GE
159 Plastics Avenue
Pittsfield, MA 01201
USA

May 11, 2007

Ms. Susan Svirsky
U.S. Environmental Protection Agency
c/o Weston Solutions, Inc.
10 Lyman Street
Pittsfield, MA 01201

Re: GE-Pittsfield/Housatonic River Site
Rest of River (GECD850)
Corrective Measures Study Proposal – Supplement

Dear Ms. Svirsky:

As you know, the General Electric Company (GE) submitted its Corrective Measures Study (CMS) Proposal for the Rest of River to the U.S. Environmental Protection Agency (EPA) in February 2007. EPA's letter dated April 13, 2007 "conditionally approved" the CMS Proposal, subject to a number of conditions and directives; and it directed GE to submit, for EPA review and approval, a Supplement to the CMS Proposal addressing a number of those conditions and directives.

On April 27, 2007, GE invoked dispute resolution under Special Condition II.N.1 of the Reissued RCRA Corrective Action Permit with respect to certain conditions and directives in EPA's Conditional Approval Letter. That dispute directly involved one of the conditions that EPA required GE to address in the Supplement (General Condition 21). As a result, GE believes that its obligation to submit the Supplement is stayed under the Permit. Nevertheless, in the interest of moving forward with the CMS, GE is submitting the enclosed Supplement at the present time to address the conditions and directives that can be addressed at this time. As described in that Supplement, the remaining information that EPA required to be addressed in the Supplement (i.e., the information affected by GE's dispute) will be provided separately to EPA following resolution of GE's dispute.

EPA's April 13, 2007 letter also requested GE to develop and submit a work plan for a treatability study to further evaluate the chemical extraction of PCBs from removed sediments and soils. Since that time, GE has been researching the literature and contacting vendors to compile available information on chemical extraction. GE is preparing a Request for Proposal (RFP), and intends to solicit a number of vendors for additional technical information. That RFP will be distributed shortly. However, the vendors will need some time to prepare their responses; and after that, GE will need time to review the responses and subsequently select a vendor, as well as to carry out several other procurement-related tasks. Given the time needed to perform these activities, GE currently anticipates submitting the requested treatability study work plan to EPA before the end of June 2007.

Please let me know if you have any questions about the enclosed Supplement or would like to discuss any issues.

Very truly yours,

Andrew T. Silfer, P.E.
GE Project Coordinator

Enclosure

cc: Dean Tagliaferro, EPA
Timothy Conway, EPA
John Kilborn, EPA
Robert Cianciarulo, EPA
Holly Inglis, EPA
Rose Howell, EPA (cover letter and CD)
Richard McGrath, Sleeman Hanley & DiNitto
Scott Campbell, Weston Solutions
Joel Lindsay, Weston Solutions
Edward Garland, HydroQual
Michael Palermo, Mike Palermo Consulting
Susan Steenstrup, MDEP (2 copies)
Anna Symington, MDEP
Jane Rothchild, MDEP
Thomas Angus, MDEP
Dale Young, MA EOEA
Susan Peterson, CDEP
Michael Carroll, GE
Jane Gardner, GE
Roderic McLaren, GE
Kevin Mooney, GE
Stuart Messur, ARCADIS BBL
Mark Gravelding, ARCADIS BBL
James Rhea, QEA
Kevin Russell, QEA
James Bieke, Goodwin Procter
Samuel Gutter, Sidley Austin
Donna Voorhees, Menzie-Cura
John Lortie, Woodlot Alternatives
Gary Lawrence, EVS Environment
Mark Velleux, HydroQual
Public Information Repositories
GE Internal Repository

REPORT

Housatonic River - Rest of River Corrective Measures Study Proposal Supplement

General Electric Company
Pittsfield, Massachusetts

May 2007

QEA
Quantitative Environmental Analysis, LLC

ARCADIS BBL
Infrastructure, environment, facilities

Table of Contents

Tables

Figures

Appendix

1. Introduction

On February 27, 2007, the General Electric Company (GE) submitted to the United States Environmental Protection Agency (EPA) a Corrective Measures Study (CMS) Proposal for the Rest of River area of the GE Pittsfield/Housatonic River Site (ARCADIS BBL and QEA, 2007). The CMS Proposal was submitted pursuant to Special Condition II.E of a permit issued to GE by EPA on July 18, 2000 (the Permit) under the corrective action provisions of the federal Resource Conservation and Recovery Act (RCRA), as part of a comprehensive settlement embodied in the Consent Decree (CD) for the GE-Pittsfield/Housatonic River Site.

The CMS Proposal identified the corrective measures that GE proposes to study in the CMS, provided a justification for selecting those corrective measures, and presented GE's proposed methodology for evaluating those measures. In a letter dated April 13, 2007, EPA "conditionally approved" the CMS Proposal, subject to a number of conditions and directives (the Conditional Approval Letter). Among other requirements, EPA's letter directed GE to submit, for EPA review and approval, a Supplement to the CMS Proposal addressing 11 of EPA's comments on the CMS Proposal.

On April 27, 2007, GE invoked dispute resolution under Special Condition II.N.1 of the Permit with respect to certain conditions and directives in EPA's Conditional Approval Letter. That dispute directly involved one of the conditions that EPA required GE to address in the Supplement – namely, General Condition 21, which directed GE to revise the depths of sediment removal for several of the identified sediment remediation alternatives to be evaluated in the CMS, and to provide the revised depths in the Supplement, along with a revised Table 5-1 (which summarizes the sediment remediation alternatives). As a result of this dispute, GE believes that its obligation to submit the Supplement is stayed under the Permit. Nevertheless, in the interest of moving forward with the CMS, GE is submitting this Supplement at the present time to address the conditions and directives that can be addressed at this time. The remaining information that EPA required to be addressed in the Supplement – namely, revised removal depths for the sediment remediation alternatives (if applicable) and a revised Table 5-1 – will be provided separately to EPA within 10 days of resolution of GE's dispute.

In addition to these directives, EPA requested (in General Condition 30) that GE develop and submit, in the Supplement, a work plan for a treatability study to further evaluate the chemical extraction of PCBs from river sediments and floodplain soils. Since receipt of that request, GE has been researching the literature and contacting vendors to compile available information on chemical extraction. GE is preparing a Request for

Proposal (RFP), and intends to solicit a number of vendors for additional technical information. The RFP will be distributed shortly. However, the vendors will need some time to prepare their responses; and after that, GE will need time to review the responses and subsequently select a vendor, as well as to carry out several other procurement-related tasks. Given the time needed to perform these activities, GE currently anticipates submitting the requested Treatability Study Work Plan to EPA by the end of June 2007.

The following table identifies each EPA condition that directed or requested GE to provide certain information in the Supplement and specifies the section of this Supplement where that condition is addressed (or the document in which that condition will be addressed):

Comment in EPA Conditional Approval Letter; Summary of Comment	**Response/Location in Supplement**
General Condition 1. Justification and discussion of the corrective measure alternatives for Reaches 9 through 16. Revised Table 5-1 to reflect those alternatives.	Section 2 provides further justification for the corrective measure alternatives for Reaches 9 through 16 – namely, Monitored Natural Recovery (MNR). A revised Table 5-1 is not provided herein because other portions of this table are the subject of GE's April 27, 2007 dispute. A revised Table 5-1 will be provided within 10 days of resolution of that dispute.
General Condition 2. Justification and discussion of the screening of *in situ* treatment technologies for sediment and soil.	Section 3 presents an expanded discussion of the justification for the screening of *in situ* treatment technologies that were presented in the CMS Proposal.
General Condition 3. Plan for conducting a Phase I Cultural Resource Evaluation.	Section 4 introduces the plan for a Phase I Cultural Resource Evaluation, and Appendix A presents the work plan for the evaluation.
General Condition 14. Proposed methodology using the assumptions in the Ecological Risk Assessment (ERA) for determining floodplain soil PCB concentrations consistent with the Interim Media Protection Goals (IMPGs) for mink.	Section 5 provides a proposed methodology for developing target floodplain soil concentrations associated with achieving the PCB IMPGs for mink.
General Condition 21. Revised depths of removal for sediment remediation alternatives and revised Table 5-1.	This comment is subject to GE's April 27, 2007 dispute. This information will be provided (as applicable) within 10 days of resolution of that dispute.

