 0.72 and 0.77, respectively, based on Karasov (1990), Ricklefs (1974), and Bryant and Bryant (1988). As also consistent with the ERA (Vol. 5, p. G-47, Table G.2-33), terrestrial and aquatic invertebrates were assumed to have Gs of 1,600 kcal/kg and 1,100 kcal/kg, respectively, based on Cummins and Wuycheck (1971), Collopy (1975), Bell (1990), Tyler (1973), Jorgensen et al. (1991), Minnich (1982), and Thayer et al. (1973). The proportion of diet composed of terrestrial invertebrates was assumed to be 0.196, while the proportion of diet composed of aquatic invertebrates was assumed to be 0.564 (ERA, Vol. 5, Tables G.2-3 and G.2-34), based on Drobney and Fredrickson (1979). In order to be consistent with the ERA, which ignored the fraction of diet composed of vegetation in the derivation of the food intake rate (FIR), the proportions of diet assumed to be composed of terrestrial and aquatic invertebrates were scaled up to 0.26 and 0.74, respectively, in order to

sum to 1.0. The average body weight for wood ducks (0.564 kg) applied in the ERA (Vol. 5, pp. G-45, G-46, Table G.2-33) was also used to estimate the normalized food intake rate (FIR).

As presented in the ERA (Vol. 5, p. G-46, Table G.2-33), the free metabolic rate (FMR) was calculated as:

$$FMR = a * BW^{b}$$ Equation 4

Where:

FMR	=	Free metabolic rate (kJ/d)
a	=	Slope (kJ/g-d)
BW	=	Body weight (g)
b	=	Power (unitless)

The ERA estimated FMR probabilistically, employing distributions for a and b, based on EPA's reanalysis of the data reported by Nagy et al. (1999) and assuming an underlying normal distribution for each (ERA, Vol. 5, p. G-46). In this deterministic analysis, average values reported in the ERA (Vol. 5, pp. G-45, G-46, Table G.2-33) for all three terms were applied. Thus, a slope of 10.5, body weight of 564 g, and power of 0.68 were used to estimate FMR.

Based on these methods and exposure assumptions, the range of RMCs for PCBs in wood duck prey is 0.44 mg/kg to 26 mg/kg, with a midpoint of 13 mg/kg.

TEQ RMCs for Aquatic Invertebrates

Because the TEQ RMCs for wood ducks are egg-based, their derivation requires calculating the dose to adults that yields a maternal body burden that in turn results in the egg-based TRV. Microsoft Excel's solver function was used to simultaneously solve the following system of equations by varying the prey concentration to find the maximum egg concentration that equals the egg-based TRV.

The ERA does not explicitly present the system of equations that it used; rather, the ERA provides a narrative description of the approach employed, with most detail offered in the discussion of calculation of bald eagle egg concentrations (ERA, Vol. 6, pp. K-27 to K-29). Although an equation is provided for the tree swallow microexposure model (ERA, Vol. 5, pp. G-14 to G-15), that model differs from the equations described below in that the tree swallow microexposure model focuses on post-hatch accumulation of PCBs and TEQ by nestling tree swallows as a function of the maternal transfer to eggs and the dietary intake by the nestlings. In contrast, the egg-based TRVs applied in the derivation of wood duck RMCs are pre-hatch egg concentrations.

Based on Drobney (1977), wood ducks were assumed to arrive at the Rest of River 14 days before initiating egg-laying (ERA, Vol. 2, p. 7-11; Vol. 5, p. G-51). It was conservatively assumed that avian species do not metabolize PCBs (ERA, Vol. 5, p. G-51). The concentration of TEQs absorbed by hens during the 14-day prelaying period was calculated as the product of the chemical assimilation efficiency (CAE) and total daily intake (TDI) over each of the 14 days (ERA, Vol. 5, p. G-16):

$$Ca_j = \sum_{j=1}^{14} CAE * TDI * 1day \qquad \text{Equation 5}$$

Where:

Ca	=	Concentration of TEQs absorbed by adult hens (ng/kg)
j	=	Days in pre-laying period
CAE	=	Chemical assimilation efficiency (unitless)
TDI	=	Total daily intake (ng/kg bw/d)

For the probabilistic analysis, the ERA applied a beta distribution for CAE (ERA, Vol. 5, p. G-52). For this deterministic analysis, we applied a value of 0.891, which is the average of the beta distribution function (α = 242, β = 29.5, scale = 1) (ERA, Vol. 5, Table G.2-34).

Consistent with the ERA (Vol. 2, p. 7-10; Vol. 5, p. G-14), TDI was calculated as:

$$TDI = FT * FIR \sum_{i=1}^{n} C_i * P_i \qquad \text{Equation 6}$$

Where:

TDI	=	Total daily intake (ng/kg bw/d)
FT	=	Foraging time (unitless)
FIR	=	Normalized food intake rate (kg/kg bw/d)
i	=	Prey type
C_i	=	Concentration of TEQs in prey type i (ng/kg)
P_i	=	Proportion of prey type i in diet (unitless)

For days 15 through 27, hens were assumed to lay one egg per day, transferring a portion of the TEQ concentration to each of the 13 eggs, while continuing to absorb additional TEQs via the diet (ERA, Vol. 5, p. G-17). Thus, the concentration of TEQs in hens during each day of the egg-laying period is expressed as:

$$Ca_j = \sum_{j=15}^{27} Ca_{j-1} - [CR_{e:a} * Ca_{j-1} * \frac{EW}{BW}] + [CAE * TDI * 1\ day] \qquad \text{Equation 7}$$

Where:

Ca	=	Concentration of TEQs in adult hens (ng/kg)
j	=	Days in egg-laying period (unitless)
$CR_{e:a}$	=	Concentration ratio of eggs to adults (unitless)
EW	=	Egg weight (g)
BW	=	Adult body weight (g)
CAE	=	Chemical assimilation efficiency (unitless)
TDI	=	Total daily intake (ng/kg bw/day) (see Equation 6)

Consistent with the ERA (Vol. 2, p. 7-19; Vol. 5, p. G-52), the $CR_{e:a}$ was set equal to the mean value of 0.22, as reported by Bargar et al. (2001) for white leghorn chickens. The EW was set

equal to 41 g, the mean value employed in the ERA (Vol. 5, Table G.2-34) based on Woodlot Alternatives (2004).

The resulting egg concentration was calculated as:

$$Ce = Ca_j * CR_{e:a}$$ Equation 8

Where:

Ce	=	TEQ concentration in eggs (ng/kg)
Ca	=	TEQ concentration in adults (ng/kg)
j	=	Days in egg-laying period (unitless)
$CR_{e:a}$	=	Concentration ratio of eggs to adults (unitless)

Equations 5 through 8 were solved simultaneously to determine the maximum dietary concentration (C_i) that is associated with egg concentrations equal to the egg-based TEQ TRVs. Three TRVs were employed. The first, 20 ng/kg egg wet weight (ww), reflects the lower end of the range of thresholds identified in White and Seginak's (1994) field study on reproductive effects of TEQs on wood ducks (ERA, Vol. 2, p. 7-40; Vol. 5, p. G-84). The second, 50 ng/kg egg ww reflects the upper end of the range of thresholds identified by White and Seginak (1994) (ERA, Vol. 2, p. 7-40; Vol. 5, p. G-84). The third, 35 ng/kg egg ww, is the midpoint of the other two TRVs.

The RMC was set equal to the maximum dietary concentration that did not exceed each of the egg-based TRVs. Based on these methods and exposure assumptions, the range of RMCs for TEQs in wood duck prey is 1.7×10^{-5} mg/kg to 4.2×10^{-5} mg/kg, with a midpoint of 2.9×10^{-5} mg/kg. These RMCs are equal to 17 nanograms per kilogram (ng/kg) to 42 ng/kg, with a midpoint of 29 ng/kg.

Uncertainties

The RMCs for wood ducks are quite uncertain. Although the ERA evaluated most receptors using multiple lines of evidence, risks to wood ducks were calculated solely through HQs. Thus, no site-specific studies either corroborate or refute the conclusions of the modeling. Specific uncertainties relate to exposure assumptions, particularly FIR, composition of diet, maternal transfer and metabolism of PCBs, as well as the selected TRVs. In all cases, conservative assumptions were applied to compensate for those uncertainties. Some examples follow.

First, consistent with the ERA, the calculation of FIR considered ingestion of aquatic invertebrates and terrestrial invertebrates only, even though vegetation makes up at least 24 percent of the wood duck's diet (Drobney and Fredrickson, 1979). Because the gross energy provided by plants is more than double that provided by invertebrates (EPA 1993), exclusion of plants from the calculation of FIR resulted in overestimation of FIR. That is, because it was assumed that wood ducks do not eat plants, their overall FIR was inflated to meet their metabolic energy requirements only through invertebrates.

Second, the proportion of invertebrates (P_i) in the diets of breeding wood ducks (0.76) applied in the ERA (and in this attachment) represents the dietary composition only during the egg-laying

period (Drobney and Fredrickson, 1979). Those authors also report that, during the 14-day pre-laying period, invertebrates comprise only 53% of the wood duck's diet. Because the calculation of RMCs spans both the pre-laying and egg-laying periods, setting P_i equal to 0.76 biases the RMCs low.

Third, the manner in which the Bargar et al. (2001) study was used to estimate maternal transfer also biases the TEQ RMCs low. Using white leghorn chickens, Bargar et al. (2001) quantified maternal transfer of PCBs to eggs based on both mass and ratios of concentrations. On a mass basis, 0.42% to 0.61% of the injected PCBs were excreted to eggs. On a concentration ratio basis, the egg:hen concentration ratio averaged 0.22. The latter method was used in the ERA and the RMC calculations to estimate maternal transfer. Due to the considerable differences in the relative masses of hens and eggs between white leghorn chickens and wood ducks, the concentration ratio approach yields estimates of maternal transfer that are higher than those generated from mass-based measures of maternal transfer.

Fourth, the ERA and the RMC calculations assumed that birds do not metabolize PCBs (ERA, Vol. 5, p. G-51). However, as noted in the ERA (Vol. 6, p. K-28), Dahlgren et al. (1972) estimated that 2.4% of the PCB dose to birds is metabolized over a 28-day period.

Fifth, the PCB TRVs were not based on wood ducks or closely related species and, instead, reflect toxicity data on white leghorn chickens and American kestrels under the assumption that they reflect most sensitive and most tolerant avian species, respectively. This assumption contributes significant uncertainty to the PCB RMCs.

Sixth, the TEQ TRVs were based on a field study of wood ducks (White and Seginak, 1994) that had a number of differences from the present situation. For example, White and Seginak (1994) employed the International TEQ system (EPA, 1989), whereas the ERA employed the World Health Organization's TEQ system (Van den Berg et al., 1998) (ERA, Vol. 2, p. 7-41; Vol. 5, p. G-84). In addition, the mixtures of dioxins, furans, and PCBs differ substantially between the Rest of River and the site where that study was conducted, Bayou Meto, Arkansas. Dioxins are the main constituents in Bayou Meto, while PCBs are predominant in the Rest of River. The different mixtures may have different toxicities that are not fully reflected in TEQs. These differences, as well as other potential inter-site differences (e.g., in food sources, bioenergetics, co-contaminants, breeding season duration, etc.) contribute further uncertainty to the TEQ RMCs.

References

Bargar, T.A., G.I. Scott, and G.P. Cobb. 2001. Maternal transfer of contaminants: Case study of the excretion of three polychlorinated biphenyl congeners and technical-grade endosulfan into eggs by white leghorn chickens (Gallus domesticus). *Environmental Toxicology and Chemistry* 20:61-67.

Bell, G.P. 1990. Birds and mammals on an insect diet: A primer on diet composition analysis in relation to ecological energetics. *Studies in Avian Biology* 12:391-415.

Bosveld, A.T.C. 1995. Effects of polyhalogenated aromatic hydrocarbons on piscivorous avian wildlife. PhD. Thesis. University of Utrecht, Utrecht, The Netherlands. In: Drouillard, K.G. and

R.J. Norstrom. 2000. Dietary absorption efficiencies and toxicokinetics of polychlorinated biphenyls in ring doves following exposure to Aroclor mixtures. *Environmental Toxicology and Chemistry* 19(11):2707-2714.

Bryant, D.M., and V.M. Bryant. 1988. Assimilation efficiency and growth of nestling insectivores. *Ibis* 130:268-274.

Collopy, M.W. 1975. Behavioral and predatory dynamics of kestrels wintering in the Arcata Bottoms. Master's Thesis. Arcata, California: Humboldt State University.

Cummins, K.W., and J.C. Wuycheck. 1971. Caloric equivalents for investigations in ecological energetics. Stuttgart, West Germany: International Association of Theoretical and Applied Limnology.

Dahlgren, R.B., R.L. Linder, and C.W. Carlson. 1972. Polychlorinated biphenyls: Their effects on penned pheasants*. Environmental Health Perspectives* 1:89-101.

Drobney, R.D. 1977. The feeding ecology, nutrition and reproductive bioenergetics of wood ducks. Ph.D. Thesis, Univ. Missouri, Columbia. 170 pp.

Drobney, R.D. 1980. Reproductive bioenergetics of wood ducks. *Auk* 97:480-490.

Drobney, R.D., and L.H. Fredrickson. 1979. Food selection by wood ducks in relation to breeding status. *Journal of Wildlife Management* 43:109-120.

Drouillard, K.G., and R.J. Norstrom. 2001. Quantifying material and dietary sources of 2,2',4,4',5,5'-hexachlorobiphenyl deposited in eggs of the ring dove (*Streptopeliz risoria*). *Environmental Toxicology and Chemistry* 20:561-567.

EPA. 1989. Interim procedures for estimating risks associated with exposure to mixtures of chlorinated dibenzo-*p*-dioxins and dibenzofurans (CDDs and CDFs). U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC. EPA/625/3-89/016. 66 pp.

EPA. 1993. Wildlife Exposure Factors Handbook. EPA/600/R-93/187a. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

Fernie, K.J., J.E. Smits, G.R. Bortolotti, and D.M. Bird. 2001. Reproductive success of American kestrels exposed to dietary polychlorinated biphenyls. *Environmental Toxicology and Chemistry* 20:776-781.

Jorgensen, S.E., S.N. Nielsen, and L.A. Jorgensen. 1991. *Handbook of Ecological Parameters and Ecotoxicoloty.* Elsevier Science Publishers, Amsterdam, The Netherlands.

Karasov, W.H. 1990. Digestion in birds: chemical and physiological determinants and ecological implications. *Studies in Avian Biology* 13:391-415.

Lillie, R.J., H.C. Cecil, J. Bitman, and G.F. Fries. 1974. Differences in response of caged white leghorn layers to various polychlorinated biphenyls (PCBs) in the diet. *Poultry Science* 53:726-732.

Minnich, J.E. 1982. The use of water. In: Gans, C.; Pough, F.H. eds. Biology of the Reptilia, Physiology C; Physiological Ecology. V. 12. Academic Press, New York, New York.

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles and birds. *Annual Reviews in Nutrition* 19:247-277.

Ricklefs, R.E. 1974. Energetics of reproduction in birds. In: Paynter, R.A. ed. Avian Energetics. Nuttall Ornithological Club, Cambridge, Massachusetts.

Thayer, G.W., W.E. Schaaf, J.W. Angelovic, and M.W. LaCroix. 1973. Caloric measurements of some estuarine organisms. *Fishery Bulletin* 71:289-296.

Tyler, A.V. 1973. Caloric values of some North Atlantic invertebrates. *Marine Biology* 19:258-261.

Van den Berg, M.L., L. Birnbaum, A.T.C. Bosveld, B. Brunstrom, P. Cook, M. Feeley, J.P. Giesy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X.R. van Leeuwen, A.K.D. Liem, C. Nolt, R.E. Petersen, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski. 1998. Toxic equivalency factors (TEFs) for tPCBs, PCDDs, PCDFs for humans and wildlife. *Environ. Health Perspectives* 106:775-792.

White, D. H. and J.T. Seginak. 1994. Dioxin and furans linked to reproductive impairment in wood ducks. *Journal of Wildlife Management* 58(1):100-106.

Woodlot Alternatives. 2004. Final Report: Collection and Analysis of Wood Duck (*Aix sponsa*) Eggs, Housatonic River, Pittsfield, Lenox, and Lee, Massachusetts. Woodlot Alternatives, Inc., Topsham, Maine. November 4.

APPENDIX F

ATTACHMENTS 30 THROUGH 42

Attachment 30
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
In High- and Medium-High Use Recreational Areas
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil in high-use recreational areas. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of young children, older children, and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, health-protective RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 30a. With the exception of the soil ingestion rate, the fraction of soil ingested from the Site, and the exposure frequency for certain high-use exposure areas, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

While EPA's HHRA has evaluated High-Use, Medium-Use, and Low-Use general recreation scenarios, GE believes that it is more appropriate to consider four frequency-of-use categories of recreational properties within the Housatonic River floodplain (see Section 3.1.1.3 of this proposal). This attachment provides the calculations of RMCs for exposure areas that are subject to a High-Use scenario. This includes those areas that are readily accessible for recreational activity and have known recreational features like trails and recreational use areas. This attachment also provides RMCs based on an additional Medium-High-Use scenario, which is applicable to those EAs that are readily accessible but at which there are no trails or other known recreational use areas.

For the High-Use scenario, RMCs have been developed for young children, older children and adults using the same frequencies of 90 days/year (RME) and 30 days/year (CTE) that were used in EPA's HHRA. However, in developing RMCs for the Medium-High-Use scenario, slightly reduced exposure frequencies of 60 days/year (RME) and 21 days/year (CTE) have been used for adults and older children, to account for the likely lower usage of such areas. In

this scenario, an exposure frequency of 15 days/year has been used for the young child for both the RME and CTE conditions, as was done in EPA's alternative analysis for High-Use areas in the HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate the general recreation scenarios. For this RME analysis, upper bound soil ingestion rates of 100 mg/day and 50 mg/day have been used to develop RMCs for young children and older children/adults, respectively. For the CTE analysis, a soil ingestion rate of 20 mg/day has been used to evaluate young children, and a soil ingestion rate of 10 mg/day has been used to evaluate older children and adults.

While GE agrees with the EPA's assumption that 50 percent of the soil ingested in the CTE scenario is derived from the Site, it does not agree with the assumption that 100 percent of the soil ingested in the RME recreational scenario will be derived from the Site. As discussed in Section 3.1.1.2 of this proposal, the short duration of most recreational activities that are likely to occur under the general recreation scenarios makes it likely that, even for the RME receptor, the fraction of daily soil ingestion that is derived from the Site does not likely exceed 50 percent for the general recreational scenarios. Thus, for this analysis, GE has used a factor of 0.5 (50 percent) to represent the fraction of total daily soil ingestion that is derived from the Site for both the RME and CTE scenarios for all age groups.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group (adults, older children, young children with high exposure frequency, and young children with lower exposure frequency). The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints under High-Use conditions are presented in the following tables for adults (Table 30b), older children (Table 30c), and young children (Table 30d). Estimated RMCs for cancer and non-cancer endpoints under

Medium-High-Use recreational conditions are also presented in the following tables for adults (Table 30e), older children (Table 30f), and young children (Table 30g). These RMCs are summarized below.

	RME (mg/kg)				CTE (mg/kg)			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
High-Use	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	2.9	29	291	781	87	870	8,696	3,230
Older Child	8.6	86	857	588	76	759	7,586	2,601
Young Child	3.1	31	307	105	28	282	2,817	483
Medium-High-Use								
Adult	4.4	44	436	1,171	124	1,242	12,423	4,614
Older Child	13	129	1,286	882	108	1,084	10,837	3,716
Young Child	18	184	1,842	632	56	563	5,635	966

Table 30a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the High Use Recreational Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Highest use areas					
Young child (high frequency)			90	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Older child			90	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Adult			90	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Young child (alternative frequency)			15	15	HHRA, Vol. IIIA; Section 4.5.3.2.1; Page 4-54; Lower usage for areas without well defined trails.
Medium-high use areas					
Young child (high frequency)			60	21	Two days per week for 30 weeks (RME) and three days/month for 7 months (CTE) per year; Professional judgment.
Older child			60	21	Two days per week for 30 weeks (RME) and three days/month for 7 months (CTE) per year; Professional judgment.
Adult			60	21	Two days per week for 30 weeks (RME) and three days/month for 7 months (CTE) per year; Professional judgment.
Young child (alternative frequency)			15	15	HHRA, Vol. IIIA; Section 4.5.3.2.1; Page 4-54; Lower usage for areas without well defined trails.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol. IIIA; Table 4-23; From age 1 to 6 years. EPA, 1991.
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			47	13	HHRA, Vol. IIIA; Table 4-23; Aged 19 to 65 years (RME); 19 to 31 years (CTE). Based on MDPH, 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			17,155	4,745	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Young child			100	20	Stanek and Calabrese (2000) and Calabrese (2003).
Older child			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Adult			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	0.5	0.5	Professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Young child			0.2	0.2	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Children playing in wet soil weighted by exposed body area.
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Young child			0.35	0.35	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Children playing in wet soil weighted by exposed body area.
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.

Table 30a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the High Use Recreational Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Skin surface area (warmer months)	cm^2/day	SA_1			
Young child			2,800	2,800	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and head.
Older child			4,400	4,400	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Adult			5,700	5,700	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Skin surface area (cooler months)	cm^2/day	SA_2			
Young child			684	684	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* Exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.
Stanek, E.J., and E.J. Calabrese. 2000. Daily soil ingestion estimates for children at a Superfund Site. *Risk Analysis* 20(5):627-635.
Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 30b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Highest Use Recreational Areas (Alternative Assumptions)
Adults

Parameter		Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Adult		47	47	47	13	13	13
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		50	50	50	10	10	10
Fraction attributable to site		0.5	0.5	0.5	0.5	0.5	0.5
RAF-oral (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$		5.9E-08	5.9E-08	5.9E-08	1.1E-09	1.1E-09	1.1E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		8.8E-08	8.8E-08	8.8E-08	5.9E-09	5.9E-09	5.9E-09
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	5700	5700	5700	5700	5700	5700
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$		1.1E-07	1.1E-07	1.1E-07	1.0E-08	1.0E-08	1.0E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		1.7E-07	1.7E-07	1.7E-07	5.6E-08	5.6E-08	5.6E-08
CARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		1.1E-07	1.1E-07	1.1E-07	1.0E-08	1.0E-08	1.0E-08
Total Exposure, soil ingestion $(days)^{-1}$		5.9E-08	5.9E-08	5.9E-08	1.1E-09	1.1E-09	1.1E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**291**	**29**	**2.9**	**8696**	**870**	**87**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$		1.7E-07			5.6E-08		
Total Exposure, soil ingestion $(days)^{-1}$		8.8E-08			5.9E-09		
Reference Dose (RfD) (mg/kg-day)		2.00E-04			2.00E-04		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**781**			**3230**		

Table 30c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Highest Use Recreational Areas (Alternative Assumptions)
Older Child

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	50	50	50	10	10	10
Fraction attributable to site	0.5	0.5	0.5	0.5	0.5	0.5
RAF-oral (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.3E-08	2.3E-08	2.3E-08	1.6E-09	1.6E-09	1.6E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	9.1E-09	9.1E-09	9.1E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)						
Older child Warmer months	4400	4400	4400	4400	4400	4400
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	3.5E-08	3.5E-08	3.5E-08	1.2E-08	1.2E-08	1.2E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.0E-07	2.0E-07	2.0E-07	6.8E-08	6.8E-08	6.8E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	3.5E-08	3.5E-08	3.5E-08	1.2E-08	1.2E-08	1.2E-08
Total Exposure, soil ingestion $(days)^{-1}$	2.3E-08	2.3E-08	2.3E-08	1.6E-09	1.6E-09	1.6E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**857**	**86**	**8.6**	**7586**	**759**	**76**
NONCARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.0E-07			6.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$	1.4E-07			9.1E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**588**			**2601**		

Table 30d. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Highest Use Recreational Areas (Alternative Assumptions)
Young Child

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Young child	6	6	6	6	6	6
Body weight (kg)						
Young child	15	15	15	15	15	15
Averaging time - noncarcinogenic (days)						
Young child	2,190	2,190	2,190	2,190	2,190	2,190
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Young child	100	100	100	20	20	20
Fraction attributable to site	0.5	0.5	0.5	0.5	0.5	0.5
RAF-oral (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	7.0E-08	7.0E-08	7.0E-08	4.7E-09	4.7E-09	4.7E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	8.2E-07	8.2E-07	8.2E-07	5.5E-08	5.5E-08	5.5E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Young child Warmer months	0.2	0.2	0.2	0.2	0.2	0.2
Cooler months	0.35	0.35	0.35	0.35	0.35	0.35
Skin surface area exposed (cm^2/day)						
Young child Warmer months	2800	2800	2800	2800	2800	2800
Cooler months	684	684	684	684	684	684
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	9.2E-08	9.2E-08	9.2E-08	3.1E-08	3.1E-08	3.1E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.1E-06	1.1E-06	1.1E-06	3.6E-07	3.6E-07	3.6E-07
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	9.2E-08	9.2E-08	9.2E-08	3.1E-08	3.1E-08	3.1E-08
Total Exposure, soil ingestion $(days)^{-1}$	7.0E-08	7.0E-08	7.0E-08	4.7E-09	4.7E-09	4.7E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**307**	**31**	**3.1**	**2817**	**282**	**28**
NONCARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.1E-06			3.6E-07		
Total Exposure, soil ingestion $(days)^{-1}$	8.2E-07			5.5E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**105**			**483**		

Table 30e. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Medium-High Use Recreational Areas (Alternative Assumptions)
Adults

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	47	47	47	13	13	13
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	50	50	50	10	10	10
Fraction attributable to site	0.5	0.5	0.5	0.5	0.5	0.5
RAF-oral (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	60	60	60	21	21	21
Exposure (soil ing)-carcinogenic $(days)^{-1}$	3.9E-08	3.9E-08	3.9E-08	7.6E-10	7.6E-10	7.6E-10
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	5.9E-08	5.9E-08	5.9E-08	4.1E-09	4.1E-09	4.1E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)						
Adult Warmer months	5700	5700	5700	5700	5700	5700
Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	60	60	60	21	21	21
Exposure (dermal con)-carcinogenic $(days)^{-1}$	7.5E-08	7.5E-08	7.5E-08	7.3E-09	7.3E-09	7.3E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.1E-07	1.1E-07	1.1E-07	3.9E-08	3.9E-08	3.9E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	7.5E-08	7.5E-08	7.5E-08	7.3E-09	7.3E-09	7.3E-09
Total Exposure, soil ingestion $(days)^{-1}$	3.9E-08	3.9E-08	3.9E-08	7.6E-10	7.6E-10	7.6E-10
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**436**	**44**	**4.4**	**12423**	**1242**	**124**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.1E-07			3.9E-08		
Total Exposure, soil ingestion $(days)^{-1}$	5.9E-08			4.1E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**1171**			**4614**		

Table 30f. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Medium-High Use Recreational Areas (Alternative Assumptions)
Older Child

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	50	50	50	10	10	10
Fraction attributable to site	0.5	0.5	0.5	0.5	0.5	0.5
RAF-oral (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	60	60	60	21	21	21
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.6E-08	1.6E-08	1.6E-08	1.1E-09	1.1E-09	1.1E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	9.1E-08	9.1E-08	9.1E-08	6.4E-09	6.4E-09	6.4E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)						
Older child Warmer months	4400	4400	4400	4400	4400	4400
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	60	60	60	21	21	21
Exposure (dermal con)-carcinogenic $(days)^{-1}$	2.3E-08	2.3E-08	2.3E-08	8.1E-09	8.1E-09	8.1E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	4.7E-08	4.7E-08	4.7E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.3E-08	2.3E-08	2.3E-08	8.1E-09	8.1E-09	8.1E-09
Total Exposure, soil ingestion $(days)^{-1}$	1.6E-08	1.6E-08	1.6E-08	1.1E-09	1.1E-09	1.1E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**1286**	**129**	**13**	**10837**	**1084**	**108**
NONCARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.4E-07			4.7E-08		
Total Exposure, soil ingestion $(days)^{-1}$	9.1E-08			6.4E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**882**			**3716**		

Table 30g. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Medium-High Use Recreational Areas (Alternative Assumptions)
Young Child

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Young child	6	6	6	6	6	6
Body weight (kg)						
Young child	15	15	15	15	15	15
Averaging time - noncarcinogenic (days)						
Young child	2,190	2,190	2,190	2,190	2,190	2,190
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Young child	100	100	100	20	20	20
Fraction attributable to site	0.5	0.5	0.5	0.5	0.5	0.5
RAF-oral (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	15	15	15	15	15	15
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.2E-08	1.2E-08	1.2E-08	2.3E-09	2.3E-09	2.3E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	2.7E-08	2.7E-08	2.7E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Young child Warmer months	0.2	0.2	0.2	0.2	0.2	0.2
Cooler months	0.35	0.35	0.35	0.35	0.35	0.35
Skin surface area exposed (cm^2/day)						
Young child Warmer months	2800	2800	2800	2800	2800	2800
Cooler months	684	684	684	684	684	684
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
RAF-dermal (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	15	15	15	15	15	15
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08
Total Exposure, soil ingestion $(days)^{-1}$	1.2E-08	1.2E-08	1.2E-08	2.3E-09	2.3E-09	2.3E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**1842**	**184**	**18**	**5635**	**563**	**56**
NONCARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.8E-07			1.8E-07		
Total Exposure, soil ingestion $(days)^{-1}$	1.4E-07			2.7E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**632**			**966**		

Attachment 31
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
In Medium-Use Recreational Areas
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil in medium-use recreational areas. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, health-protective RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 31a. With the exception of the soil ingestion rate, the fraction of soil ingested from the Site, and the exposure frequency for the medium-use exposure areas, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

This attachment provides the calculations of RMCs for exposure areas that are subject to a Medium-Use scenario. This includes those areas for which portions are accessible but that access is more limited.

For the Medium-Use scenario, RMCs have been developed for older children and adults using revised frequencies of 30 days/year (RME) and 15 days/year (CTE). These are consistent with the frequencies used in the HHRA for the Low-Use Recreational scenario.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate the general recreation scenarios. For this RME analysis, an upper bound soil ingestion rate of 50 mg/day has been used to develop RMCs for older children and adults. For the CTE analysis, a soil ingestion rate of 10 mg/day has been used to evaluate older children and adults.