Comment in EPA Conditional Approval Letter; Summary of Comment	Response/Location in Supplement
General Condition 23. Revised Sediment Alternative 7 to evaluate removal in Reaches 7 and 8 to 3 mg/kg, the IMPG for benthic invertebrates. Revised Table 5-1.	This comment is addressed in Section 6. However, a revised Table 5-1 is not provided herein because other portions of this table are the subject of GE's April 27, 2007 dispute. A revised Table 5-1 will be provided within 10 days of resolution of that dispute.
General Condition 30. Request for work plan for a chemical extraction treatability study.	This requested work plan is not included in this Supplement because there has not been adequate time to develop it. GE anticipates submitting this work plan to EPA by the end of June 2007.
Specific Condition 36. Use of all sediment and biota data in evaluating alternatives below Rising Pond Dam.	This comment has been followed in the evaluation presented in Section 2 of this Supplement.
Specific Condition 47. Flow chart of the overall corrective measures evaluation process.	Section 7 briefly summarizes the sequence of steps that will be undertaken to evaluate corrective measure alternatives, and presents an overall flow chart for the process.
Specific Condition 66. Specifics on the assumptions of operating production rates, projects from which the rates have been estimated, and effective time in hours, days, and weeks used to calculate the effective production rate over a season.	Section 8 presents additional information regarding the production rates identified in the CMS Proposal.
Specific Condition 68. Clarification of spatial scale for residual and resuspension concentrations used in model.	Section 9 presents a clarification of the spatial scale at which post-remediation concentrations and resuspension rates will be calculated and applied in the model.
Specific Condition 75. Proposed applicable or relevant and appropriate requirements (ARARs) that are relevant to the alternatives for Reaches 9 through 16 discussed in the Supplement provided in response to General Condition 1.	Section 2.5 identifies the ARARs that are relevant to the alternatives to be evaluated for Reaches 9 through 16 (i.e., MNR).

In each of the following sections, the relevant EPA comment is quoted in italics at the beginning of the section, and GE's response to that comment is then provided.

2. Justification for Corrective Measure Alternatives for Reaches 9 – 16 and Identification of Associated ARARs

2.1 Introduction

This section provides justification for the corrective measure alternatives to be evaluated for Reaches 9 through 16 and identifies the ARARs associated with those alternatives. Specifically, this section addresses the following EPA directives:

- **General Condition 1.** *GE shall provide further justification and discussion (in the Supplement) of the corrective measure alternatives for Reaches 9 through 16. Table 5-1 shall reflect the alternatives retained for Reaches 5 through 16.*

- **Specific Condition 36.** *All sediment and biota data shall be used when evaluating alternatives below Rising Pond Dam in the Supplement and in the CMS.*

- **Specific Condition 75.** . . . *EPA has not provided comments on ARARs that might apply to Reaches 9 through 16 at this time. GE shall propose ARARs (in the Supplement) that are relevant to the alternatives for Reaches 9 through 16 discussed in the Supplement provided in response to General Condition 1.*

2.2 Corrective Measures Alternatives Identified for Reaches 9-16

Upon review of the technologies and process options retained during the identification and screening process, Monitored Natural Recovery (MNR) was identified in the CMS Proposal as the most appropriate remedial alternative for the river sediments located within Reaches 9-16 (downstream of Rising Pond Dam). As described in the CMS Proposal, MNR is a response action that relies on ongoing, naturally occurring processes to contain, destroy, or otherwise reduce the bioavailability or toxicity of chemical constituents in sediment, with monitoring to assess the rate of recovery or attenuation. The rate and success of such recovery are typically linked to the effectiveness of upstream source control, which prevents or minimizes the continuing contribution of contaminants to the sediments. Simply stated, MNR is the combined effect of multiple natural physical, biological, and chemical processes that act together to reduce the mass, toxicity, mobility, concentration, and/or availability of contaminants in the sediment (EPA, 2005b).

Within Reaches 9-16 of the Housatonic River, the physical processes of sedimentation and dilution of upstream sources contribute to the natural recovery of PCB containing sediments. The progressive increase in river flow and associated solids from tributaries located downstream of Rising Pond naturally attenuate PCB concentrations in sediments as they combine with PCB-impacted upstream water and solids and are subsequently transported downstream. Hence, the concentration of PCB on solids settling onto, and becoming part of, the bottom sediments within Reaches 9-16 are lower than those settling in upstream reaches. This attenuation process produced the spatial trend of decreasing sediment and biota PCB concentrations with distance downstream observed within the Housatonic River. These trends were documented in GE's *RCRA Facility Investigation Report* (RFI Report; BBL & QEA, 2003) and discussed in EPA's *Final Model Documentation Report* (Weston, 2006).

Remediation of the Upper 2-Mile Reach as well as other ongoing and future remedial activities conducted upstream of Rising Pond Dam will further reduce PCB concentrations in downstream reaches. The CMS Proposal identified a number of options for active remediation of PCB-containing sediments upstream of Rising Pond Dam. These remedial actions, if implemented, will further reduce the transport of PCBs over the dam, thereby reducing PCB concentrations in particulate matter depositing within Reaches 9-16. This reduction in PCB concentrations in surficial sediments, the point of exposure for biological receptors, will in turn result in reductions in PCB concentrations in fish and other receptors.

The selection of MNR as the most appropriate alternative for PCB-containing sediments downstream of Rising Pond Dam was based on the following observations:

- Water, sediment, and biota data collected downstream of Rising Pond (Reaches 9-16) exhibit low PCB levels;
- Decreasing trends in fish and benthic invertebrate PCB levels have been observed in those reaches during the last 25 years;
- Analysis of historical data indicates that PCB levels in Reaches 9-16 are controlled by dilution of upstream PCB sources; as these upstream sources are reduced by remediation, sediments and biota in Reach 9 (i.e.,

Rising Pond Dam to the MA/CT border) and the Connecticut portions (Reaches 10-16) of the River will respond accordingly; and

- Many of the Interim Media Protection Goals (IMPGs) established for the Rest of River (GE, 2006a) have already been met in this portion of the River, prior to any additional upstream remediation that will serve to further reduce PCB levels in these downstream reaches.

The remainder of this section identifies and describes the weight of evidence supporting MNR as the most appropriate remedial alternative for PCB-containing sediments in reaches of the River downstream of Rising Pond Dam. Section 2.3 presents a summary of the sediment and biota data collected from Reaches 9-16 of the River. Section 2.4 provides a detailed assessment of these data and presents the conclusions drawn from the data assessment. Finally, Section 2.5 identifies the ARARs associated with application of MNR for Reaches 9-16.

2.3 PCB Data Collected Downstream of Rising Pond Dam

PCBs were initially identified in the sediments and fish within the Connecticut impoundments of the Housatonic River in the mid 1970s; since then, numerous investigations have been conducted to characterize the presence and extent of PCBs in both Massachusetts and Connecticut. The major investigations included:

- Studies performed during the 1970s by the Connecticut Department of Environmental Protection (CDEP), United States Geological Survey (USGS), and Connecticut Agricultural Experiment Station (CAES);
- An investigation by GE in the 1980s pursuant to Consent Orders executed by GE and EPA and the Commonwealth of Massachusetts in 1981;
- Additional investigations by GE in the 1990s pursuant to an Administrative Consent Order (ACO) executed by GE and MDEP in 1990 pursuant to the Massachusetts Contingency Plan (MCP) and the prior RCRA permit issued by EPA to GE in February 1991 and reissued effective January 1994 (referred to herein as the “MCP Phase II/RFI investigations”);
- Investigations performed by GE under the 1984, 1990, and 1999 Cooperative Agreements between GE and CDEP; and
- A multi-year sampling effort conducted by EPA that commenced in 1998 and was largely completed by 2002 in anticipation of and pursuant to the CD.