While GE agrees with the EPA's assumption that 50 percent of the soil ingested in the CTE scenario is derived from the Site, it does not agree with the assumption that 100 percent of the

soil ingested in the RME recreational scenario will be derived from the Site. As discussed in Section 3.1.1.2 of this proposal, the short duration of most recreational activities that are likely to occur under the general recreation scenarios makes it likely that, even for the RME receptor, the fraction of daily soil ingestion that is derived from the Site does not likely exceed 50 percent for the general recreational scenarios. Thus, for this analysis, GE has used a factor of 0.5 (50 percent) to represent the fraction of total daily soil ingestion that is derived from the Site for both the RME and CTE scenarios for all age groups.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for adults and older children. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 31b) and older children (Table 31c) under Medium-Use conditions. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Medium-Use	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	8.7	87	872	2,342	174	1,739	17,392	6,460
Older Child	26	257	2,571	1,763	152	1,517	15,172	5,202

Table 31a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Medium Use Recreational Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Older child			30	15	One day per week (RME) and one day every two weeks (CTE) for 30 weeks per year; Professional judgment.
Adult			30	15	One day per week (RME) and one day every two weeks (CTE) for 30 weeks per year; Professional judgment.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			47	13	HHRA, Vol. IIIA; Table 4-23; Aged 19-65 years (RME); 19-31 years (CTE). Based on MDPH, 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			17,155	4,745	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Adult			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	0.5	0.5	Professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,400	4,400	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Adult			5,700	5,700	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 31b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Medium Use Recreational Areas (Alternative Assumptions)
Adults

Parameter		Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Adult		47	47	47	13	13	13
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		50	50	50	10	10	10
Fraction attributable to site		0.5	0.5	0.5	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (soil ing)-carcinogenic $(days)^{-1}$		2.0E-08	2.0E-08	2.0E-08	5.5E-10	5.5E-10	5.5E-10
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		2.9E-08	2.9E-08	2.9E-08	2.9E-09	2.9E-09	2.9E-09
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	5700	5700	5700	5700	5700	5700
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (dermal con)-carcinogenic $(days)^{-1}$		3.8E-08	3.8E-08	3.8E-08	5.2E-09	5.2E-09	5.2E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		5.6E-08	5.6E-08	5.6E-08	2.8E-08	2.8E-08	2.8E-08
CARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		3.8E-08	3.8E-08	3.8E-08	5.2E-09	5.2E-09	5.2E-09
Total Exposure, soil ingestion $(days)^{-1}$		2.0E-08	2.0E-08	2.0E-08	5.5E-10	5.5E-10	5.5E-10
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)		**872**	**87**	**9**	**17392**	**1739**	**174**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$		5.6E-08			2.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$		2.9E-08			2.9E-09		
Reference Dose (RfD) (mg/kg-day)		2.00E-04			2.00E-04		
Target Hazard Index		1			1		
Risk-based Media Concentrations (mg/kg)		**2342**			**6460**		

Table 31c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Medium Use Recreational Areas (Alternative Assumptions)
Older Child

Parameter		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Common Parameters							
Exposure duration (yrs)							
Older child		12	12	12	12	12	12
Body weight (kg)							
Older child		45	45	45	45	45	45
Averaging time - noncarcinogenic (days)							
Older child		4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Older child		50	50	50	10	10	10
Fraction attributable to site		0.5	0.5	0.5	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (soil ing)-carcinogenic $(days)^{-1}$		7.8E-09	7.8E-09	7.8E-09	7.8E-10	7.8E-10	7.8E-10
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		4.6E-08	4.6E-08	4.6E-08	4.6E-09	4.6E-09	4.6E-09
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Older child	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)							
Older child	Warmer months	4400	4400	4400	4400	4400	4400
	Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (dermal con)-carcinogenic $(days)^{-1}$		1.2E-08	1.2E-08	1.2E-08	5.8E-09	5.8E-09	5.8E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		6.8E-08	6.8E-08	6.8E-08	3.4E-08	3.4E-08	3.4E-08
CARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		1.2E-08	1.2E-08	1.2E-08	5.8E-09	5.8E-09	5.8E-09
Total Exposure, soil ingestion $(days)^{-1}$		7.8E-09	7.8E-09	7.8E-09	7.8E-10	7.8E-10	7.8E-10
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)		**2571**	**257**	**26**	**15172**	**1517**	**152**
NONCARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		6.8E-08			3.4E-08		
Total Exposure, soil ingestion $(days)^{-1}$		4.6E-08			4.6E-09		
Reference Dose (RfD) (mg/kg-day)		2.00E-04			2.00E-04		
Target Hazard Index		1			1		
Risk-based Media Concentrations (mg/kg)		**1763**			**5202**		

Attachment 32
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
In Low-Use Recreational Areas
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil in low-use recreational areas. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 32a. With the exception of the soil ingestion rate, the fraction of soil ingested from the Site, and the exposure frequency for the low-use exposure areas, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

This attachment provides the calculations of RMCs for exposure areas that are subject to a Low-Use scenario. This includes those areas that are remotely located from residences and have no readily accessible points of entry.

For the Low-Use scenario, RMCs have been developed for older children and adults using revised frequencies of 15 days/year (RME) and 7 days/year (CTE). These are based on the assumption that remote and inaccessible areas are not likely to be visited more than 2 days/month for the RME and one day/month for a typical user.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate the general recreation scenarios. For this RME analysis, an upper bound soil ingestion rate of 50 mg/day has been used to develop RMCs for older children and adults. For the CTE analysis, a soil ingestion rate of 10 mg/day has been used to evaluate older children and adults.

While GE agrees with the EPA's assumption that 50 percent of the soil ingested in the CTE scenario is derived from the Site, it does not agree with the assumption that 100 percent of the soil ingested in the RME recreational scenario will be derived from the Site. As discussed in Section 3.1.1.2 of this proposal, the short duration of most recreational activities that are likely to occur under the general recreation scenarios makes it likely that, even for the RME receptor, the fraction of daily soil ingestion that is derived from the Site does not likely exceed 50 percent for the general recreational scenarios. Thus, for this analysis, GE has used a factor of 0.5 (50 percent) to represent the fraction of total daily soil ingestion that is derived from the Site for both the RME and CTE scenarios for all age groups.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for adults and older children. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 32b) and older children (Table 32c) under Low-Use conditions. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Low-Use	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	17	174	1,744	4,684	373	3,727	37,268	13,843
Older Child	51	514	5,143	3,527	325	3,251	32,512	11,147

Table 32a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Low Use Recreational Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Older child			15	7	Two days per month (RME) and one day per month (CTE) for 7 months of the year; professional judgment.
Adult			15	7	Two days per month (RME) and one day per month (CTE) for 7 months of the year; professional judgment.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			47	13	HHRA, Vol. IIIA; Table 4-23; Aged 19 to 65 years (RME); 19 to 31 years (CTE). Based on MDPH, 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			17,155	4,745	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Adult			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,400	4,400	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head
Adult			5,700	5,700	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 32b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Low Use Recreational Areas (Alternative Assumptions)
Adults

Parameter		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Common Parameters							
Exposure duration (yrs)							
Adult		47	47	47	13	13	13
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		50	50	50	10	10	10
Fraction attributable to site		0.5	0.5	0.5	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		15	15	15	7	7	7
Exposure (soil ing)-carcinogenic (days)$^{-1}$		9.9E-09	9.9E-09	9.9E-09	2.5E-10	2.5E-10	2.5E-10
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$		1.5E-08	1.5E-08	1.5E-08	1.4E-09	1.4E-09	1.4E-09
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	5700	5700	5700	5700	5700	5700
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		15	15	15	7	7	7
Exposure (dermal con)-carcinogenic (days)$^{-1}$		1.9E-08	1.9E-08	1.9E-08	2.4E-09	2.4E-09	2.4E-09
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$		2.8E-08	2.8E-08	2.8E-08	1.3E-08	1.3E-08	1.3E-08
CARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		1.9E-08	1.9E-08	1.9E-08	2.4E-09	2.4E-09	2.4E-09
Total Exposure, soil ingestion (days)$^{-1}$		9.9E-09	9.9E-09	9.9E-09	2.5E-10	2.5E-10	2.5E-10
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**1744**	**174**	**17**	**37268**	**3727**	**373**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact (days)$^{-1}$		2.8E-08			1.3E-08		
Total Exposure, soil ingestion (days)$^{-1}$		1.5E-08			1.4E-09		
Reference Dose (RfD) (mg/kg-day)		2.00E-04			2.00E-04		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**4684**			**13843**		

Table 32c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Low Use Recreational Areas (Alternative Assumptions)
Older Child

Parameter		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Common Parameters							
Exposure duration (yrs)							
Older child		12	12	12	12	12	12
Body weight (kg)							
Older child		45	45	45	45	45	45
Averaging time - noncarcinogenic (days)							
Older child		4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Older child		50	50	50	10	10	10
Fraction attributable to site		0.5	0.5	0.5	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		15	15	15	7	7	7
Exposure (soil ing)-carcinogenic $(days)^{-1}$		3.9E-09	3.9E-09	3.9E-09	3.7E-10	3.7E-10	3.7E-10
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		2.3E-08	2.3E-08	2.3E-08	2.1E-09	2.1E-09	2.1E-09
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Older child	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)							
Older child	Warmer months	4400	4400	4400	4400	4400	4400
	Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		15	15	15	7	7	7
Exposure (dermal con)-carcinogenic $(days)^{-1}$		5.8E-09	5.8E-09	5.8E-09	2.7E-09	2.7E-09	2.7E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		3.4E-08	3.4E-08	3.4E-08	1.6E-08	1.6E-08	1.6E-08
CARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		5.8E-09	5.8E-09	5.8E-09	2.7E-09	2.7E-09	2.7E-09
Total Exposure, soil ingestion $(days)^{-1}$		3.9E-09	3.9E-09	3.9E-09	3.7E-10	3.7E-10	3.7E-10
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**5143**	**514**	**51**	**32512**	**3251**	**325**
NONCARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		3.4E-08			1.6E-08		
Total Exposure, soil ingestion $(days)^{-1}$		2.3E-08			2.1E-09		
Reference Dose (RfD) (mg/kg-day)		2.00E-04			2.00E-04		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**3527**			**11147**		

Attachment 33
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Bank Fishing Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil during bank fishing activities. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 33a. With the exception of the soil ingestion rate, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate to evaluate potential exposures for older children and adults. For this RME analysis, an upper bound soil ingestion rate of 50 mg/day has been used to develop RMCs for these age groups. For the CTE analysis, a soil ingestion rate of 10 mg/day has been used to develop the RMCs.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this

analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for adults and older children. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 33b) and older children (Table 33c) under the Bank Fishing Scenario. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Bank Fishing	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	3.1	31	305	663	77	768	7,678	2,413
Older Child	7.7	77	768	527	59	588	5,880	2,016

Table 33a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Bank Fishing Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Older child			30	10	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.6.1. EPA's professional judgment based on numerous studies.
Adult			30	10	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.6.1. EPA's professional judgment based on numerous studies.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			38	11	HHRA, Vol. IIIA; Table 4-23; Based on MDPH, 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			13,870	4,015	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Adult			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.31	0.31	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Adult			0.3	0.3	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.43	0.43	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Adult			0.47	0.47	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,471	4,471	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Adult			6,074	6,074	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 33b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Bank Fishing Scenario (Alternative Assumptions)
Adults

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	38	38	38	11	11	11
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	13,870	13,870	13,870	4,015	4,015	4,015
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	30	30	30	10	10	10
Exposure (soil ing)-carcinogenic $(days)^{-1}$	3.2E-08	3.2E-08	3.2E-08	3.1E-10	3.1E-10	3.1E-10
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	5.9E-08	5.9E-08	5.9E-08	2.0E-09	2.0E-09	2.0E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult Warmer months	0.3	0.3	0.3	0.3	0.3	0.3
Cooler months	0.47	0.47	0.47	0.47	0.47	0.47
Skin surface area exposed (cm^2/day)						
Adult Warmer months	6074	6074	6074	6074	6074	6074
Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	30	30	30	10	10	10
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.3E-07	1.3E-07	1.3E-07	1.3E-08	1.3E-08	1.3E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.4E-07	2.4E-07	2.4E-07	8.1E-08	8.1E-08	8.1E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.3E-07	1.3E-07	1.3E-07	1.3E-08	1.3E-08	1.3E-08
Total Exposure, soil ingestion $(days)^{-1}$	3.2E-08	3.2E-08	3.2E-08	3.1E-10	3.1E-10	3.1E-10
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**305**	**31**	**3.1**	**7678**	**768**	**77**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	2.4E-07			8.1E-08		
Total Exposure, soil ingestion $(days)^{-1}$	5.9E-08			2.0E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**663**			**2413**		

Table 33c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Bank Fishing Scenario (Alternative Assumptions)
Older Child

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	30	30	30	10	10	10
Exposure (soil ing)-carcinogenic (days)$^{-1}$	1.6E-08	1.6E-08	1.6E-08	5.2E-10	5.2E-10	5.2E-10
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$	9.1E-08	9.1E-08	9.1E-08	3.0E-09	3.0E-09	3.0E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child Warmer months	0.31	0.31	0.31	0.31	0.31	0.31
Cooler months	0.43	0.43	0.43	0.43	0.43	0.43
Skin surface area exposed (cm^2/day)						
Older child Warmer months	4471	4471	4471	4471	4471	4471
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	30	30	30	10	10	10
Exposure (dermal con)-carcinogenic (days)$^{-1}$	4.9E-08	4.9E-08	4.9E-08	1.6E-08	1.6E-08	1.6E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$	2.9E-07	2.9E-07	2.9E-07	9.6E-08	9.6E-08	9.6E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$	4.9E-08	4.9E-08	4.9E-08	1.6E-08	1.6E-08	1.6E-08
Total Exposure, soil ingestion (days)$^{-1}$	1.6E-08	1.6E-08	1.6E-08	5.2E-10	5.2E-10	5.2E-10
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**768**	**77**	**7.7**	**5880**	**588**	**59**
NONCARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$	2.9E-07			9.6E-08		
Total Exposure, soil ingestion (days)$^{-1}$	9.1E-08			3.0E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**527**			**2016**		

Attachment 34
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Dirt Bike/ATV Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil during dirt biking/ATVing activities. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left((AF_1 * SA_1 * AD_1) + (AF_2 * SA_2 * AD_2)\right)/(AD_1 + AD_2)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for in this analysis, and the basis of each, are summarized in Table 34a. With the exception of the soil ingestion rate and the exposure frequencies, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate to evaluate potential exposures for adults. For this RME analysis, an upper bound soil ingestion rate of 50 mg/day has been used to develop RMCs for this scenario. For the CTE analysis, a soil ingestion rate of 10 mg/day has been used to develop the RMCs.