These sampling and analysis programs were described in the RFI Report (BBL and QEA, 2003). As part of these investigations, surface water, sediment, and biota samples were collected from the portion of the Rest of River downstream of Rising Pond Dam (Figure 2-1). These sampling and analysis programs are summarized below by medium, and a summary of total PCB results for each program is provided in Tables 2-1 (surface water), 2-2 (sediment), 2-3 (fish tissue), and 2-4 (benthic invertebrates).

2.3.1 Water Column

In 1978-1980, CAES, CDEP, and the USGS performed water column monitoring studies to establish the presence and distribution of PCBs within the Connecticut reaches of the river. Samples were collected from three stations including: (1) Near Great Barrington, MA; (2) Falls Village, CT; and (3) Gaylordsville, CT. These samples were analyzed for total and dissolved PCBs and total suspended solids (TSS) (Frink et al., 1982).

In 1982, Stewart Laboratories, Inc. conducted water column monitoring at two stations downstream of Rising Pond Dam: Division Street Bridge located at the upper end of Reach 9, and Andrus Road Bridge located near the lower end of Reach 9 (Figure 2-1). Samples were analyzed for dissolved and total PCBs and TSS.

CDEP, in cooperation with the USGS, conducted water column monitoring during five high-flow events from 1984 to 1988. Samples were collected from five USGS gauging sites located downstream of Rising Pond Dam: (1) Great Barrington, MA; (2) Ashley Falls, MA; (3) Canaan, CT; (4) Falls Village, CT; and (5) Kent, CT. These samples were analyzed for total and dissolved PCBs and TSS (Kulp, 1991; BBL and QEA, 2003).

As part of the MCP Phase II/RFI investigations, Blasland, Bouck & Lee, Inc. (BBL), on behalf of GE, collected 21 water column samples between 1989 and 1992 from the Division Street Bridge location in Great Barrington, MA. These samples were analyzed for total PCBs and TSS.

During 1991-1993, Lawler, Mutusky, and Skelly Engineers, Inc. (LMS) collected composite water column samples during eight high flow events. Samples were collected from between one and seven stations within Reaches 9-16 of the Housatonic River to support calibration of a PCB fate and transport model (LMS, 1994). Samples were analyzed for total and dissolved PCBs, total organic carbon (TOC), and TSS.

In addition, BBL on behalf of GE conducted water column monitoring on the Housatonic River beginning in 1995 and continuing to the present. The primary sampling location downstream of Rising Pond Dam is the Division Street Bridge in Great Barrington, MA, approximately one mile downstream of Rising Pond Dam (within Reach 9). This monitoring has generally included total PCBs, TSS, and particulate organic carbon (POC). In 1997, additional samples were collected from Andrus Road Bridge near the MA/CT border and in Bulls Bridge, CT.

2.3.2 Sediments

As part of the 1979-1982 study to determine the presence and distribution of PCBs within the Housatonic River, CAES, in cooperation with the USGS and CDEP, collected sediment samples from both the Massachusetts and Connecticut portions of the river (Frink et al., 1982). These samples consisted of cores of varying lengths that were segmented and analyzed for total PCBs and total organic carbon (TOC).

The Stewart Laboratory, Inc. baseline study conducted in 1980-1982 on behalf of GE included the collection and analysis of sediment cores from Reach 9 in Massachusetts and a single sample from the Connecticut portion of the river (Stewart, 1984). The Reach 9 sediment cores were collected from sediment accumulation areas. Samples were analyzed for total PCBs only.

In 1986 and 1992, in support of a PCB fate and transport modeling effort, LMS, on behalf of GE, collected surface sediment samples and finely segmented (high resolution) cores from Reach 9 and Connecticut portions of the river (LMS, 1988, 1994). In 1986, finely segmented cores were collected from six locations within impounded areas of the river: Falls Village, Bulls Bridge, Lake Lillinonah (two cores), and Lake Zoar (two cores)**.** These cores were sectioned into 1-inch segments and analyzed for total PCBs and TOC. Additionally, a subset of the core segments was analyzed for bulk density and grain size. In 1992, surface sediment samples (0- to 3-inch intervals) were collected from 47 stations and analyzed for PCBs, TOC, bulk density, and particle size. Also in 1992, finely segmented cores collected from Falls Village and Bulls Bridge Dam impoundments were sectioned into 1 inch depth increments and analyzed for total PCBs, TOC, and Cs^{137} (LMS, 1988, 1994).

From 1997 to 1998, as part of the MCP Phase II/RFI investigations, BBL, on behalf of GE, collected sediment samples from Reaches 9, 10, and 12. These programs included a surface sediment survey to compare sediment PCB concentrations with the earlier CAES and Stewart surveys and a high resolution sediment coring program. The surface sediment sampling program consisted of composite samples that were collected from

Reaches 9, 10, and 12 and analyzed for total PCBs and TOC. Two high resolution sediment cores were collected from both Falls Village Dam and Bulls Bridge Dam Impoundments and sectioned into 1 cm segments and analyzed for Cs^{137}. Cores that produced vertical profiles of Cs^{137} with defined peaks at depth were selected for PCB analysis. Based on this approach, only the core from the Bulls Bridge Dam impoundment was further analyzed for PCBs.

From 1998 to 2002, EPA collected discrete sediment cores from Reaches 9-16 to provide data for the human health and ecological risk assessments. These sediment cores were segmented into 6-inch intervals and analyzed for total PCBs, TOC, and grain size. A subset of the samples was analyzed for congener-specific PCBs and certain non-PCB constituents.

In August 2005, while the Falls Village Dam impoundment was lowered to facilitate dam repairs, sediment samples were collected from 5 locations by Northeast Generation Services and analyzed for PCBs and TOC. During that same time, HydroTechnologies, Inc., on behalf of the Housatonic River Commission, collected four discrete and one composite sample from locations within the impoundment, which were analyzed for total PCBs.

2.3.3 Fish

The 1980 and 1982 Stewart study included the sampling and analysis of fish from Reach 9 (Stewart, 1984). These data consist of an individual fillet sample for bass (species unidentified), sunfish, yellow perch, brown trout, and largemouth bass. Samples were analyzed for PCBs and percent lipids.

In 1998, as part of the MCP Phase II/RFI investigations, BBL on behalf of GE collected adult fish whole body and fillet samples from Reach 9 and submitted the samples for PCB and lipid content analysis. Fish species analyzed included largemouth bass, bluntnose minnows, brown bullhead, pumpkinseed, and yellow perch. In addition, ARCADIS, on behalf of GE, collected five whole body samples of largemouth bass in 1999 from Reach 9.

GE’s biannual young-of-year (YOY) fish monitoring program (which has been conducted since 1994) targets largemouth bass, yellow perch, and pumpkinseed or bluegill from five locations within the river, one of which is located in Reach 9. Fish tissues are prepared as composite whole body samples that are analyzed for total PCB concentrations and percent lipids.

A routine fish monitoring program has been conducted in the Connecticut reaches of the Housatonic River since the late 1970s. This program has focused on four areas of the river: West Cornwall (Reach 11), Bulls Bridge (Reach 12), Lake Lillinonah (Reach 14), and Lake Zoar (Reach 15) and has generally targeted brown trout and smallmouth bass. Initially, these fish samples were collected and analyzed by CDEP. However, starting in 1984, under cooperative agreements between GE and CDEP, these data have been collected by the Academy of Natural Sciences of Philadelphia (ANSP). Fish tissue preparations varied during the earlier years of the program, but were standardized in 1984 as skin-on/scales-on fillet samples for trout and skin-on/scales-off fillet samples for bass and most other species. Samples have been analyzed for percent lipids and PCBs by Aroclors. Beginning in 1992, ANSP also quantified total PCBs by congener analysis. The two methods were found to yield comparable total PCB concentrations (ANSP, 1997); hence only the Aroclor-based total PCB concentrations are presented in Table 2-3.

2.3.4 Benthic Invertebrates

Benthic invertebrate samples including caddisfly, stonefly, and hellgrammite (dobsonfly) larvae composites have been collected from the West Cornwall Connecticut region of the river (Reach 11) from 1978 to the present by CDEP and ANSP. These samples have been analyzed for total PCB Aroclors. Starting in 1992, these samples were also analyzed for percent lipids and total PCBs by congener analysis.

2.4 Assessment of Data from Reaches 9 – 16

2.4.1 Water, Sediment, and Biota Data Collected from Downstream of Rising Pond Exhibit Low PCB Levels.

Compared to the Primary Study Area (PSA; River Reaches 5 and 6), which is the central focus of the remedial actions considered in the CMS Proposal, water column, sediment, and biota samples collected downstream of Rising Pond contain markedly lower PCB concentrations.

2.4.1.1. Water Column

Water column PCB concentrations downstream of Rising Pond are low and often less than the limits of analytical detection. Between 1996-2002, median water column total PCB concentration was 0.013

microgram per liter (µg/L) at Division Street Bridge (located in Reach 9), a factor of 4 lower than the median of 0.062 µg/L directly downstream of Woods Pond (Schweitzer/Lenoxdale Bridge) over the same period (BBL and QEA, 2003).[1] This four-fold reduction in median water column PCB concentrations can be attributed largely to dilution by tributary flows, but also other PCB fate processes including particle settling and, to a limited extent, volatilization (BBL & QEA, 2003). Moreover, of the 139 water column samples collected and analyzed for PCBs from the Division Street Bridge location between 1995 and 2006, 69% were less than the method detection limit (MDL) of 0.022 µg/L (Table 2-1). Further downstream in Reaches 9 and 12, only 1 of 4 and 0 of 4 samples collected in 1997 from the Andrus Rd. Bridge and Bull Bridge Dam stations, respectively, had detectable PCB concentrations (Table 2-1).

2.4.1.2. Sediment

Sediment PCB concentrations downstream of Rising Pond Dam are low compared to upstream reaches, both historically and under contemporary conditions (Figures 2-2 and 2-3). For example, contemporary surface sediment (0-6 in) PCB concentrations in Reaches 5 and 6 average between 20 and 30 milligrams per kilogram (mg/kg) (BBL and QEA, 2003), while PCB concentrations in Reach 9 average less than approximately 1 mg/kg and PCB concentrations in the Connecticut reaches of the River (Reaches 10-16) generally average less than approximately 0.1 mg/kg. Stated differently, sediment PCB concentrations are a factor of 10 lower in Reach 9 and a factor of 100 lower in Connecticut (Reaches 10-16) than in the PSA. Indeed, the highest surface sediment (0-6 inch) PCB concentration measured in recent years downstream of Rising Pond was approximately 1.2 mg/kg in a sample collected from Reach 9 (BBL and QEA, 2003). By comparison approximately 86% of the samples collected in Reaches 5 and 6 were above 1 mg/kg (Figure 2-4).

PCB concentrations in recent sediment data (i.e., 1997-2002) generally decline with distance downstream from Rising Pond Dam (Figure 2-4). This trend reflects the greater distance from the upstream sources, and the associated attenuation processes occurring over the approximately 100 miles of River between Rising Pond Dam and Reach 16.

---

[1] In fact, the median water column concentration of 0.013 µg/L at Division Street Bridge is lower than EPA's freshwater aquatic life ambient water quality criterion of 0.014 µg/L (EPA, 2002a).

2.4.1.3. Fish

As with the lower water column and sediment PCB exposure concentrations, fish PCB levels downstream of Rising Pond Dam are low relative to those measured in the PSA. For example, as reported in the RFI Report (BBL and QEA, 2003), the 2002 median fillet PCB concentrations of top predatory fish (largemouth bass) in Woods Pond was 26.8 mg/kg wet weight. By contrast, median fillet concentrations in adult top predatory fish (smallmouth bass) in the Connecticut reaches of the River in the same year ranged from 0.35 mg/kg wet weight in Lake Zoar (Reach 15) to 1.03 mg/kg wet weight in West Cornwall (Reach 11). Hence, fillet PCB concentrations in predatory species are on the order of 25 to 75 times lower in Connecticut than in Woods Pond. In addition, median whole body wet weight PCB concentrations measured in Reach 9 largemouth bass in 1999 were 5 times lower than comparable measurements made in Woods Pond in 1998 (i.e., 86 mg/kg in Woods Pond versus 17.6 mg/kg in Reach 9; BBL and QEA, 2003).

YOY fish collected as part of GE's biannual monitoring program produced spatial trends similar to those for adult fish. YOY fish collected from the PSA average between 15 and 30 mg/kg total PCBs over the 1994 to 2006 sampling period. By contrast YOY fish sampled from Reach 9, downstream of Rising Pond Dam, generally average between 2 and 4 mg/kg, a factor of 4 to 15 lower than observed in the PSA. For example, in 2006, the average YOY largemouth bass PCB concentration in Woods Pond was 32 mg/kg compared to a Reach 9 average of 2.8 mg/kg.[2]

2.4.2 PCB Levels Have Declined Downstream of Rising Pond During the Last 25 Years.

During the last approximately 25 years, natural attenuation processes have reduced PCB levels in sediment, fish, and benthic invertebrates sampled from the River downstream of Rising Pond. Between the late 1970s and late 1990s, surface sediment PCB concentrations declined by approximately a factor of 4 in Reach 9 (Table 2-2a and Figure 2-5) and generally by about an order of magnitude in most of the Connecticut reaches (Table 2-2b-h and Figure 2-5), except in Reach 12 (which showed no decline) and Reach 14 (Lake Lillinonah) (which showed a two-fold decline over the same period).[3] For example, PCB concentrations in surface sediments in Reach 10 located between the MA-CT border and Great Falls Dam declined from a mean of 0.7

---

[2] The YOY data discussed in this paragraph were extracted from the April 2007 version of GE Housatonic River PCB database.

[3] Frink et al. (1982) suggested that the Still River may have contributed PCBs to Lake Lillinonah and Lake Zoar. This potential additional source may be contributing to the lower decline observed in Reach 14.

mg/kg in 1980 to approximately 0.1 mg/kg or below in the various sampling programs conducted between 1997 and 2005 (Table 2-2b). Further downstream in Reach 15 located between the Shepaug Dam and Stevenson Dam (Lake Zoar), PCB concentrations in surface sediments declined from a mean of 0.7 mg/kg in 1980 to a mean of 0.06 mg/kg in 1992 (the latest year of substantial sampling; Table 2-2g).

Finely segmented sediment cores collected downstream of Rising Pond Dam provide further evidence of declining trends in surface sediment PCB concentrations. Four of the six finely segmented sediment cores collected from depositional environments in the CT reaches of the River in 1986 depict increasing PCB concentrations with sediment depth (Figure 2-6). Within Lake Lillinonah (Reach 14) and Lake Zoar (Reach 15), peak PCB concentrations of approximately 8 and 6 mg/kg occurred at depths of 40 to 60 cm below the sediment-water interface, respectively (Figure 2-6). In contrast, these cores had surface sediment total PCB concentrations less than 2 mg/kg (Figure 2-6). A third core collected from the Bulls Bridge Dam Impoundment (Reach 12) also showed increasing PCB concentration with depth; however, maximum PCB concentrations of less than 1.5 mg/kg were found at the bottom segment of this approximately 35 cm core (Figure 2-6). The remaining two cores exhibited low level PCB concentrations (less than 0.3 mg/kg) throughout the core depth (Figure 2-6).