The HHRA used an RME exposure frequency of 90 days/year to evaluate this scenario. However, as discussed in Section 3.1.1.3 of this proposal, GE believes that an RME exposure frequency of 72 days/year is more appropriate for this activity. This frequency has been used to develop the alternative RMCs for the RME analysis of this scenario. For the CTE analysis, the same exposure frequency used in the HHRA (30 days/year) has been used.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for older children who engage in Dirt BikingATVing activities. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in the following table for older children (Table 34b) under the Dirt Biking/ATVing scenario. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Dirt Bike/ATV	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Older Children	6	60	604	414	49	491	4,905	1,682

Table 34a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Dirt Biking/ATV Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-13.
Exposure frequency	days/year	EF	72	30	Three d/wk for 3 months and two d/wk for 4 months (RME). One day/week for 7 months (CTE).
Exposure duration	years	ED	12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Calculated by EPA.
Body weight	kg/mg	BW	45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint	days	ATnc	4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-13. EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1	0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.3.4. Heavy equipment operators and construction workers.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2	0.24	0.24	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.3.4. Heavy equipment operators and construction workers.
Skin surface area (warmer months)	cm^2/day	SA_1	3,522	3,522	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Section 4.5.3.3.4. Hands, forearms, lower legs, and face.
Skin surface area (cooler months)	cm^2/day	SA_2	1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Section 4.5.3.3.4. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-13; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-13; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-13, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Stanek, E.J., E.J. Calabrese, R. Barnes, P. Pekow. 1997. Soil ingestion in adults - Results of a second pilot study. *Ecotoxicology and Environmental Safety* 36:249-257
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 34b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Dirt Bike/ATV Scenario (Alternative Assumptions)
Older Child

Parameter	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Common Parameters						
Exposure duration (yrs)	12	12	12	12	12	12
Body weight (kg)	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	72	72	72	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	3.8E-08	3.8E-08	3.8E-08	1.6E-09	1.6E-09	1.6E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	2.2E-07	2.2E-07	2.2E-07	9.1E-09	9.1E-09	9.1E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Warmer months	0.14	0.14	0.14	0.14	0.14	0.14
Cooler months	0.24	0.24	0.24	0.24	0.24	0.24
Skin surface area exposed (cm^2/day)						
Warmer months	3522	3522	3522	3522	3522	3522
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	72	72	72	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	4.5E-08	4.5E-08	4.5E-08	1.9E-08	1.9E-08	1.9E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.6E-07	2.6E-07	2.6E-07	1.1E-07	1.1E-07	1.1E-07
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	4.5E-08	4.5E-08	4.5E-08	1.9E-08	1.9E-08	1.9E-08
Total Exposure, soil ingestion $(days)^{-1}$	3.8E-08	3.8E-08	3.8E-08	1.6E-09	1.6E-09	1.6E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**604**	**60**	**6.0**	**4905**	**491**	**49**
NONCARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.6E-07			1.1E-07		
Total Exposure, soil ingestion $(days)^{-1}$	2.2E-07			9.1E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**414**			**1682**		

Attachment 35
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Marathon Canoeing Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil during marathon canoeing activities. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left((AF_1 * SA_1 * AD_1) + (AF_2 * SA_2 * AD_2)\right)/(AD_1 + AD_2)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for in this analysis, and the basis of each, are summarized in Table 34a. With the exception of the soil ingestion rate, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate to evaluate potential exposures for adults. For this RME analysis, an upper bound soil ingestion rate of 50 mg/day has been used to develop RMCs for this scenario. For the CTE analysis, a soil ingestion rate of 10 mg/day has been used to develop the RMCs.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for adults who engage in marathon canoeing. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in Table 34b for adults under the Marathon Canoeing scenario. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Marathon Canoe	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	0.78	7.8	78	133	6.3	63	630	270

Table 35a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Marathon Canoeing Scenario - Alternative Assumptions

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-14.
Exposure frequency	days/year	EF	150	90	HHRA, Vol. IIIA; Table 4-22; Weston 2001.
Exposure duration	years	ED	30	15	HHRA, Vol. IIIA; Table 4-23; RME based on Weston 2001. CTE based on EPA's professional judgment.
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	10,950	5,475	HHRA, Vol. IIIA. Table 4-14; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	50	50	HHRA, Vol. IIIA; Tables 4-14 and 4-24; Section 4.5.3.4.5 (RME). CTE based on Stanek et al. (1997) and Calabrese (2003)
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-14; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1	0.32	0.32	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.4.4. Reed gatherers.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2	0.658	0.658	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.4.4. Reed gatherers.
Skin surface area (warmer months)	cm^2/day	SA_1	5,672	5,672	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Section 4.5.3.4.4. Hands, forearms, lower legs, and feet.
Skin surface area (cooler months)	cm^2/day	SA_2	904	904	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.3.4.4. Hands.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-14; Professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-14; Professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-14, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environ. Toxicology and Environ. Health* 39:375-382.
Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.
Weston 2001. Email memorandum from M. Isabel Zapisek (Weston Pittsfield, MA Office) to Robert Warwick (West Chester, PA office). October 9.

Table 35b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Marathon Canoeing Scenario - Alternative Assumptions
Adults

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)	30	30	30	15	15	15
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	10,950	10,950	10,950	5,475	5,475	5,475
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	150	150	150	90	90	90
Exposure (soil ing)-carcinogenic (days)$^{-1}$	1.3E-07	1.3E-07	1.3E-07	3.8E-09	3.8E-09	3.8E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$	2.9E-07	2.9E-07	2.9E-07	1.8E-08	1.8E-08	1.8E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Warmer months	0.32	0.32	0.32	0.32	0.32	0.32
Cooler months	0.658	0.658	0.658	0.658	0.658	0.658
Skin surface area exposed (cm^2/day)						
Warmer months	5672	5672	5672	5672	5672	5672
Cooler months	904	904	904	904	904	904
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	150	150	150	90	90	90
Exposure (dermal con)-carcinogenic (days)$^{-1}$	5.2E-07	5.2E-07	5.2E-07	1.5E-07	1.5E-07	1.5E-07
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$	1.2E-06	1.2E-06	1.2E-06	7.2E-07	7.2E-07	7.2E-07
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$	5.2E-07	5.2E-07	5.2E-07	1.5E-07	1.5E-07	1.5E-07
Total Exposure, soil ingestion (days)$^{-1}$	1.3E-07	1.3E-07	1.3E-07	3.8E-09	3.8E-09	3.8E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**78**	**7.8**	**0.78**	**630**	**63**	**6.3**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact (days)$^{-1}$	1.2E-06			7.2E-07		
Total Exposure, soil ingestion (days)$^{-1}$	2.9E-07			1.8E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**133**			**270**		

Attachment 36
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Recreational Canoeing Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil during recreational canoeing activities. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 36a. With the exception of the soil ingestion rate, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate to evaluate potential exposures for older children and adults. For this RME analysis, an upper bound soil ingestion rate of 50 mg/day has been used to develop RMCs for these age groups. For the CTE analysis, a soil ingestion rate of 10 mg/day has been used to develop the RMCs.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this

analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for adults and older children. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 36b) and older children (Table 36c) under the Recreational Canoeing Scenario. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Recreational Canoe	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	1.5	15	145	332	14	141	1,408	804
Older Child	7.7	77	768	527	39	392	3,920	1,344

Table 36a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Recreational Canoeing Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-15.
Exposure frequency	days/year	EF			
Older child			30	15	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Adult			60	30	HHRA, Vol. IIIA; Table 4-22; Weston 2001.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Calculated by EPA.
Adult			40	20	HHRA, Vol. IIIA; Table 4-23; RME based on Weston 2001; CTE based on EPA's professional judgment.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			14,600	7,300	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Adult			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-15; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,471	4,471	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Adult			6,074	6,074	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-15; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-15; EPA's professional judgment. April and October.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-15, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Weston 2001. Email memorandum from M. Isabel Zapisek (Weston Pittsfield, MA Office) to Robert Warwick (West Chester, PA office). October 9.

Table 36b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Recreational Canoeing (Alternative Assumptions)
Adults

Parameter		Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Adult		40	40	40	20	20	20
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		14,600	14,600	14,600	7,300	7,300	7,300
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		50	50	50	10	10	10
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$		6.7E-08	6.7E-08	6.7E-08	1.7E-09	1.7E-09	1.7E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		1.2E-07	1.2E-07	1.2E-07	5.9E-09	5.9E-09	5.9E-09
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.3	0.3	0.3	0.3	0.3	0.3
	Cooler months	0.47	0.47	0.47	0.47	0.47	0.47
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	6074	6074	6074	6074	6074	6074
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$		2.8E-07	2.8E-07	2.8E-07	6.9E-08	6.9E-08	6.9E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		4.9E-07	4.9E-07	4.9E-07	2.4E-07	2.4E-07	2.4E-07
CARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		2.8E-07	2.8E-07	2.8E-07	6.9E-08	6.9E-08	6.9E-08
Total Exposure, soil ingestion $(days)^{-1}$		6.7E-08	6.7E-08	6.7E-08	1.7E-09	1.7E-09	1.7E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)		**145**	**15**	**1.5**	**1408**	**141**	**14.1**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$		4.9E-07			2.4E-07		
Total Exposure, soil ingestion $(days)^{-1}$		1.2E-07			5.9E-09		
Reference Dose (RfD) (mg/kg-day)		2.00E-04			2.00E-04		
Target Hazard Index		1			1		
Risk-based Media Concentrations (mg/kg)		**332**			**804**		

Table 36c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Recreational Canoeing Scenario (Alternative Assumptions)
Older Child

Parameter		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Common Parameters							
Exposure duration (yrs)							
Older child		12	12	12	12	12	12
Body weight (kg)							
Older child		45	45	45	45	45	45
Averaging time - noncarcinogenic (days)							
Older child		4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Older child		50	50	50	10	10	10
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)		1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (soil ing)-carcinogenic (days)$^{-1}$		1.6E-08	1.6E-08	1.6E-08	7.8E-10	7.8E-10	7.8E-10
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$		9.1E-08	9.1E-08	9.1E-08	4.6E-09	4.6E-09	4.6E-09
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Older child	Warmer months	0.31	0.31	0.31	0.31	0.31	0.31
	Cooler months	0.43	0.43	0.43	0.43	0.43	0.43
Skin surface area exposed (cm^2/day)							
Older child	Warmer months	4471	4471	4471	4471	4471	4471
	Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Fraction attributable to site		1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (dermal con)-carcinogenic (days)$^{-1}$		4.9E-08	4.9E-08	4.9E-08	2.5E-08	2.5E-08	2.5E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$		2.9E-07	2.9E-07	2.9E-07	1.4E-07	1.4E-07	1.4E-07
CARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		4.9E-08	4.9E-08	4.9E-08	2.5E-08	2.5E-08	2.5E-08
Total Exposure, soil ingestion (days)$^{-1}$		1.6E-08	1.6E-08	1.6E-08	7.8E-10	7.8E-10	7.8E-10
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)		**768**	**77**	**7.7**	**3920**	**392**	**39**
NONCARCINOGENIC		**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		2.9E-07			1.4E-07		
Total Exposure, soil ingestion (days)$^{-1}$		9.1E-08			4.6E-09		
Reference Dose (RfD) (mg/kg-day)		2.00E-04			2.00E-04		
Target Hazard Index		1			1		
Risk-based Media Concentrations (mg/kg)		**527**			**1344**		

Attachment 37
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Waterfowl Hunting Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil during waterfowl hunting activities. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 37a. With the exception of the soil ingestion rate, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate to evaluate potential exposures for older children and adults. For this RME analysis, an upper bound soil ingestion rate of 50 mg/day has been used to develop RMCs for these age groups. For the CTE analysis, a soil ingestion rate of 10 mg/day has been used to develop the RMCs.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this

analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for adults and older children. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 37b) and older children (Table 37c) under the Waterfowl Hunting Scenario. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Waterfowl Hunting	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	12	124	1,237	2,685	112	1,124	11,239	8,028
Older Child	58	581	5,813	1,993	376	3,764	37,642	6,453

Table 37a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Waterfowl Hunting Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-17.
Exposure frequency	days/year	EF			
Older child			14	7	HHRA, Vol. IIIA; Table 4-22; Based on USFWS 2001 and EOEA 2000.
Adult			14	7	HHRA, Vol. IIIA; Table 4-22; Based on USFWS 2001 and EOEA 2000.
Exposure duration	years	ED			
Older child			6	6	HHRA, Vol. IIIA; Table 4-23; Age 12 -18 years. Section 4.5.3.7.2. Based on MassWildlife 2001.
Adult			38	38	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.7.2. Based on MDPH 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			2,190	2,190	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			13,870	13,870	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Adult			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-17; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF			
Older child			0.43	0.43	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.7.4. Reed gatherers (hands), gardeners (face).
Adult			0.47	0.47	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.7.4. Reed gatherers (hands), gardeners (face).
Skin surface area	cm^2/day	SA			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands and face.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-17, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.

EOEA 2000. Masschusetts Executive Office of Environmental Affairs. Massachusetts Outdoors 2000! Statewide Comprehensive Outdoor Recreational Plan (SCORP).

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.

USFWS 2001. U.S. Fish and Wildlife Service. *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation - Massachusetts.* FHW/01-MA-Rev.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 37b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Waterfowl Hunting (Alternative Assumptions)
Adults

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	38	38	38	25	25	25
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	13,870	13,870	13,871	9,125	9,125	9,125
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	4.9E-10	4.9E-10	4.9E-10
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	2.7E-08	2.7E-08	2.7E-08	1.4E-09	1.4E-09	1.4E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult	0.47	0.47	0.47	0.47	0.47	0.47
Skin surface area exposed (cm^2/day)						
Adult	1306	1306	1306	1306	1306	1306
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (dermal con)-carcinogenic $(days)^{-1}$	2.6E-08	2.6E-08	2.6E-08	8.4E-09	8.4E-09	8.4E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	4.7E-08	4.7E-08	4.7E-08	2.4E-08	2.4E-08	2.4E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.6E-08	2.6E-08	2.6E-08	8.4E-09	8.4E-09	8.4E-09
Total Exposure, soil ingestion $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	4.9E-10	4.9E-10	4.9E-10
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**1237**	**124**	**12**	**11239**	**1124**	**112**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	4.7E-08			2.4E-08		
Total Exposure, soil ingestion $(days)^{-1}$	2.7E-08			1.4E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**2685**			**8028**		

Table 37c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Waterfowl Hunting (Alternative Assumptions)
Older Child

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	6	6	6	6	6	6
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	2,190	2,190	2,190	2,190	2,190	2,190
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (soil ing)-carcinogenic $(days)^{-1}$	3.7E-09	3.7E-09	3.7E-09	1.8E-10	1.8E-10	1.8E-10
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	4.3E-08	4.3E-08	4.3E-08	2.1E-09	2.1E-09	2.1E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child	0.43	0.43	0.43	0.43	0.43	0.43
Skin surface area exposed (cm^2/day)						
Older child	1125	1125	1125	1125	1125	1125
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (dermal con)-carcinogenic $(days)^{-1}$	4.9E-09	4.9E-09	4.9E-09	2.5E-09	2.5E-09	2.5E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	5.8E-08	5.8E-08	5.8E-08	2.9E-08	2.9E-08	2.9E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	4.9E-09	4.9E-09	4.9E-09	2.5E-09	2.5E-09	2.5E-09
Total Exposure, soil ingestion $(days)^{-1}$	3.7E-09	3.7E-09	3.7E-09	1.8E-10	1.8E-10	1.8E-10
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**5813**	**581**	**58**	**37642**	**3764**	**376**
NONCARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	5.8E-08			2.9E-08		
Total Exposure, soil ingestion $(days)^{-1}$	4.3E-08			2.1E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**1993**			**6453**		

Attachment 38
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Agricultural Use Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil during agricultural activities. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis, and the basis of each, are summarized in Table 38a. With the exception of the soil ingestion rate, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the enhanced RME soil ingestion rate of 200 mg/day that has been used to evaluate potential exposures to farmers. For the RME analysis, an enhanced soil ingestion rate of 137 mg/day has been used to develop RMCs for this scenario. The CTE soil ingestion rate is the same as that used in the HHRA.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for farmers. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in Table 38b for adults under the Agricultural Use Scenario. These RMCs are summarized below.

	RME (mg/kg)				CTE (mg/kg)			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Agricultural Use	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	1.5	15	149	546	42	419	4,195	3,476

Table 38a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Farmer Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-19.
Exposure frequency	days/year	EF	40	10	HHRA, Vol. IIIA; Table 4-22; Based on Fries 2002.
Exposure duration	years	ED	64	29	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.9.2. Based on MDPH 2001.
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	23,360	10,585	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	137	100	RME based on EPA 1999. CTE based on HHRA, Vol. IIIA; Tables 4-19 and 4-24; Section 4.5.3.9.3.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-19; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.21	0.21	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.9.4. Based on farmers.
Skin surface area	cm^2/day	SA	3,300	3,300	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and head.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-19, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

EPA 1999. *Protectiveness of Cleanup Levels for Removal Actions Outside the River - Protection of Human Health.* Memorandum from A-M. Burke to R. Cavagnero, EPA Region I. August 4.

Fries 2002. USDA (retired). Personal communication.