Finely segmented cores collected from the CT portions of the River by LMS and BBL in 1992 and 1998 were analyzed for total PCBs and Cs^{137}. These cores generally exhibit the same characteristic total PCB profile with increasing concentrations with sediment depth (Figures 2-7 and 2-8), indicating that PCB concentrations on depositing sediment particles have declined over time. Through the interpretation of vertical profiles of Cs^{137}, an approximate date can be established for each core depth increment analyzed (BBL and QEA, 2003). In summary, peak Cs^{137} concentrations within the sediment profile correspond to the maximum fallout from atmospheric testing of nuclear weapons and are interpreted as the 1963 horizon (BBL and QEA, 2003). The sediment water interface, interpreted as the year of sampling, provides the second time horizon. Assuming a uniform deposition rate, approximate dates can be established for the different sediment segments. In this way, a time series of PCB concentrations on particles deposited within the impoundments can be estimated. Applying this methodology to the finely segmented cores collected from the Bulls Bridge Dam Impoundment (Reach 12) in 1998 found that PCB concentrations on depositing sediment particles have declined from approximately 1.5 -2.0 mg/kg in the 1970s to less than 0.5 mg/kg in the late 1990s (Figure 2-9). Similarly, applying this methodology to one of the cores collected by LMS in 1992 (only one of the 1992 LMS cores [RM 29.8] had an interpretable Cs^{137} profile for this dating analysis) found that PCB concentrations on depositing sediment particles within Reach 14 declined from approximately 1.5-2.0 mg/kg in the late 1960s to

0.2-0.8 mg/kg in the 1980s. These estimated declines in PCB concentrations on depositing sediment particles within the Connecticut impoundments of the Housatonic River are consistent with that observed from the surficial sediment surveys described above. These data provide further evidence of the ongoing natural recovery of sediment PCBs within the River downstream of Rising Pond. Moreover, due to the quiescent nature of the impoundments in these reaches, the deeper sediments containing higher PCB concentrations in these impoundments will remain buried and will not be mobilized so as to become available for human or ecological exposure.

Consistent with the reduction in surface sediment PCB concentrations, benthic invertebrates collected from West Cornwall, CT region of the River (Reach 11) have declined substantially since the late 1970s for both filter feeders (caddisfly) and predators (hellgrammite larvae/stonefly nymphs (Figure 2-10). The concentrations in 1978 and 1979 ranged from 5 to 20 mg/kg for both functional groups, declined through the 1980s and 1990s, and reached levels at and below 1 mg/kg in 2001, 2002, and 2005, which are among the lowest levels observed in these insects since monitoring began (ANSP, 2005).

The YOY fish collected from Reach 9 exhibit year-to-year variability in PCB concentration and no discernible temporal trend (Figure 2-11). The lack of a consistent temporal trend suggests that the exposure concentrations in this reach of the river have changed little since the inception of the YOY program in 1994. However, due to their age when collected (< 1 year), PCB concentrations within these fish are highly influenced by variability in PCB exposure produced by year-to-year differences in river flow, temperature, food resources, and habitat. These same factors also influence fish growth rate. Consequently, due to the relationship among body size, growth dilution, and diet, these factors also influence YOY fish PCB concentrations at the time of sampling.

PCB concentrations in top predator fish species sampled from CT portions of the Housatonic River have declined substantially during the last approximately 25 years. Although there is considerable year-to-year variability, these general trends are apparent in both smallmouth bass and brown trout fillets (Figure 2-12 and 2-13). These trends are consistent with the observed declines in water column, sediment, and benthic invertebrate PCB concentration during the same period, as described above. PCB concentrations in brown trout fillets declined from average concentrations of greater than 20 mg/kg in 1976 to concentrations that ranged between 5 and 10 mg/kg between 1986 and 1994 (Figure 2-12). A second period of decline is apparent between the early to late 1990s. Contemporary (2000-2004) PCB concentrations in brown trout fillets collected from West Cornwall, CT (Reach 11) are generally less than 2 mg/kg wet weight (Figure 2-12).

Similarly, while exhibiting substantial year-to-year variability, particularly over the mid 1980s to early 1990s period, mean smallmouth bass fillet PCB concentrations declined substantially from 3 to 5 mg/kg in the early 1990s to approximately 1 mg/kg 2004 at West Cornwall, CT (Figure 2-13). Similar temporal declines are observed at the other CT sampling stations located at Bulls Bridge, Lake Lillinonah, and Lake Zoar (Figure 2-13), with the most recent data at or below 1 mg/kg. Overall, these data indicate that fish PCB concentrations in the Connecticut portion of the River declined significantly from the late 1970s until 1994 and have remained at low and generally similar levels since then.

2.4.3 Remediation of Upstream Reaches Will Accelerate the Ongoing Natural Attenuation of PCBs Downstream of Rising Pond.

Completed and continuing remedial actions upstream of the Confluence, as well as additional remedial actions identified for evaluation in the CMS for the Rest of River upstream of Rising Pond Dam, will enhance the observed natural attenuation of sediment and biota PCB concentrations in reaches downstream of Rising Pond Dam. The low levels of PCBs observed in sediment and fish tissue downstream of Rising Pond Dam are controlled, in part, by PCB loadings originating upstream. As additional remedial measures are implemented upstream, PCB loadings to Reaches 9 to 16 will further decline. These reductions in loadings will ultimately produce lower water column and sediment PCB exposure concentrations, and fish and other biota within the region will respond similarly.[4]

This link between upstream PCB loadings and biota PCB concentrations can be observed in the smallmouth bass PCB data. PCB concentrations in smallmouth bass fillets sampled from different CT reaches of the river depict a strong spatial gradient that is characterized by a decrease in concentration with distance downstream (Figure 2-14). PCB concentrations at West Cornwall (Reach 11) and Bulls Bridge (Reach 12) averaged approximately 1 mg/kg between 1998 and 2004, while concentrations further downstream in Lake Lillinonah (Reach 14) and Lake Zoar (Reach 15) averaged approximately 0.5 mg/kg. This spatial relationship reflects lower PCB exposure concentrations produced by increases in river flow and clean solids loading with downstream distance in the river. This correlation between smallmouth bass fillet PCB concentrations and river flow is depicted graphically in Figure 2-15. The flow between the Falls Village and Stevenson gaging

---

[4] The response of sediments and fish within Reaches 9 to 16 to potential remedial actions conducted upstream of Rising Pond Dam will be quantified during the CMS using a semi-quantitative PCB mass balance framework described in the CMS Proposal and referred to as the "CT 1D Analysis." The CT 1D Analysis leverages PCB fate and transport and fish bioaccumulation modeling work performed by EPA for upstream portions of the site with the observed relationship among river mile, river flow rate, and PCB levels observed in the different media within the Bulls Bridge Dam Impoundment, Lake Lillinonah, Lake Zoar, and Lake Housatonic.

stations increases by approximately the same factor as the smallmouth bass fillet PCB concentration decreases, suggesting fish PCB exposure concentrations are controlled largely by dilution of the upstream sources. Consequently, future reductions in fish PCB concentrations within the CT impoundments should be expected as remedial actions upstream reduce the PCB loading past Rising Pond Dam.