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 38b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Farmer Scenario (Alternative Assumptions)
Adults

Parameter	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Common Parameters						
Exposure duration (yrs)	64	64	64	29	29	29
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	137	137	137	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	40	40	40	10	10	10
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.0E-07	2.0E-07	2.0E-07	8.1E-09	8.1E-09	8.1E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	2.1E-07	2.1E-07	2.1E-07	2.0E-08	2.0E-08	2.0E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.21	0.21	0.21	0.21	0.21	0.21
Skin surface area exposed (cm^2/day)	3300	3300	3300	3300	3300	3300
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	40	40	40	10	10	10
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	1.6E-08	1.6E-08	1.6E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.5E-07	1.5E-07	1.5E-07	3.8E-08	3.8E-08	3.8E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	1.6E-08	1.6E-08	1.6E-08
Total Exposure, soil ingestion $(days)^{-1}$	2.0E-07	2.0E-07	2.0E-07	8.1E-09	8.1E-09	8.1E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**149**	**15**	**1.5**	**4195**	**419**	**42**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.5E-07			3.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$	2.1E-07			2.0E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**546**			**3476**		

Attachment 39
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
High-Use Commercial Groundskeeping Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil during high-use commercial groundskeeping activities. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis, and the basis of each, are summarized in Table 39a. With the exception of the soil ingestion rate, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate to evaluate potential exposures for adults. For this RME analysis, an upper bound soil ingestion rate of 50 mg/day has been used to develop RMCs for this age group. For the CTE analysis, a soil ingestion rate of 10 mg/day has been used to develop the RMCs.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for the High-Use Commercial areas. The RMCs based on potential

carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in Table 39b for adults under the High-Use Commercial Groundskeeping Scenario. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
High-Use Commercial	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	2.8	28	282	402	25	250	2,502	858

Table 39a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the High-use Commercial Groundskeeper Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-20.
Exposure frequency	days/year	EF	150	150	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.10.1. Based on EPA's professional judgment.
Exposure duration	years	ED	25	12	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.10.2. EPA 1991 (RME) and EPA's professional judgment (CTE).
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	9,125	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-20; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.1	0.1	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.10.4. Based on gardeners.
Skin surface area	cm^2/day	SA	2,479	2,479	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and face.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-20, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 39b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Commercial Groundskeeper Scenario (Alternative Assumptions)
Adults

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)	25	25	25	12	12	12
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	9,125	9,125	9,125	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	150	150	150	150	150	150
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.0E-07	1.0E-07	1.0E-07	5.0E-09	5.0E-09	5.0E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	2.9E-07	2.9E-07	2.9E-07	2.9E-08	2.9E-08	2.9E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.1	0.1	0.1	0.1	0.1	0.1
Skin surface area exposed (cm^2/day)	2479	2479	2479	2479	2479	2479
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	150	150	150	150	150	150
Exposure (dermal con)-carcinogenic $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	3.5E-08	3.5E-08	3.5E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.0E-07	2.0E-07	2.0E-07	2.0E-07	2.0E-07	2.0E-07
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	3.5E-08	3.5E-08	3.5E-08
Total Exposure, soil ingestion $(days)^{-1}$	1.0E-07	1.0E-07	1.0E-07	5.0E-09	5.0E-09	5.0E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**282**	**28**	**2.8**	**2502**	**250**	**25**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	2.0E-07			2.0E-07		
Total Exposure, soil ingestion $(days)^{-1}$	2.9E-07			2.9E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**402**			**858**		

Attachment 40
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Low-Use Commercial Groundskeeping Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil during low-use commercial groundskeeping activities. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis, and the basis of each, are summarized in Table 40a. With the exception of the soil ingestion rate, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil ingestion rates that have been used to evaluate to evaluate potential exposures for adults. For this RME analysis, an upper bound soil ingestion rate of 50 mg/day has been used to develop RMCs for this age group. For the CTE analysis, a soil ingestion rate of 10 mg/day has been used to develop the RMCs.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for Low-Use Commercial areas. The RMCs based on potential

carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in Table 40b for adults under the Low-Use Commercial Groundskeeping Scenario. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Low-Use Commercial	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	14	141	1,408	2,011	250	2,502	25,024	8,580

Table 40a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Low-Use Commercial Groundskeeper Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-20.
Exposure frequency	days/year	EF	30	15	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.10.1. Based on EPA's professional judgment.
Exposure duration	years	ED	25	12	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.10.2. EPA 1991 (RME) and EPA's professional judgment (CTE).
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	9,125	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-20; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.1	0.1	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.10.4. Based on gardeners.
Skin surface area	cm^2/day	SA	2,479	2,479	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and face.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-20, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 40b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Low-Use Commercial Groundskeeper Scenario (Alternative Assumptions)
Adults

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)	25	25	25	12	12	12
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	9,125	9,125	9,125	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	30	30	30	15	15	15
Exposure (soil ing)-carcinogenic (days)$^{-1}$	2.1E-08	2.1E-08	2.1E-08	5.0E-10	5.0E-10	5.0E-10
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$	5.9E-08	5.9E-08	5.9E-08	2.9E-09	2.9E-09	2.9E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.1	0.1	0.1	0.1	0.1	0.1
Skin surface area exposed (cm^2/day)	2479	2479	2479	2479	2479	2479
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	30	30	30	15	15	15
Exposure (dermal con)-carcinogenic (days)$^{-1}$	1.5E-08	1.5E-08	1.5E-08	3.5E-09	3.5E-09	3.5E-09
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$	4.1E-08	4.1E-08	4.1E-08	2.0E-08	2.0E-08	2.0E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$	1.5E-08	1.5E-08	1.5E-08	3.5E-09	3.5E-09	3.5E-09
Total Exposure, soil ingestion (days)$^{-1}$	2.1E-08	2.1E-08	2.1E-08	5.0E-10	5.0E-10	5.0E-10
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**1408**	**141**	**14**	**25024**	**2502**	**250**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact (days)$^{-1}$	4.1E-08			2.0E-08		
Total Exposure, soil ingestion (days)$^{-1}$	5.9E-08			2.9E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**2011**			**8580**		

Attachment 41
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Utility Work Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with floodplain soil during utility work activities. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis, and the basis of each, are summarized in Table 41a. With the exception of the soil ingestion rate, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the enhanced RME soil ingestion rate of 330 mg/day that has been used to evaluate potential exposures to utility workers. For the RME analysis, an enhanced soil ingestion rate of 137 mg/day has been used to develop RMCs for this scenario. The CTE soil ingestion rate is the same as that used in the HHRA.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for utility workers. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent

with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in Table 41b for adults under the Utility Work Scenario. These RMCs are summarized below.

	RME (mg/kg)				CTE (mg/kg)			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Utility Work	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	31	312	3,119	4,455	208	2,093	20,933	7,177

Table 41a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Utility Worker Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-21.
Exposure frequency	days/year	EF	5	5	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.11.1. Based on EPA's professional judgment.
Exposure duration	years	ED	25	12	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.11.2. EPA 1991 (RME) and EPA's professional judgment (CTE).
Body weight	kg/mg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	9,125	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	137	100	RME based on EPA 1999. CTE based on HHRA, Vol. IIIA; Tables 4-19 and 4-24; Section 4.5.3.9.3.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-21; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.2	0.2	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.11.4. Based on utility workers.
Skin surface area	cm^2/day	SA	3,300	3,300	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and head.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-21, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 1999. *Protectiveness of Cleanup Levels for Removal Actions Outside the River - Protection of Human Health.* Memorandum from A-M. Burke to R. Cavagnero, EPA Region I. August 4.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 41b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Utility Worker Scenario (Alternative Assumptions)
Adults

Parameter	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Common Parameters						
Exposure duration (yrs)	25	25	25	12	12	12
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	9,125	9,125	9,125	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	137	137	137	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	5	5	5	5	5	5
Exposure (soil ing)-carcinogenic $(days)^{-1}$	9.6E-09	9.6E-09	9.6E-09	1.7E-09	1.7E-09	1.7E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	2.7E-08	2.7E-08	2.7E-08	9.8E-09	9.8E-09	9.8E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.2	0.2	0.2	0.2	0.2	0.2
Skin surface area exposed (cm^2/day)	3300	3300	3300	3300	3300	3300
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	5	5	5	5	5	5
Exposure (dermal con)-carcinogenic $(days)^{-1}$	6.5E-09	6.5E-09	6.5E-09	3.1E-09	3.1E-09	3.1E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.8E-08	1.8E-08	1.8E-08	1.8E-08	1.8E-08	1.8E-08
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	6.5E-09	6.5E-09	6.5E-09	3.1E-09	3.1E-09	3.1E-09
Total Exposure, soil ingestion $(days)^{-1}$	9.6E-09	9.6E-09	9.6E-09	1.7E-09	1.7E-09	1.7E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**3119**	**312**	**31**	**20933**	**2093**	**209**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.8E-08			1.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$	2.7E-08			9.8E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**4455**			**7177**		

Attachment 42
Risk-based Media Concentrations for Direct Contact with Sediment
Sediment Exposure Scenario
(Alternative Assumptions)

GE has developed an alternative range of Risk-based Media Concentrations (RMCs) for PCBs based on potential for direct contact with sediment during miscellaneous sediment exposure activities. Consistent with the approach used in EPA's HHRA, potential sediment ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the sediment ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with sediment (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the sediment ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with sediment (day^{-1})

In both of the above equations, the exposures due to sediment ingestion ($Exp_{ingestion}$) and dermal contact with sediment (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * ABS_o * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Sediment ingestion rate (mg/day)
FI	=	Fraction of sediment ingested that is attributable to the Site (unitless)
ABS_o	=	Relative, chemical-specific, oral absorption factor (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Relative, chemical-specific, dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 42a. With the exception of the sediment ingestion rate and RME exposure frequency, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.1.1.1 of this proposal, GE does not agree with the soil/sediment ingestion rates that have been used to evaluate to evaluate potential exposures for older children and adults. For this RME analysis, an upper bound sediment ingestion rate of 50 mg/day has been used to develop RMCs for these age groups. For the CTE analysis, a sediment ingestion rate of 10 mg/day has been used to develop the RMCs.

The HHRA uses an exposure frequency of 36 days/year to evaluate RME exposure under the Sediment Exposure Scenario. As discussed in Section 3.1.1.3 of this proposal, however, GE believes that a more appropriate exposure frequency for the RME receptor under this scenario is 24 days/year. This exposure frequency has been used to calculate the RMCs for the RME analysis. For the CTE analysis, the same exposure frequency used in the HHRA (12 days/year) has been used.

Standard EPA cancer slope factors (CSF) have been used for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for this analysis, a chronic RfD of 2E-04 mg/kg-day has been used to develop RMCs based on the non-cancer endpoint.

Consistent with the HHRA methodology, separate cancer-based and non-cancer-based RMCs have been developed for adults and older children. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 42b) and older children (Table 42c) under the Sediment Exposure Scenario. These RMCs are summarized below.

	RME (mg/kg)				**CTE (mg/kg)**			
Scenario	**Cancer Risk**			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Sediment Exposure	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	2.3	23	235	698	30	302	3,016	1,637
Older Child	8.2	82	818	561	40	401	4,011	1,375

Table 42a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Sediment Exposure Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-18.
Exposure frequency	days/year	EF			
Older child			24	12	Two d/wk for three summer months (RME). CTE based on HHRA, Vol. IIIA; Table 4-22.
Adult			24	12	Two d/wk for three summer months (RME). CTE based on HHRA, Vol. IIIA; Table 4-22.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Age 7 -18 years. Section 4.5.3.8.2. Calculated by EPA.
Adult			52	19	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.8.2. Based on MDPH 2001.
Body weight	kg/mg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			18,980	6,935	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Adult			50	10	Based on Stanek et al. (1997) and Calabrese (2003).
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-18; EPA's professional judgment.
Relative oral absorption factor	unitless	ABS_o	1.0	1.0	Conservative default.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF			
Older child			0.31	0.31	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.8.4. Gardeners (face) and Reed gatherers (other body parts).
Adult			0.3	0.3	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.8.4. Gardeners (face) and Reed gatherers (other body parts).
Skin surface area	cm^2/day	SA			
Older child			4,471	4,471	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Adult			6,074	6,074	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Relative dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-18, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. HHRA Volume and Table and/or Section numbers provided.

Calabrese, E.J. 2003. Letter from Edward J. Calabrese, Director of Northeast Regional Environmental Public Health Center, to Kevin Holtzclaw, GE, re: Soil Ingestion Rates. July 23.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.
Stanek, E.J., E.J. Calabrese, R. Barnes and P. Pekow. 1997. Soil ingestion in adults – Results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 42b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Sediment Exposure Scenario (Alternative Assumptions)
Adults

Parameter	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Common Parameters						
Exposure duration (yrs)						
Adult	52	52	52	19	19	19
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	18,980	18,980	18,980	6,935	6,935	6,935
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	24	24	24	12	12	12
Exposure (soil ing)-carcinogenic (days)$^{-1}$	3.5E-08	3.5E-08	3.5E-08	6.4E-10	6.4E-10	6.4E-10
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$	4.7E-08	4.7E-08	4.7E-08	2.3E-09	2.3E-09	2.3E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult	0.3	0.3	0.3	0.3	0.3	0.3
Skin surface area exposed (cm^2/day)						
Adult	6074	6074	6074	6074	6074	6074
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	24	24	24	12	12	12
Exposure (dermal con)-carcinogenic (days)$^{-1}$	1.8E-07	1.8E-07	1.8E-07	3.3E-08	3.3E-08	3.3E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$	2.4E-07	2.4E-07	2.4E-07	1.2E-07	1.2E-07	1.2E-07
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$	1.8E-07	1.8E-07	1.8E-07	3.3E-08	3.3E-08	3.3E-08
Total Exposure, soil ingestion (days)$^{-1}$	3.5E-08	3.5E-08	3.5E-08	6.4E-10	6.4E-10	6.4E-10
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**235**	**23**	**2.3**	**3016**	**302**	**30**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact (days)$^{-1}$	2.4E-07			1.2E-07		
Total Exposure, soil ingestion (days)$^{-1}$	4.7E-08			2.3E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**698**			**1637**		

Table 42c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Sediment Exposure Scenario (Alternative Assumptions)
Older Child

Parameter	Alternative RME Analysis			Alternative CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	50	50	50	10	10	10
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Relative oral absorption factor (unitless)	1	1	1	1	1	1
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	24	24	24	12	12	12
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.3E-08	1.3E-08	1.3E-08	6.3E-10	6.3E-10	6.3E-10
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	3.7E-09	3.7E-09	3.7E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child	0.31	0.31	0.31	0.31	0.31	0.31
Skin surface area exposed (cm^2/day)						
Older child	4471	4471	4471	4471	4471	4471
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Relative dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	24	24	24	12	12	12
Exposure (dermal con)-carcinogenic $(days)^{-1}$	4.9E-08	4.9E-08	4.9E-08	2.4E-08	2.4E-08	2.4E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.8E-07	2.8E-07	2.8E-07	1.4E-07	1.4E-07	1.4E-07
CARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	4.9E-08	4.9E-08	4.9E-08	2.4E-08	2.4E-08	2.4E-08
Total Exposure, soil ingestion $(days)^{-1}$	1.3E-08	1.3E-08	1.3E-08	6.3E-10	6.3E-10	6.3E-10
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**818**	**82**	**8.2**	**4011**	**401**	**40**
NONCARCINOGENIC	**Alternative RME Analysis**			**Alternative CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.8E-07			1.4E-07		
Total Exposure, soil ingestion $(days)^{-1}$	7.3E-08			3.7E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**561**			**1375**		

APPENDIX G

ATTACHMENTS 43 THROUGH 48

Attachment 43
Risk-based Media Concentrations for PCBs in
Fish Tissue Obtained from Standing Reaches of the Housatonic River
Fish Consumption Scenario (Alternative Assumptions)

A range of alternative Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for exposure, via human consumption, to PCBs in the edible tissue of fish obtained from standing reaches of the Housatonic River in Massachusetts and Connecticut. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. Alternative RMCs have been developed using both a deterministic approach and a probabilistic Microexposure Event (MEE) model. For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

The RMCs for the non-cancer endpoint (RMC_{nc}) for this scenario have been calculated using the following equation. Non-cancer RMCs have been calculated separately for young children and adults.

Young Child

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_a * ED_a}{BW_a}}$$

In the above equations:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
RMC_{nc}	=	RMC based on the non-cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
HI	=	Target hazard index (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)

ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Fish ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Fish ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
RfD	=	Reference dose (mg/kg-day)

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 43a. With the exception of the fish consumption rates, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.2.1.1, fish consumption rates for adults were based on an analysis of raw data collected in the Maine angler survey (Ebert et al., 1993) for anglers who reported that they consumed fish from lakes and ponds. The RME adult consumption rate of 16 g/day is the 95th percentile of that distribution of consumption rates,[1] and the CTE adult consumption rate of 1.7 g/day is the 50th percentile value from the distribution. The child consumption rates are based on AMEC's analysis of the raw data provided by Knuth et al. (1998) for children aged 8 to 14 years (see Section 3.2.1.1). The RME rate of 4 g/day is based on the 95th percentile of the distribution and the CTE rate of 2 g/day is based on the arithmetic mean of that distribution.

For the MEE analysis, the input distributions were those used in the alternative MEE model developed by AMEC and presented as Exhibit H.1 in GE's 2003 comments on the draft HHRA (AMEC and BBL, 2003). Summary descriptions of these distributions are provided in Table 43b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer hazard index of 1 (evaluating adults and children separately).

Standard EPA cancer slope factors (CSF) have been used to develop the deterministic RMCs for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are consistent with the values published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

For the probabilistic analysis, as noted in Section 3.2.1.5 of this proposal, a range of cancer-based RMCs for PCBs was developed using the version of the MEE model that includes a distribution of CSFs to reflect the uncertainty surrounding these estimates. This distribution is presented in Table 43b and discussed in Exhibit H.2 in GE's 2003 comments (AMEC and BBL, 2003).

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the

[1] ChemRisk (1991) reported an analysis of the lake/pond consumption rates and derived a slightly lower 95th percentile value of 15 g/day.

RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for the deterministic analysis, a chronic RfD of 2E-04 mg/kg-day was used to develop RMCs based on the non-cancer endpoint.

For the MEE analysis, as noted in Section 3.2.1.5, a distribution of RfDs was used to evaluate the uncertainty surrounding the RfD. A summary of the distribution is provided in Table 43b and it is described in Exhibit H.2 in GE's 2003 comments (AMEC and BBL, 2003).

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. Deterministic RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

For the probabilistic analysis, the same cancer risk range and non-cancer Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution values exceed the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints based on the deterministic analysis are presented in Table 43c. A summary of the distribution of the RME and CTE RMCs calculated using the MEE model is provided in Table 43d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Deterministic Analysis								
Young child/Adult	0.0040	0.040	0.40	NC	0.15	1.5	15	NC
Adult	NC	NC	NC	1.2	NC	NC	NC	22
Young child	NC	NC	NC	1.0	NC	NC	NC	4.0
MEE Analysis								
Young child/Adult	0.018	0.18	1.8	NC	0.32	3.2	32	NC
Adult	NC	NC	NC	1.0	NC	NC	NC	14
Young child	NC	NC	NC	1.2	NC	NC	NC	17

NC = Not calculated

Table 43a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption from Standing Reaches (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			4	2	Based on raw data provided by Knuth et al. (1998)
Adult			16	1.7	95th (RME) and 50th (CTE) percentile values for consumption from lakes and ponds from Maine Angler Survey[2]
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA.
Adult			44	17	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			16,060	6,205	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005) except where noted. Volume and Table and/or Section numbers provided.

[1]Analysis of unpublished raw data from the Maine Angler Survey (Ebert et al., 1993) for fish consumed from standing waters (lakes and ponds) in Maine.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*

Knuth, B.A., N.A. Connelly, and B.E. Matthews. 1998. Children's Fishing and Fish Consumption Patterns. Cornell University Human Dimensions Research Unit. HDRU Series No. 98-3. May.

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 43b. Input Distributions Used to Develop the RMCs Using the Alternative MEE Model For Fish Consumption - Standing Reaches

Number of Anglers Modeled		50,000											
		Summary of Percentiles of Input Distributions											
Parameter	**Units**	**Min**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**Basis**
Ingestion Rate Distribution	g/d	0.014	0.3	0.5	0.89	1.3	1.7	2.5	3.3	5.5	9.7	92	Table 2, Exhibit H.1, AMEC and BBL (2003)
Exposure Frequency	d/yr	365											Based on use of annualized average consumption rates
Oral absorption factor	unitless	1.0											Default value
Cooking Method Preference													
Fry	unitless	0.48											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Bake	unitless	0.25											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Broil/Grill	unitless	0.18											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Poach/Boil/Soup	unitless	0.08											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Raw	unitless	0.009											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Cooking Loss Factor													
Fry	unitless	0.37											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Bake	unitless	0.13											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Broil/Grill	unitless	0.18											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Poach/Boil/Soup	unitless	0.12											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Raw	unitless	0											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Body Weight	kg	Age- and gender-specific distributions based on information provided in EPA's (1997) *Exposure Factors Handbook*											Tables 6 and 7, Exhibit H.1, AMEC and BBL (2003)
Exposure Duration	yr	Variable. Based on census data for age distribution of population in CT/MA (to determine probability of start age) and mortality/mobility data for Berkshire County (to detemine end age). Exposure durations ranged from 1 to 75 years.											Tables 1 and 8, Exhibit H.1, AMEC and BBL (2003)
Chronic RfD (Exposure >6yrs)	mg/kg-d	0.000018	0.000084	0.000123	0.000163	0.000205	0.000246	0.000307	0.000369	0.000465	0.000595	0.001786	Table 10, Exhibit H.1, AMEC and BBL (2003)
Subchronic RfD (Exposure <6yrs)	mg/kg-d	0.000038	0.000164	0.000239	0.000313	0.000386	0.000459	0.000563	0.000667	0.00082	0.001023	0.002587	Table 10, Exhibit H.1, AMEC and BBL (2003)
CSF	$(mg/kg\text{-}d)^{-1}$	0.4	0.42	0.44	0.46	0.48	0.5	0.78	1.06	1.27	1.42	2.2	Table 10, Exhibit H.1, AMEC and BBL (2003)
Averaging time													
Cancer	d	27,375 days. Based on an average lifetime of 75 years * 365 days/year											EPA (1997)
Noncancer	d	Variable. Based on duration modeled for each individual angler (years) * 365 days/year											EPA (1989)

AMEC and BBL 2003. Comments of the General Electric Company on the U.S. Environmental Protection Agency's Human Health Risk Assessment for the Housatonic River Site - Rest of River. Prepared by AMEC Earth and Environmental, Inc. and BBL Sciences, Inc. July 28.

EPA 1997. Exposure Factors Handbook. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. EPA/600/P-95/002Fa. Washington, D.C.

EPA 1989. Risk Assessment Guidance for Superfund; Volume I: Human Health Evaluation Manual (Part A) – Interim Final. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89-002. July.

Table 43c. Alternative Deterministic RMCs for PCBs (mg/kg) in Fish Tissue from Standing Reaches
Fish Consumption (Alternative Assumptions)

Parameter	Alternative RME Approach			Alternative CTE Approach		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	16,060	16,060	16,060	6,205	6,205	6,205
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	4	4	4	2	2	2
Adult	16	16	16	1.7	1.7	1.7
Fraction attributable to site (unitless)	1.00	1.00	1.00	0.5	0.5	0.5
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure - carcinogenic (days)$^{-}$	1.2E-04	1.2E-04	1.2E-04	6.5E-06	6.5E-06	6.5E-06
Exposure - noncarcinogenic (days)$^{-1}$ - Child	2.0E-04	2.0E-04	2.0E-04	5.0E-05	5.0E-05	5.0E-05
Exposure - noncarcinogenic (days)$^{-1}$ - Adult	1.71E-04	1.71E-04	1.71E-04	9.11E-06	9.11E-06	9.11E-06
CARCINOGENIC	**Alternative RME Approach**			**Alternative CTE Approach**		
Total Exposure, fish ingestion (days)$^{-1}$	1.2E-04	1.2E-04	1.2E-04	6.5E-06	6.5E-06	6.5E-06
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.40**	**0.040**	**0.0040**	**15**	**1.5**	**0.15**
CARCINOGENIC	**Child 1-6 years**			**Child 1-6 years**		
Total Exposure, fish ingestion (days)$^{-1}$	2.0E-04			5.0E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**1.0**			**4**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, fish ingestion (days)$^{-1}$	1.7E-04			9.1E-06		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**1.2**			**22**		

Table 43d. Alternative Probabilistic RMCs for PCBs (mg/kg) in Fish Tissue from Standing Reaches Fish Consumption (Alternative Assumptions)

Percentile of Output Distribution*	Concentration (mg/kg) per Cancer Risk Level		
	1E-04	1E-05	1E-06
RME (5th percentile)	1.8	0.18	0.018
CTE (50th percentile)	32	3.2	0.32

Percentile of Output Distribution*	Concentration (mg/kg) at Hazard Quotient of 1 - Child
RME (5th percentile)	1.2
CTE (50th percentile)	17

Percentile of Output Distribution*	Concentration (mg/kg) at Hazard Quotient of 1 - Adult
RME (5th percentile)	1.0
CTE (50th percentile)	14

*For this analysis, the 5th percentile PCB concentration is protective of 95 percent of the exposed population.

Attachment 44
Risk-based Media Concentrations for PCBs in
Fish Tissue Obtained from Flowing Reaches of the Housatonic River
Fish Consumption Scenario (Alternative Assumptions)

A range of alternative Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for exposure, via human consumption, to PCBs in the edible tissue of fish obtained from flowing reaches of the Housatonic River in Massachusetts and Connecticut. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. Alternative RMCs have been developed using both a deterministic approach and a probabilistic Microexposure Event (MEE) model. For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

The RMCs for the non-cancer endpoint (RMC_{nc}) for this scenario have been calculated using the following equation. Non-cancer RMCs have been calculated separately for young children and adults.

Young Child

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_a * ED_a}{BW_a}}$$

In the above equations:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
RMC_{nc}	=	RMC based on the non-cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
HI	=	Target hazard index (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)

ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Fish ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Fish ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
RfD	=	Reference dose (mg/kg-day)

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 44a. With the exception of the fish consumption rates, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.2.1.1, fish consumption rates for adults were based on an analysis of data collected in the Maine angler survey (Ebert et al., 1993) for anglers who reported that they consumed fish from rivers and streams. The RME adult consumption rate of 12 g/day is the 95^{th} percentile of that distribution of consumption rates, and the CTE adult consumption rate of 1.0 g/day is the 50^{th} percentile value from the distribution. The child consumption rates are based on AMEC's analysis of the raw data provided by Knuth et al. (1998) for children aged 8 to 14 years (see Section 3.2.1.1). The RME rate of 4 g/day is based on the 95^{th} percentile of the distribution and the CTE rate of 2 g/day is based on the arithmetic mean of that distribution.

For the MEE analysis, the input distributions were those used in the alternative MEE model developed by AMEC and presented as Exhibit H.1 in GE's 2003 comments on the draft HHRA (AMEC and BBL, 2003). Summary descriptions of these distributions are provided in Table 44b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer hazard index of 1 (evaluating adults and children separately).

Standard EPA cancer slope factors (CSF) have been used to develop the deterministic RMCs for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are consistent with the values published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overestimate the carcinogenic potential of PCBs in humans.

For the probabilistic analysis, as noted in Section 3.2.1.5 of this proposal, a range of cancer-based RMCs for PCBs was developed using the version of the MEE model that includes a distribution of CSFs to reflect the uncertainty surrounding these estimates. This distribution is presented in Table 43b and discussed in Exhibit H.2 in GE's 2003 comments (AMEC and BBL, 2003).

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, for the

deterministic analysis, a chronic RfD of 2E-04 mg/kg-day was used to develop RMCs based on the non-cancer endpoint.

For the MEE analysis, as noted in Section 3.2.1.5, a distribution of RfDs was used to evaluate the uncertainty surrounding the RfD. A summary of the distribution is provided in Table 44b and it is described in Exhibit H.2 in GE's 2003 comments (AMEC and BBL, 2003).

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. Deterministic RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

For the probabilistic analysis, the same cancer risk range and non-cancer Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution values exceed the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints based on the deterministic analysis are presented in Table 44c. A summary of the distribution of the RME and CTE RMCs calculated using the MEE model is provided in Table 44d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (mg/kg)				**CTE (mgkg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-}$**	**HI = 1**
Deterministic Analysis								
Young child/Adult	0.0051	0.051	0.51	NC	0.18	1.8	18	NC
Adult	NC	NC	NC	1.6	NC	NC	NC	37
Young child	NC	NC	NC	1.0	NC	NC	NC	4
MEE Analysis								
Young child/Adult	0.021	0.21	2.1	NC	0.55	5.5	55	NC
Adult	NC	NC	NC	1.2	NC	NC	NC	25
Young child	NC	NC	NC	1.5	NC	NC	NC	25

NC = Not calculated

Table 44a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption from Flowing Reaches (Alternative Approach)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			4	2	Based on raw data provided by Knuth et al. (1998).
Adult			12	1.0	95th (RME) and 50th (CTE) percentile values for consumption from rivers and streams (Ebert et al., 1993)
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.3. EPA's evaluation based on multiple studies.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA.
Adult			44	17	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			16,060	6,205	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005) except where noted. Volume and Table and/or Section numbers provided.

Knuth, B.A., N.A. Connelly, and B.E. Matthews. 1998. *Children's Fishing and Fish Consumption Patterns.* Cornell University Human Dimensions Research Unit. HDRU Series No. 98-3. May.

Ebert, E.S., N.W. Harrington, K.J. Boyle, J.W. Knight, and R.E. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers. *N. Am. J. Fish. Mgt.* 13:737-745.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 44b. Input Distributions Used to Develop the RMCs Using the MEE Model For Fish Consumption - Flowing Reaches (Alternative Approach)

Number of Anglers Modeled		50,000											
		Summary of Percentiles of Input Distributions											
Parameter	**Units**	**Min**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**Basis**
Ingestion Rate Distribution	g/d	0.023	0.18	0.32	0.54	0.73	1	1.5	2.1	3.6	6.1	118	Table 2, Exhibit H.1, AMEC and BBL (2003)
Exposure Frequency	d/yr	365											Based on use of annualized daily consumption rate
Oral absorption factor	unitless	1.0											Default assumption
Cooking Method Preference													
Fry	unitless	0.48											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Bake	unitless	0.25											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Broil/Grill	unitless	0.18											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Poach/Boil/Soup	unitless	0.08											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Raw	unitless	0.009											Point estimate based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Cooking Loss Factor													
Fry	unitless	0.37											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Bake	unitless	0.13											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Broil/Grill	unitless	0.18											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Poach/Boil/Soup	unitless	0.12											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Raw	unitless	0											Point estimate based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Body Weight	kg	Age- and gender-specific distributions based on information provided in EPA's (1997) *Exposure Factors Handbook*											Tables 6 and 7, Exhibit H.1, AMEC and BBL (2003)
Exposure Duration	yr	Variable. Based on census data for age distribution of population in CT/MA (to determine probability of start age) and mortality/mobility data for Berkshire County (to detemine end age). Exposure durations ranged from 1 to 75 years.											Tables 1 and 8, Exhibit H.1, AMEC and BBL (2003)
Chronic RfD (Exposure >6yrs)	mg/kg-d	0.000018	0.000084	0.000123	0.000163	0.000205	0.000246	0.000307	0.000369	0.000465	0.000595	0.001786	Table 10, Exhibit H.1, AMEC and BBL (2003)
Subchronic RfD (Exposure <6yrs)	mg/kg-d	0.000038	0.000164	0.000239	0.000313	0.000386	0.000459	0.000563	0.000667	0.00082	0.001023	0.002587	Table 10, Exhibit H.1, AMEC and BBL (2003)
CSF	$(mg/kg\text{-}d)^{-1}$	0.4	0.42	0.44	0.46	0.48	0.5	0.78	1.06	1.27	1.42	2.2	Table 10, Exhibit H.1, AMEC and BBL (2003)
Averaging time													
Cancer	d	27,375 days. Based on an average lifetime of 75 years * 365 days/year											EPA (1997)
Noncancer	d	Variable. Based on duration modeled for each individual angler (years) * 365 days/year											EPA (1989)

AMEC and BBL 2003. Comments of the General Electric Company on the U.S. Environmental Protection Agency's Human Health Risk Assessment for the Housatonic River Site - Rest of River. Prepared by AMEC Earth and Environmental, Inc. and BBL Sciences, Inc. July 28.