2.4.4 Many IMPGs Already Have Been Met Downstream of Rising Pond Dam.

As described in the Permit, IMPGs are preliminary goals that are considered to be protective of human health and the environment. The Permit specifies that achievement of the IMPGs is one of several "Selection Decision Factors" that must be balanced against one another in evaluating potential remedial alternatives in the CMS. The revised IMPG Proposal developed by GE (GE, 2006a), subsequently approved by EPA, presented numerical concentration-based IMPGs in sediments, floodplain soil, fish tissue, and/or other biota tissue for the protection of both human health and ecological receptors.[5]

A comparison of the most recent PCB concentrations presented in Tables 2-2a-h and 2-3a-g to the applicable IMPGs indicates that many of the IMPGs already have been met in Reaches 9 to 16, even without any additional upstream remediation. For example, for sediments, the average surface PCB concentrations (0-6") from the most recent data sets in Reaches 9 to 16 (Tables 2-2a through 2-2h) are all less than the most restrictive IMPG for human direct contact with sediments of 1.3 mg/kg. Likewise, the average sediment concentrations in Reaches 9 to 16 are all less than the range of sediment IMPGs established for benthic invertebrates of 3 to 10 mg/kg. In addition, average fish tissue PCB concentrations from the most recent available data sets for Reaches 9 to 16 (Tables 2-3a to 2-3g) are all well below the IMPGs for fish reproduction (55 and 14 mg/kg for warmwater and coldwater fish, respectively) as well as the IMPG for protection of threatened and endangered species (30.41 mg/kg). Further, the most recent average fish tissue PCB concentrations for some of the Connecticut reaches, including Lakes Lillinonah and Zoar, are below the IMPG for piscivorous birds (3.2 mg/kg) and are close to or within the range of the IMPGs for piscivorous mammals (0.984 to 2.43 mg/kg).[6]

---

[5] GE disagrees with several of the underlying assumptions that EPA directed GE to use in the development of IMPGs. These are discussed in GE's Statement of Position on objections to EPA's disapproval of GE's original IMPG Proposal (GE, 2006b).

[6] For fish tissue, the ecological receptor IMPGs are applied on a whole-body basis. While fish whole-body data are available in Reach 9 (Table 2-3a), the fish data from the other reaches were collected as fillets. Consequently, no direct comparison of the fish tissue data to the ecological receptor IMPGs can be made for Reaches 10-16. However, in the

2.4.5 Regardless of PCB Levels, a Fish Consumption Advisory Will Remain in Effect in the Connecticut Portion of the River due to Mercury.

Based on the fish tissue data from the Connecticut portion of the River, the Connecticut Department of Public Health (CDPH) has established a fish consumption advisory for that portion of the River based on PCBs. At the same time, however, the CDEP has established a state-wide fish consumption advisory based on mercury levels in fish. The state-wide consumption advisory for mercury is 1 meal/month for the high-risk group (women who are pregnant, children under 16, etc.) and 1 meal/week for the low-risk group (everyone else) for all fish except trout. The CDPH's PCB consumption advisory for the Housatonic River above Derby Dam (Reaches 10-16) is the same as the mercury advisory for some species (e.g., panfish), although it is stricter than the mercury advisory for other species (e.g., trout, bass, and bottom-feeding fish). In any event, regardless of the extent of further reductions in fish PCB concentrations in the Connecticut portion of the River, unrestricted fish consumption will not be allowed, since a fish consumption advisory will remain in effect due to mercury.

2.4.6 Conclusions

Upon review of the technologies and process options retained during the identification and screening process documented in the CMS Proposal, MNR was chosen as the most appropriate remedial alternative for the river sediments downstream of Rising Pond Dam (Reaches 9-16). The identification of MNR for these reaches of the River was based upon the weight of evidence provided by water column, sediment, and biota data collected over the last 30 years. These data exhibit low levels when compared to upstream reaches, show evidence of declining trends in surface sediment and biota concentrations, and indicate that many of the risk-based IMPGs established for the site have already been met.. Moreover, the historical data indicate that as PCB levels upstream of Rising Pond Dam are controlled through additional remediation, sediment and biota concentrations downstream in Reaches 9-16 will be further reduced from their existing low levels. Finally, because the CDPH fish consumption advisory is based not only on PCBs but also mercury, further reductions in the PCB levels will not result in lifting of the fish consumption advisory.

For the above reasons, MNR will be specified for Reaches 9 through 16 in all sediment remediation alternatives evaluated in the CMS. GE will reflect that selection in a revision of Table 5-1 of the CMS Proposal. As noted above, that revised table will be submitted to EPA following resolution of GE's dispute

---

comparisons discussed in this paragraph for those reaches, GE has taken into account the likely whole body fish tissue concentrations that would be associated with the reported fillet data.

relating to EPA's comment regarding minimum sediment removal depths for the sediment remediation alternatives (General Condition 21).

2.5 ARARs Associated with MNR for Reaches 9 – 16

Condition 75 of EPA's Conditional Approval Letter directed GE to propose, in the Supplement, the ARARs that are relevant to the remedial alternatives for Reaches 9 through 16. Since MNR has been selected as the appropriate remedial option for sediments in those reaches in all sediment remedial alternatives, ARARs that would apply to active remediation activities are not applicable or relevant in those reaches. Accordingly, the location-specific and action-specific ARARs which would apply to active remediation are not pertinent for these reaches. As a result, the only pertinent ARARs for these reaches are the chemical-specific ARARs that apply to areas without active remediation.

Consistent with GE's revised IMPG Proposal (GE, 2006a), EPA's April 3, 2006 approval letter for that proposal, and Condition 75 of EPA's April 13, 2007 Conditional Approval Letter, GE has identified the following chemical-specific ARARs for these areas: (a) the National Ambient Water Quality Criteria for PCBs (EPA, 2002a); (b) the Massachusetts water quality criteria for PCBs, as set forth in the *Massachusetts Surface Water Quality Standards* (314 CMR 4.05(5)(e)); and (c) the Connecticut water quality criteria for PCBs, as set forth in the *Connecticut Water Quality Standards* (effective December 2002).[7] In addition, as directed by EPA in Condition 75 of its Conditional Approval Letter, GE identifies the following as "To Be Considered" (TBC): (a) Cancer Slope Factors (CSFs) for PCBs; (b) non-cancer Reference Doses for PCBs; and (c) EPA's guidance titled *PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures* (EPA, 1996), which includes revised CSFs for PCBs.

---

[7] As noted in the CMS Proposal, GE will consider in the CMS Report whether these or any other ARARs should be waived under the conditions in CERCLA and the National Contingency Plan.

3. Further Justification for Screening of In Situ Treatment Technologies

3.1 Introduction

This section provides additional justification for the screening of *in situ* treatment technologies and addresses the following EPA comment:

- **General Condition 2.** *GE shall provide further justification and discussion (in the Supplement) of the screening of* in situ *treatment technologies for sediment and soil.*

3.2 Overview of Screening Process

In the CMS Proposal, *in situ* sediment and soil treatment technologies for the Rest of River were identified and screened in a two-step process. This Supplement elaborates on this process and provides additional detail regarding the evaluation of potential *in situ* treatment technologies. Potential *in situ* treatment options were identified using available information from several EPA websites, including the EPA's Superfund Innovative Technology Evaluation (SITE) Program, Clu-in, and the Federal Remediation Technology Roundtable.

The two-step screening process used in the CMS Proposal consisted of an initial and secondary screening step. The initial screening generally consisted of an evaluation based on technical implementabilty to eliminate those technologies that are not appropriate based on site conditions or chemical/physical characteristics of the site media, or that have not been successfully applied on a full-scale basis at other PCB-impacted sites.

Those technologies that were retained as a result of the initial screening were then subject to a secondary screening based on effectiveness and implementability. The effectiveness of each treatment technology was evaluated based on: (a) its general ability to reduce the potential for human and/or ecological exposure to PCBs; and (b) the extent to which long-term maintenance and/or monitoring is required to ensure effectiveness. Implementability included consideration of both the technical and administrative feasibility of implementing a technology process option, as well as the availability of equipment, materials, and personnel.

An expanded and more detailed discussion of the identification and screening of potential *in situ* treatment technologies is provided below.

3.3 Overview of Identified *In Situ* Treatment Process Options

In situ treatment typically involves using physical, chemical, biological, or thermal processes to destroy or degrade contaminants or immobilize the contaminants in place within the soil or sediment. Each of these process options is summarized below, as it would apply to the Rest of River area.

- ***In situ* physical treatment** can be applied to sediment or soil and involves injecting and/or mixing an immobilization agent to reduce the mobility of PCBs. The agent can be coal, coke breeze, activated carbon, Portland cement, fly ash, limestone, or other additive. It is injected/mixed into the sediment or soil to encapsulate the contaminants in a solid matrix and/or chemically alter the contaminants by converting them into a less bioavailable, less mobile, or less toxic form.

- ***In situ* chemical treatment** can be applied to sediment or soil and involves injecting chemical surfactants/solvents or oxidants into the treatment area to remove or destroy PCB constituents. Chemical treatment processes may include common or proprietary solvents and other liquids.

- ***In situ* biological treatment** can be applied to sediment or soil and involves introducing microorganisms and/or nutrients into the treatment zone to increase ongoing biodegradation rates of PCBs. Biodegradation of PCBs may occur either in the absence of oxygen (anaerobic conditions) or with oxygen present (aerobic conditions).

- ***In situ* thermal treatment** is applicable only to soil media and involves heating the PCB-containing soil to high enough temperatures to remove and/or destroy PCBs in the floodplain soils. It could include the use of steam or direct heat (via heat elements) and thermal conductivity to heat soils and vaporize contaminants for collection and treatment/disposal. In addition, resistance heating could be employed, which uses electromagnetic waves to heat targeted soils in an effort to enhance contaminant removal. *In situ* vitrification, a higher energy form of thermal treatment, uses temperatures high enough to vitrify the soil (i.e., turn it into a stable glass-like material), destroying or immobilizing contaminants that are present. The success of any of these forms of *in situ* thermal treatment is highly dependent on soil homogeneity, subsurface conditions, and the effectiveness of the delivery system.

These treatment options are evaluated individually below for sediment and soil applications. However, as a general matter, all *in situ* treatment technologies, regardless of type, are subject to a number of general challenges that could make their application to the Rest of River problematic. Physical access to the area to be treated must be obtained. Additionally, for the floodplain soils, removal of all vegetation (including clearing and grubbing of root systems) would likely be required to achieve effective treatment. The effectiveness of *in situ* treatment technologies is also dependent upon subsurface characteristics, such as moisture content and material type, which can be highly variable, especially in the floodplain, and would make technologies such as *in situ* thermal treatment prohibitive for the sediments. Moreover, these technologies require an effective *in situ* delivery system and adequate process controls/containment, which have been shown to be difficult to design, effectively operate, and maintain. In addition, unreacted treatment reagents and/or byproducts generated by the reagents may remain in the subsurface, with potentially unknown environmental effects. Following remediation, treated areas would likely not be suitable for restoration without nutrient amendment or covering with clean materials, which could affect the flow of surface water or groundwater, flood storage capacity, and future use by both humans and wildlife. Finally, given the lack of full-scale use of most *in situ* technologies, little is known about their long-term effectiveness and permanence.

3.4 Evaluation of Identified *In Situ* Treatment Technologies for Sediment

Methods for *in situ* treatment of sediments are currently under development, but few options are commercially available. EPA has noted that “significant technical limitations currently exist for many of the treatment technologies,” especially in terms of their effectiveness (EPA, 2005a). The efficiency of *in situ* treatment is summarized by Renholds (1998) as “almost always less than ex situ treatment.” The EPA has also cited *in-situ* mixing as “most difficult alternative in terms of control of safety and environmental considerations” (EPA, 1986). In the CMS Proposal, each of the *in situ* treatment process options for sediments was screened out in the initial screening step. Additional information and justification for such screening are provided in the following subsections.

3.4.1 *In Situ* Physical Treatment

In situ physical treatment processes have not yet been sufficiently developed for sediment nor been successfully implemented full-scale for PCBs. The problems noted by others with implementation of *in situ* physical treatment processes for sediments include:

- Lack of an effective delivery system (EPA, 2005a), including difficulties in maneuvering about rocks and cobbles that may be on the river bottom;
- Lack of good process controls, particularly for mixing conditions and curing temperatures (Kita and Kubo, 1983);
- Lack of good quality control during the mixing process (EPA, 1986);
- Difficulty in controlling safety and environmental considerations during *in-situ* mixing since the entire process is open to the atmosphere, leading to environmental problems such as generation of odors, vapors, and fugitive dust (EPA, 1986);
- Potential need for frequent and potentially sizeable onshore staging areas to support application;
- Ability to control the mixing process to mitigate impacts to the water column and surrounding environment;
- High degree of sediment handling (EPA, 1994); and
- Potential to increase in place sediment volume due to the addition of a stabilizing agent.

Based on a review of two sediment projects (Fox River [WI], which included the field implementation of a stabilization treatment technology, and the Manitowoc River [WI], which consisted of a pilot-scale evaluation of a solidification treatment technology), Renholds (1998) noted that although there was a relatively high treatment efficiency observed in most laboratory studies for *in situ* physical treatments, there was difficulty in the implementation of the treatment and engineering controls in the field. The feasibility of *in situ* physical treatment must consider the technology's environmental impact on the water column and aquatic environment. For instance, *in situ* physical treatment technologies, which often include mixing processes, need to operate without dispersing the sediments or creating conditions more harmful to aquatic life than already exist (EPA, 1994). Significant issues with mixing were encountered during the Manitowoc River (WI) demonstration project. The river sediments contained polycyclic aromatic hydrocarbons (PAHs) and several heavy metals from a former coal gasification plant. During the demonstration project, good controls could not be established for the mixing of cement/fly ash slurry with the sediment (Renholds, 1998), resulting in the dispersal of sediments and little treatment (according to the Wisconsin Department of Natural Resources). On the Fox River, *in situ* stabilization was implemented on sediments containing lead in a small scale application (500 tons of sediment treated) using a shoreline-based crane and clamshell. While the mixing process was reportedly successful at stabilizing the lead to a sufficient degree that the material would not be classified as a hazardous waste under RCRA, several stages of mixing were required, and the stabilized material was subsequently removed and transported to an off-site landfill, precluding any opportunity to record/monitor this project as a true *in situ* process. Issues with resuspension were reported during mixing, and the need for containment was noted if a similar mixing process were to be considered on a larger scale (Renholds, 1998).

According to the National Research Council in *A Risk Management Strategy for PCB-Contaminated Sediments,* (NRC, 2001), the lack of adequate process controls has relegated the use of *in situ* physical treatment to instances when the contaminated sediment can be isolated from the water body. Even if some sort of containment system such as cofferdams were used, the effects on groundwater/surface water interaction beneath the river bottom would need to be considered and its use may be limited by water depth and river bottom conditions. In addition, other substantial issues associated with using a containment system include: the presence of variable river bottom and debris which would interfere with the mixing process; the potential need for removal following stabilization to address any concerns regarding loss in flow capacity resulting from the addition of a stabilization agent; and the potential need to add cover material to provide a viable habitat for biota. It is likely that *in situ* physical treatment has not been attempted full-scale on river sediments because of the many factors that preclude effective implementation.

In light of the fact that *in situ* physical treatment processes have not yet been sufficiently developed to treat sediment *in situ* nor been successfully implemented full-scale for PCBs, coupled with the potential concerns regarding implementation noted above, there is insufficient precedent or technical information available to retain this technology as a potentially viable remedial option for the Housatonic River sediments at this time.