EPA 1997. Exposure Factors Handbook. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. EPA/600/P-95/002Fa. Washington, D.C.

EPA 1989. Risk Assessment Guidance for Superfund; Volume I: Human Health Evaluation Manual (Part A) – Interim Final. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89-002. July.

Table 44c. Alternative Deterministic RMCs for PCBs (mg/kg) in Fish Tissue from Flowing Reaches
Fish Consumption (Alternative Approach)

Parameter	Alternative RME Approach			Alternative CTE Approach		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	16,060	16,060	16,060	6,205	6,205	6,205
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	4	4	4	2	2	2
Adult	12	12	12	1	1	1
Fraction attributable to site	1.00	1.00	1.00	0.5	0.5	0.5
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic (days)$^{-1}$	9.8E-05	9.8E-05	9.8E-05	5.6E-06	5.6E-06	5.6E-06
Exposure - noncarcinogenic (days)$^{-1}$ - Child	2.0E-04	2.0E-04	2.0E-04	5.0E-05	5.0E-05	5.0E-05
Exposure - noncarcinogenic (days)$^{-1}$ - Adult	1.29E-04	1.29E-04	1.29E-04	5.36E-06	5.36E-06	5.36E-06
CARCINOGENIC	**Alternative RME Approach**			**Alternative CTE Approach**		
Total Exposure, fish ingestion (days)$^{-1}$	9.8E-05	9.8E-05	9.8E-05	5.6E-06	5.6E-06	5.6E-06
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.51**	**0.051**	**0.0051**	**18**	**1.8**	**0.18**
NONCARCINOGENIC	**Child 1-6 years**			**Child 1-6 years**		
Total Exposure, fish ingestion (days)$^{-1}$	2.0E-04			5.0E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**1.0**			**4**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, fish ingestion (days)$^{-1}$	1.3E-04			5.4E-06		
Reference Dose (RfD) (mg/kg-day)	2.00E-04			2.00E-04		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**1.6**			**37**		

Table 44d. Alternative Probabilistic RMCs for PCBs (mg/kg) in Fish Tissue from Flowing Reaches Fish Consumption - (Alternative Approach)

Percentile of Output Distribution*	Concentration (mg/kg) per Cancer Risk Level		
	1E-04	1E-05	1E-06
RME (5th percentile)	2.1	0.21	0.021
CTE (50th percentile)	55	5.5	0.55

Percentile of Output Distribution*	Concentration (mg/kg) at Hazard Quotient of 1 - Child
RME (5th percentile)	1.5
CTE (50th percentile)	25

Percentile of Output Distribution*	Concentration (mg/kg) at Hazard Quotient of 1 - Adult
RME (5th percentile)	1.2
CTE (50th percentile)	25

*For this analysis, the 5th percentile PCB concentration is protective of 95 percent of the exposed population.

Attachment 45
Risk-based Media Concentrations for PCBs in
Waterfowl Tissue Obtained from the Housatonic River
Waterfowl Consumption Scenario (Alternative Assumptions)

A range of alternative Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for exposure, via human consumption, to PCBs in the edible tissue of waterfowl obtained from the Housatonic River study area. Consistent with the approach used in EPA's HHRA, potential waterfowl consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. Alternative RMCs have been developed for this scenario using only a deterministic approach. These RMCs have been developed for each set of exposure conditions and have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using scientifically supportable exposure assumptions and toxicity values.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

The RMCs for the non-cancer endpoint (RMC_{nc}) for this scenario have been calculated using the following equation. Non-cancer RMCs have been calculated separately for young children and adults.

Young Child

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * ABS_o * (1 - LOSS) * \frac{IR_a * ED_a}{BW_a}}$$

In the above equations:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
RMC_{nc}	=	RMC based on the non-cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
HI	=	Target hazard index (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Ingestion rate for adults (g/day)

ED_c = Exposure duration for children aged 1-6 years (years)
ED_a = Exposure duration for adults (years)
BW_c = Body weight for children aged 1-6 years (kg)
BW_a = Body weight for adults (kg)
CSF = Cancer slope factor $(mg/kg\text{-}day)^{-1}$
RfD = Reference dose (mg/kg-day)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 45a. With the exception of the fraction of resident waterfowl and the cooking loss factor, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

For this analysis, it is assumed that 40 percent of the waterfowl consumed from the study area are resident ducks. The basis for this estimate is discussed in Section 3.2.1.2. This fraction has been applied to both RME and CTE scenarios.

As discussed in Section 3.2.1.4 of this proposal, a cooking loss factor of 30 percent has been used in both the RME and CTE analyses. This factor accounts for the fraction of PCBs that are lost during the cooking process.

Standard EPA cancer slope factors (CSF) have been used to develop the deterministic RMCs for PCBs. These include a CSF of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario. These CSFs are consistent with the values published in EPA's IRIS database and were used in EPA's HHRA. They have been used here as a conservative measure even though GE believes that they overstated the carcinogenic potential of PCBs in humans.

As discussed in Section 3.1.1.4 of this proposal, GE believes that a careful evaluation of the toxicological data upon which the Reference Dose (RfD) for PCBs is based indicates that the RfD of 2E-05 mg/kg-day, which is published in EPA's IRIS database and used in EPA's HHRA, overestimates the non-cancer toxic potential of PCBs by at least a factor of 10. Thus, a chronic RfD of 2E-04 mg/kg-day was used to develop RMCs based on the non-cancer endpoint.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

Summary of Results

Estimated alternative RMCs for cancer and non-cancer endpoints based on this deterministic analysis are presented in Table 45c. These RMCs are summarized in the following table.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Young child/Adult	0.030	0.30	3.0	NC	0.24	2.4	24	NC
Adult	NC	NC	NC	10	NC	NC	NC	21
Young child	NC	NC	NC	4.3	NC	NC	NC	8.9

NC = Not calculated

Table 45a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Waterfowl Consumption Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-38 and 4-40.
Ingestion rate	g/day	IR			
Young child			2.5	1.2	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Calculated by EPA based on one-half adult rate.
Adult			5	2.4	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Meal size based on poultry meal sizes from Pao et al. 1982; meal frequency based on 90th percentile from MDPH 2001 survey.
Fraction ingested from site	unitless	FI	0.4	0.4	40 percent of birds harvested are likely to be resident birds based on MDFW data.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-38 and 4-40. Waterfowl consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.3	0.3	Based on lowest PCB loss in turkey and chicken reported by Zabik 1974 and 1990.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-39 and 4-40. Ages 1 to 6 years. Calculated by EPA based on EPA 1989.
Adult			44	17	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.5. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-38; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IV. Table 4-40; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			16,060	6,205	HHRA, Vol. IV. Table 4-40; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005) except where noted. Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Pao, E., K. Fleming, P. Guenther, S. Mickle. 1982. *Foods Commonly Esten by Individuals: Amount Per Day and Per Eating Occasion.* Consumer Nutrition Center, Human Nutrition Information Service, U.S. Department of Agriculture. Hyattsville, MD. Home Economics Reserach Report Number 44.

Zabik, M.E. 1974. Polychlorinated biphenyl levels in raw and cooked chicken and chicken broth. *Poultry Science* 53:1785-1790.

Zabik, M.E. 1990. Effect of roasting, hot-holding or microwave heating on polychlorinated biphenyl levels in turkey. *School Food Ser. Res. Review* 14:98-102.

Table 45b. Deterministic RMCs for PCBs (mg/kg) in Waterfowl Tissue
Waterfowl Consumption Scenario (Alternative Assumptions)

Parameter	Alternative RME Approach			Alternative CTE Approach		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	16,060	16,060	16,060	6,205	6,205	6,205
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	2.5	2.5	2.5	1.2	1.2	1.2
Adult	5	5	5	2.4	2.4	2.4
Fraction attributable to site	0.4	0.4	0.4	0.4	0.4	0.4
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.30	0.30	0.30	0.30	0.30	0.30
Conversion factor, waterfowl ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic $(days)^{-1}$	1.7E-05	1.7E-05	1.7E-05	4.3E-06	4.3E-06	4.3E-06
Exposure - noncarcinogenic $(days)^{-1}$ - Child	4.7E-05	4.7E-05	4.7E-05	2.2E-05	2.2E-05	2.2E-05
Exposure - noncarcinogenic $(days)^{-1}$ - Adult	2.00E-05	2.00E-05	2.00E-05	9.60E-06	9.60E-06	9.60E-06
CARCINOGENIC	**Alternative RME Approach**			**Alternative CTE Approach**		
Total Exposure, waterfowl ingestion $(days)^{-1}$	1.7E-05	1.7E-05	1.7E-05	4.3E-06	4.3E-06	4.3E-06
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**3.0**	**0.30**	**0.030**	**24**	**2.4**	**0.24**

NONCARCINOGENIC	**Child 1-6 years**	**Child 1-6 years**
Total Exposure, waterfowl ingestion $(days)^{-1}$	4.7E-05	2.2E-05
Reference Dose (RfD) (mg/kg-day)	2.00E-04	2.00E-04
Target Hazard Index	1	1
Risk-based Media Concentration (mg/kg)	**4.3**	**8.9**

NONCARCINOGENIC	**Adult**	**Adult**
Total Exposure, waterfowl ingestion $(days)^{-1}$	2.0E-05	9.6E-06
Reference Dose (RfD) (mg/kg-day)	2.00E-04	2.00E-04
Target Hazard Index	1	1
Risk-based Media Concentration (mg/kg)	**10**	**21**

Attachment 46
Risk-based Media Concentrations for TEQs in
Fish Tissue Obtained from Standing Reaches of the Housatonic River
Fish Consumption Scenario (Alternative Assumptions)

A range of alternative Risk-based Media Concentrations (RMCs) has been developed for dioxin toxicity equivalency quotients (TEQs) based on potential for exposure, via human consumption, to TEQs in the edible tissue of fish obtained from standing reaches of the Housatonic River in Massachusetts and Connecticut. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. Alternative RMCs have been developed using both a deterministic approach and a probabilistic Microexposure Event (MEE) model. For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks, for children and adults combined, using scientifically supportable exposure assumptions and toxicity values. Consistent with the HHRA, since EPA has not developed a non-cancer reference dose for dioxin TEQs, RMCs based on non-cancer impacts have not been developed for TEQs.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for the carcinogenic exposure (days)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_p	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$

The specific exposure assumptions used for each age group, and the basis of each, are summarized in Table 46a. With the exception of the fish consumption rates, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.2.1.1, fish consumption rates for adults were based on an analysis of raw data collected in the Maine angler survey (Ebert et al., 1993) for anglers who reported that they consumed fish from lakes and ponds. The RME adult consumption rate of 16 g/day is the 95th percentile of that distribution of consumption rates, and the CTE adult consumption rate of 1.7 g/day is the 50th percentile value from the distribution. The child consumption rates are based on AMEC's analysis of the raw data provided by Knuth et al. (1998) for children aged 8 to 14 years (see Section 3.2.1.1). The RME rate of 4 g/day is based on the 95th percentile of the distribution and the CTE rate of 2 g/day is based on the arithmetic mean of that distribution.

For the MEE analysis, the distributions of exposure inputs were those used in the alternative MEE model developed by AMEC and presented as Exhibit H.1 in GE's 2003 comments on the draft HHRA (AMEC and BBL, 2003). Summary descriptions of these distributions are provided in Table 46b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer hazard index of 1 (evaluating adults and children separately).

Currently EPA's IRIS database does not publish a cancer slope factor (CSF) for dioxin. Consistent with the approach used in the HHRA, a CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of 150,000 (mg/kg-day)$^{-1}$, which was the CSF published in EPA's 1997 *Health Effects Assessment Summary Tables*, has been used to calculate the RMCs for dioxin TEQs in both the deterministic and probabilistic analyses.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1x10^{-6}) to one-in-ten-thousand (1x10^{-4}). This risk range is consistent with EPA's acceptable risk range.

For the MEE analysis, the same cancer risk range and non0cancer Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution exceeds the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated alternative TEQ RMCs (ng/kg) for cancer endpoints based on the deterministic analysis are presented in Table 46c. A summary of the RME and CTE RMCs calculated using the MEE model is provided in Table 46d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (ng/kg)			**CTE (ng/kg)**		
	Cancer Risk			**Cancer Risk**		
Deterministic	**1x10^{-6}**	**1x10^{-5}**	**1x10^{-4}**	**1x10^{-6}**	**1x10^{-5}**	**1x10^{-4}**
Young child/Adult	0.053	0.53	5.3	1.0	10	103
MEE Analysis						
Young child/Adult	0.12	1.2	12	1.6	16	160

Table 46a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Fish Consumption Scenario for Standing Waters (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			4	2	Based on analysis of raw data provided by Knuth et al. (1998)
Adult			16	1.7	95th (RME) and 50th (CTE) percentile values for consumption from lakes and ponds from Maine Angler Survey[1]
Fraction ingested from site	unitless	FI	1	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol. IV; Tables 4-8 and 4-10.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA.
Adult			44	17	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005), except where noted. Volume and Table and/or Section numbers provided.

[1]Analysis of unpublished raw data from the Maine angler survey (Ebert et al., 1993) for fish consumed from standing waters (lakes and ponds) in Maine.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers. *North American Journal of Fisheries Management* 13:737-745.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*

Knuth, B.A., N.A. Connelly, and B.E. Matthews. 1998. *Children's Fishing and Fish Consumption Patterns.* Cornell University Human Dimensions Research Unit. HDRU Series No. 98-3. May.

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 46b. Input Distributions Used to Develop the RMCs for TEQ Using the MEE Model For Fish Consumption - Standing Reaches (Alternative Assumptions)

Number of Anglers Modeled		50,000											
		Summary of Percentiles of Input Distributions											
Parameter	**Units**	**Min**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**Basis**
Consumption Rate Distribution	g/d	0.014	0.3	0.5	0.89	1.3	1.7	2.5	3.3	5.5	9.7	92	Table 2, Exhibit H.1, AMEC and BBL (2003)
Exposure Frequency	d/yr	365											Based on use of annualized daily consumption rates
Oral absorption factor	unitless	1.0											Default value
Cooking Method Preference													
Fry	unitless	0.48											Point estimates based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Bake	unitless	0.25											
Broil/Grill	unitless	0.18											
Poach/Boil/Soup	unitless	0.08											
Raw	unitless	0.009											
Cooking Loss Factor													
Fry	unitless	0.37											Point estimates based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Bake	unitless	0.13											
Broil/Grill	unitless	0.18											
Poach/Boil/Soup	unitless	0.12											
Raw	unitless	0											
Body Weight	kg	Age- and gender-specific distributions based on information provided in EPA's (1997) *Exposure Factors Handbook*											Tables 6 and 7, Exhibit H.1, AMEC and BBL (2003)
Exposure Duration	yr	Variable. Based on census data for age distribution of population in CT/MA (to determine probability of start age) and mortality/mobility data for Berkshire County (to detemine end age). Exposure durations ranged from 1 to 75 years.											Tables 1 and 8, Exhibit H.1, AMEC and BBL (2003)
Chronic RfD (Exposure >6yrs)	mg/kg-d	0.000018	0.000084	0.000123	0.000163	0.000205	0.000246	0.000307	0.000369	0.000465	0.000595	0.001786	Table 10, Exhibit H.1, AMEC and BBL (2003)
Subchronic RfD (Exposure <u>≤6yrs</u>)	mg/kg-d	0.000038	0.000164	0.000239	0.000313	0.000386	0.000459	0.000563	0.000667	0.00082	0.001023	0.002587	Table 10, Exhibit H.1, AMEC and BBL (2003)
CSF	$(mg/kg\text{-}d)^{-1}$	0.4	0.42	0.44	0.46	0.48	0.5	0.78	1.06	1.27	1.42	2.2	Table 10, Exhibit H.1, AMEC and BBL (2003)
Averaging time	d	27,375 days. Based on an average lifetime of 75 years * 365 days/year											EPA (1997)

AMEC and BBL 2003. Comments of the General Electric Company on the U.S. Environmental Protection Agency's Human Health Risk Assessment for the Housatonic River Site - Rest of River. Prepared by AMEC Earth and Environmental, Inc. and BBL Sciences, Inc. J

EPA 1997. Exposure Factors Handbook. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. EPA/600/P-95/002Fa. Washington, D.C.

Table 46c. Deterministic RMCs for TEQ (ng/kg) in Fish Tissue from Standing Reaches
Fish Consumption Scenario (Alternative Assumptions)

Parameter	Alternative RME Approach			Alternative CTE Approach		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	4	4	4	2	2	2
Adult	16	16	16	1.7	1.7	1.7
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure-carcinogenic (days)$^{-1}$	1.2E-04	1.2E-04	1.2E-04	6.5E-06	6.5E-06	6.5E-06
CARCINOGENIC	**Alternative RME Approach**			**Alternative CTE Approach**		
Total Exposure, fish ingestion (days)$^{-1}$	1.2E-04	1.2E-04	1.2E-04	6.5E-06	6.5E-06	6.5E-06
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	150,000	150,000	150,000	150,000	150,000	150,000
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Unit conversion factor (ng/mg)	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
Risk-based Media Concentration (ng/kg)	**5.3**	**0.53**	**0.053**	**103**	**10**	**1.0**

Table 46d. Alternative Probabilistic RMCs for TEQs (ng/kg) in Fish Tissue from Standing Reaches Fish Consumption (Alternative Assumptions)*

	Cancer-Based		
Percentile of Output Distribution*	**1E-06**	**1E-05**	**1E-04**
RME (5th percentile)	0.12	1.2	12
CTE (50th percentile)	1.6	16	160

*Alternative analysis for TEQ is identical to the MEE analysis for PCBs with the exception of the use of a deterministic cancer slope factor
**For this analysis, the 5th percentile PCB concentration is protective of 95 percent of the exposed population.

Attachment 47
Risk-based Media Concentrations for TEQs in
Fish Tissue Obtained from Flowing Reaches of the Housatonic River
Fish Consumption Scenario (Alternative Assumptions)

A range of alternative Risk-based Media Concentrations (RMCs) has been developed for dioxin toxicity equivalency quotients (TEQs) based on potential for exposure, via human consumption, to TEQs in the edible tissue of fish obtained from flowing reaches of the Housatonic River in Massachusetts and Connecticut. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. Alternative RMCs have been developed using both a deterministic approach and a probabilistic Microexposure Event (MEE) model. For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks, for children and adults combined, using scientifically supportable exposure assumptions and toxicity values. Consistent with the HHRA, since EPA has not developed a non-cancer reference dose for dioxin TEQs, RMCs based on non-cancer impacts have not been developed for TEQs.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for the carcinogenic exposure (days)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IRF_c	=	Fish ingestion rate for children aged 1-6 years (g/day)
IRF_a	=	Fish ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$

The specific exposure assumptions used for each age group, and the basis of each, are summarized in Table 47a. With the exception of the fish consumption rates, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

As discussed in Section 3.2.1.1, fish consumption rates for adults were based on an analysis of data collected in the Maine angler survey (Ebert et al., 1993) for anglers who reported that they consumed fish from rivers and streams. The RME adult consumption rate of 12 g/day is the 95th percentile of that distribution of consumption rates, and the CTE adult consumption rate of 1.0 g/day is the 50th percentile value from the distribution. The child consumption rates are based on AMEC's analysis of the raw data provided by Knuth et al. (1998) for children aged 8 to 14 years (see Section 3.2.1.1). The RME rate of 4 g/day is based on the 95th percentile of the distribution and the CTE rate of 2 g/day is based on the arithmetic mean of that distribution.

For the MEE analysis, the distributions of exposure inputs were those used in the alternative MEE model developed by AMEC and presented as Exhibit H.1 in GE's 2003 comments on the draft HHRA (AMEC and BBL, 2003). Summary descriptions of these distributions are provided in Table 47b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer hazard index of 1 (evaluating adults and children separately).

Currently EPA's IRIS database does not publish a cancer slope factor (CSF) for dioxin. Consistent with the approach used in the HHRA, a CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of 150,000 (mg/kg-day)$^{-1}$, which was the CSF published in EPA's 1997 *Health Effects Assessment Summary Tables*, has been used to calculate the RMCs for dioxin TEQs in both the deterministic and probabilistic analyses.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1x10^{-6}) to one-in-ten-thousand (1x10^{-4}). This risk range is consistent with EPA's acceptable risk range.

For the MEE analysis, the same cancer risk range and non-cancer Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution exceeds the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated alternative TEQ RMCs (ng/kg) for cancer endpoints based on the deterministic analysis are presented in Table 47c. A summary of the RME and CTE RMCs calculated using the MEE model is provided in Table 47d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (ng/kg)			**CTE (ng/kg)**		
	Cancer Risk			**Cancer Risk**		
Deterministic	**1x10^{-6}**	**1x10^{-5}**	**1x10^{-4}**	**1x10^{-6}**	**1x10^{-5}**	**1x10^{-4}**
Young child/Adult	0.062	0.62	6.2	1.4	14	142
MEE Analysis						
Young child/Adult	0.13	1.3	13	2.7	27	267

Table 47a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption from Flowing Reaches (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			4	2	Based on analysis of raw data provided by Knuth et al. (1998)
Adult			12	1.0	95th (RME) and 50th (CTE) percentile values for consumption from rivers and streams (Ebert et al., 1993)
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA.
Adult			44	17	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005) except where noted. Volume and Table and/or Section numbers provided.

Ebert, E.S., N.W. Harrington, K.J. Boyle, J.W. Knight, and R.E. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers. *N. Am. J. Fish. Mgt.* 13:737-745.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

Knuth, B.A., N.A. Connelly, and B.E. Matthews. 1998. *Children's Fishing and Fish Consumption Patterns.* Cornell University Human Dimensions Research Unit. HDRU Series No. 98-3. May.

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 47b. Input Distributions Used to Develop the RMCs Using the MEE Model For Fish Consumption - Flowing Reaches (Alternative Assumptions)

Number of Anglers Modeled		50,000											
		Summary of Percentiles of Input Distributions											
Parameter	**Units**	**Min**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**Basis**
Consumption Rate Distribution	g/d	0.023	0.18	0.32	0.54	0.73	1	1.5	2.1	3.6	6.1	118	Table 2, Exhibit H.1, AMEC and BBL (2003)
Exposure Frequency	d/yr	365											Based on use of annualized daily consumption rates
Oral absorption factor	unitless	1.0											
Cooking Method Preference													Point estimates based on values for bass, Table 3, Exhibit H.1, AMEC and BBL (2003)
Fry	unitless	0.48											
Bake	unitless	0.25											
Broil/Grill	unitless	0.18											
Poach/Boil/Soup	unitless	0.08											
Raw	unitless	0.009											
Cooking Loss Factor													Point estimates based on values for bass, Table 5, Exhibit H.1, AMEC and BBL (2003)
Fry	unitless	0.37											
Bake	unitless	0.13											
Broil/Grill	unitless	0.18											
Poach/Boil/Soup	unitless	0.12											
Raw	unitless	0											
Body Weight	kg	Age- and gender-specific distributions based on information provided in EPA's (1997) *Exposure Factors Handbook*											Tables 6 and 7, Exhibit H.1, AMEC and BBL (2003)
Exposure Duration	yr	Variable. Based on census data for age distribution of population in CT/MA (to determine probability of start age) and mortality/mobility data for Berkshire County (to detemine end age). Exposure durations ranged from 1 to 75 years.											Tables 1 and 8, Exhibit H.1, AMEC and BBL (2003)
Chronic RfD (Exposure >6yrs)	mg/kg-d	0.000018	0.000084	0.000123	0.000163	0.000205	0.000246	0.000307	0.000369	0.000465	0.000595	0.001786	Table 10, Exhibit H.1, AMEC and BBL (2003)
Subchronic RfD (Exposure <6yrs)	mg/kg-d	0.000038	0.000164	0.000239	0.000313	0.000386	0.000459	0.000563	0.000667	0.00082	0.001023	0.002587	Table 10, Exhibit H.1, AMEC and BBL (2003)
CSF	$(mg/kg\text{-}d)^{-1}$	0.4	0.42	0.44	0.46	0.48	0.5	0.78	1.06	1.27	1.42	2.2	Table 10, Exhibit H.1, AMEC and BBL (2003)
Averaging time	d	27,375 days. Based on an average lifetime of 75 years * 365 days/year											EPA (1997)

AMEC and BBL 2003. Comments of the General Electric Company on the U.S. Environmental Protection Agency's Human Health Risk Assessment for the Housatonic River Site - Rest of River. Prepared by AMEC Earth and Environmental, Inc. and BBL Sciences, Inc. July 28.

EPA 1997. Exposure Factors Handbook. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. EPA/600/P-95/002Fa. Washington, D.C.

EPA 1989. Risk Assessment Guidance for Superfund; Volume I: Human Health Evaluation Manual (Part A) – Interim Final. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89-002. July.

Table 47c. Deterministic RMCs for TEQ (ng/kg) in Fish Tissue from Flowing Reaches
Fish Consumption Scenario (Alternative Assumptions)

Parameter	Alternative RME Approach			Alternative CTE Approach		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	4	4	4	2	2	2
Adult	12	12	12	1	1	1
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.18	0.18	0.18	0.37	0.37	0.37
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure - carcinogenic $(days)^{-1}$	1.1E-04	1.1E-04	1.1E-04	4.7E-06	4.7E-06	4.7E-06
CARCINOGENIC	**Alternative RME Approach**			**Alternative CTE Approach**		
Total Exposure, fish ingestion $(days)^{-1}$	1.1E-04	1.1E-04	1.1E-04	4.7E-06	4.7E-06	4.7E-06
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	150,000	150,000	150,000	150,000	150,000	150,000
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Unit conversion factor (ng/mg)	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
Risk-based Media Concentration (ng/kg)	**6.2**	**0.62**	**0.062**	**142**	**14**	**1.4**

Table 47d. Alternative Probabilistic RMCs for TEQs (ng/kg) in Fish Tissue from Flowing Reaches Fish Consumption (Alternative Assumptions)*

Percentile of Output Distribution**	Cancer-Based		
	1E-06	1E-05	1E-04
RME (5th percentile)	0.13	1.3	13
CTE (50th percentile)	2.7	27	267

*Alternative analysis for TEQ is identical to the MEE analysis for PCBs with the exception of the use of a deterministic cancer slope factor
**For this analysis, the 5th percentile PCB concentration is protective of 95 percent of the exposed population.

Attachment 48
Risk-based Media Concentrations for TEQs in
Waterfowl Tissue Obtained from the Housatonic River
Waterfowl Consumption Scenario (Alternative Assumptions)

A range of alternative Risk-based Media Concentrations (RMCs) has been developed for dioxin toxicity equivalency quotients (TEQs) based on potential for exposure, via human consumption, to TEQs in the edible tissue of waterfowl obtained from the Housatonic River study area. Consistent with the approach used in EPA's HHRA, potential waterfowl consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. Alternative RMCs have been developed for this scenario using only a deterministic approach. These RMCs have been developed for each set of exposure conditions and have been calculated based on potential cancer risks, for children and adults combined, using scientifically supportable exposure assumptions and toxicity values. Consistent with the HHRA, since EPA has not developed a non-cancer reference dose for dioxin TEQs, RMCs based on non-cancer impacts have not been developed for TEQs.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * ABS_o * (1 - LOSS) * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
ABS_o	=	Oral absorption factor (unitless)
LOSS	=	Cooking loss (unitless)
IR_c	=	Ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$

The specific exposure assumptions used for each age group, and the basis of each, are summarized in Table 48a. With the exception of the fraction of resident waterfowl and the cooking loss factor, the exposure assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

For this analysis, it is assumed that 40 percent of the waterfowl consumed from the study area are resident ducks. The basis for this estimate is discussed in Section 3.2.1.2. This fraction has been applied to both RME and CTE scenarios.

As discussed in Section 3.2.1.4 of this proposal, a cooking loss factor of 30 percent has been used in both the RME and CTE analyses. This factor accounts for the fraction of PCBs that are lost during the cooking process.

Currently EPA's IRIS database does not publish a cancer slope factor (CSF) for dioxin. Consistent with the approach used in the HHRA, a CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of 150,000 $(mg/kg\text{-}day)^{-1}$, which was the CSF published in EPA's 1997 *Health Effects Assessment Summary Tables*, has been used to calculate the RMCs for dioxin TEQs.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range.

Summary of Results

Estimated alternative RMCs for the cancer endpoint for TEQs in waterfowl tissue (ng/kg) are presented in Table 48c. These RMCs are summarized in the following table.

	RME (ng/kg)			**CTE (ng/kg)**		
	Cancer Risk			**Cancer Risk**		
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**
Young child/Adult	0.40	4.0	40	1.6	16	157

Table 48a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Waterfowl Consumption Scenario (Alternative Assumptions)

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-38 and 4-40.
Ingestion rate	g/day	IR			
Young child			2.5	1.2	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Calculated by EPA based on one-half adult rate.
Adult			5	2.4	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Meal size based on poultry meal sizes from Pao et al. 1982; meal frequency based on 90th percentile from MDPH 2001 survey.
Fraction ingested from site	unitless	FI	0.4	0.4	40 percent of birds harvested are likely to be resident birds based on MDFW data.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-38 and 4-40. Waterfowl consumption rates are average daily rates over 365 days.
Oral absorption factor	unitless	ABS_o	1	1	Conservative default.
Fraction PCBs lost during cooking	unitless	LOSS	0.3	0.3	Based on lowest PCB loss in turkey and chicken reported by Zabik 1974 and 1990.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-39 and 4-40. Ages 1 to 6 years. Calculated by EPA based on EPA 1989.
Adult			44	17	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.5. Based on MDPH 2001.
Body weight	kg/mg	BW			
Young child			15	15	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-38; based on EPA 1989. Lifetime of 70 years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005) except where noted. Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Pao, E., K. Fleming, P. Guenther, S. Mickle. 1982. *Foods Commonly Esten by Individuals: Amount Per Day and Per Eating Occasion.* Consumer Nutrition Center, Human Nutrition Information Service, U.S. Department of Agriculture. Hyattsville, MD. Home Economics Reserach Report Number 44.

Zabik, M.E. 1974. Polychlorinated biphenyl levels in raw and cooked chicken and chicken broth. *Poultry Science* 53:1785-1790.

Zabik, M.E. 1990. Effect of roasting, hot-holding or microwave heating on polychlorinated biphenyl levels in turkey. *School Food Ser. Res. Review* 14:98-102.

Table 48b. Deterministic RMCs for TEQ (ng/kg) in Waterfowl Tissue
Waterfowl Consumption Scenario (Alternative Assumptions)

Parameter	Alternative RME Approach			Alternative CTE Approach		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	2.5	2.5	2.5	1.2	1.2	1.2
Adult	5	5	5	2.4	2.4	2.4
Fraction attributable to site (unitless)	0.4	0.4	0.4	0.4	0.4	0.4
Oral absorption factor (unitless)	1	1	1	1	1	1
Cooking loss (unitless)	0.3	0.3	0.3	0.3	0.3	0.3
Conversion factor, waterfowl ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure - carcinogenic $(days)^{-1}$	1.7E-05	1.7E-05	1.7E-05	4.3E-06	4.3E-06	4.3E-06
CARCINOGENIC	**Alternative RME Approach**			**Alternative CTE Approach**		
Total Exposure, waterfowl ingestion $(days)^{-1}$	1.7E-05	1.7E-05	1.7E-05	4.3E-06	4.3E-06	4.3E-06
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	150,000	150,000	150,000	150,000	150,000	150,000
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Unit conversion factor (ng/mg)	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
Risk-based Media Concentration (ng/kg)	**40**	**4.0**	**0.40**	**157**	**16**	**1.6**