3.4.2 *In Situ* Chemical Treatment

In situ chemical treatment processes have not been successfully demonstrated full-scale for PCBs in sediment. The problems associated with implementation of *in situ* chemical treatment processes include:

- Lack of an effective delivery and homogenization system;
- Addressing toxicity associated with the chemical additives and/or byproducts of the treatment process;
- Difficulties in maneuvering about rocks and cobbles that may be on the river bottom for reagent delivery;
- Potential need for frequent and potentially sizeable on-shore staging areas to support application;
- Elevated biological oxygen demand that requires more oxidant than expected (Murphy et al., 1995);
- Difficulty in controlling the mixing reagent from spreading outside the targeted treatment area; and
- Lack of ability to control the mixing process such that mixing reagents and sediments are not released to the environment (EPA, 1994).

Current studies are underway at the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), founded by the National Oceanic and Atmospheric Administration (NOAA) and the University of New Hampshire, on an *in situ* sediment ozonator that may eventually have the potential to remediate PCBs *in situ*. However, at this time, the project remains in the research stages and has not been applied full-scale (Hong and Hayes, 2006). In addition, investigators at the University of New Hampshire are currently carrying out studies on *in situ* dechlorination of PCBs through application of zero-valent iron (ZVI) or magnesium. While these investigators' laboratory testing on sediments from the Housatonic River has shown promising results (e.g., 84% PCB removal in one day), mass balance analyses have not yet been able to account for all PCBs removed from the sediment (Mikszewski, 2004). As this technology is still in the experimental stage, no information is yet available on the performance of a demonstration-scale or full-scale application.

Oil-Free Technologies, Inc. (Oil-Free) has developed a proprietary enzyme mixture (Enzymmix) that is reported to be able to break down PCBs. Although this technology has not been demonstrated in a full-scale application for sediments, laboratory tests on soils have been performed. These tests have reportedly shown that Enzymmix, with multiple applications in a laboratory setting using soils, reduced PCB concentrations approximately 43% from an initial average concentration of 117 parts per million (ppm) (University at Albany, 2006); however, it is unknown what fraction of PCBs were lost to volatilization since the experiment was not conducted under air-tight conditions (EPA, 2005b). The vendor has indicated that diversion of river water with installation of a series of pipes installed in a 10-foot grid would be necessary as a potential procedure for applications to sediment. In fact, the Housatonic River Initiative (HRI) submitted a request to EPA to evaluate Enzymmix for possible application at the Housatonic River as part of EPA's SITE Demonstration Program.[8] Based on the information provided by HRI and the vendor, EPA concluded that the Oil-Free process would not be evaluated under the SITE Program due to incomplete data from previous studies and an absence of demonstrated performance (EPA, 2005c).

Further, the pilot-scale *in situ* chemical/biological study (via chemical injection of oxidants and/or nutrients) conducted on sediments from Hamilton Harbor (Canada) and the 1991 field research study conducted on Hudson River sediments to study the potential for *in situ* biological/chemical treatment of sediment both resulted in approximately 50% treatment efficiencies, which are low compared to treatment efficiencies of *ex situ* processes (Renholds, 1998).

In light of the fact that *in situ* chemical treatment processes have not yet been sufficiently developed for sediment *in situ* nor been successfully implemented full-scale for PCBs, coupled with the potential concerns regarding implementation noted above, there is insufficient precedent or technical information available to retain this technology as a potentially viable remedial option for the Housatonic River sediments at this time.

3.4.3 *In Situ* Biological Treatment

In situ biological treatment processes have not been successfully demonstrated full-scale for PCBs in sediment. The problems associated with implementation of *in situ* biological treatment processes include:

- Lack of an effective delivery system, including difficulties in maneuvering about rocks and cobbles that may be on the river bottom;
- Difficulty in identifying the microbes responsible for PCB biodegradation/dechlorination;

---

[8] EPA's SITE Demonstration Program was established by EPA's Office of Solid Waste and Emergency Response and Office of Research and Development (ORD), and is administered by ORD National Risk Management Research Laboratory in the Land Remediation and Pollution Control Division (LRPCD). The SITE Demonstration Program encourages the development and implementation of innovative treatment technologies for remediating hazardous waste sites, as well as measurement and monitoring technologies. In the demonstration program, a technology is field-tested and engineering and cost data are collected. EPA then documents the testing, including performance and cost data, provides an evaluation of all available information on the technology, and analyzes its overall applicability to other site characteristics/wastes (EPA, 2007a).

- Bioavailability of key contaminants such that the microorganisms feed on the target compounds rather than other substrates (Renholds, 1998);
- Lack of ability to achieve low ppm residual PCB concentrations in sediments;
- Lack of ability to establish/enhance variable sediment conditions (e.g., aerobic versus anaerobic, pH, etc.) sufficient to effectively support microbial degradation and/or dechlorination;
- Lack of ability to control the mixing process to mitigate impacts to the water column and surrounding environment;
- Potential need for frequent and potentially sizeable onshore staging areas to support application; and
- Overall resistance of PCBs to microbial degradation.

A field study was performed by GE in the Housatonic River to assess chemical activation of microbial dechlorination on Woods Pond sediments for approximately one year (Bedard et al., 1995, 1998). In this study, two caissons were driven 18 to 24 inches into the sediment, and the sediments in each caisson were mixed for homogenization twice prior to treatment. One cell was treated with 2,6-dibromobiphenyl (2,6-BB) as a microbial primer and the other was left untreated as a control. The preliminary results indicated that some dechlorination of highly chlorinated PCB congeners could be performed by native microbial populations with the addition of 2,6-BB, but significant changes in PCB concentration were not noted (Bedard et al., 1995). Further research exhibited positive results for accelerated *in situ* microbial dehalogenation of PCBs through use of brominated biphenyls, but progress was slowed by lack of naturally occurring and effective priming compounds, and again significant changes in PCB concentration were not noted (Bedard et al., 1998). Reasons that PCBs are resistant to microbial degradation include the following (Renholds, 1998):

- Preferential feeding of microorganisms on other substrates;
- Microorganisms' inability to use a compound as a source of carbon and energy;
- Unfavorable environmental conditions in sediments for propagation of appropriate microorganisms; and
- Poor contaminant bioavailability to microorganisms.

Recent research has identified specific anaerobic microorganisms (*Dehalococcoides*) that are capable of partially dechlorinating PCBs and obtain energy from this process (Bedard et al., 2007). However, this research is still in the early stages and the authors have indicated that more research is necessary before it can be determined if this technology can be implemented for full-scale *in situ* applications. In addition, the subject experiment looked at only an aqueous medium and did not consider any factors that would affect *in situ* sediment applications (e.g., desorption of PCBs). Further, the experiment used a fresh source of PCBs, but the PCBs found in the environment have been “aged,” which may affect the microorganisms’ ability to dechlorinate the biphenyl ring.

Overall, this recent research has shown that the microorganisms only partially dechlorinate PCBs, which may mean that the form of the PCBs might be altered without reduction in total PCB concentrations in the sediment. The research indicates that another mixed culture of organisms previously studied could continue the PCB dechlorination process; however, these two groups of microorganisms were not obtained from the same source/location (i.e., they have not been found together in the environment). Therefore, it is likely that the sediments of the Rest of River would need to be amended with non-native microorganisms for the dechlorination process to occur. In addition, the microorganism population had to grow to a minimum level before measurable dechlorination occurred in this study. The investigators indicated that this microorganism population level is not likely to occur naturally in a sediment environment (such as the Rest of River) and that further research would be required to determine the necessary changes to environmental conditions that could increase the microorganism population (Bedard et al., 2007).

In light of the fact that *in situ* biological treatment processes have not yet been sufficiently developed for sediments nor been successfully implemented full-scale for PCBs, coupled with the potential concerns regarding implementation noted above, there is insufficient precedent or technical information available to retain this technology as a potentially viable remedial option for the Housatonic River sediments at this time.

3.4.4 Summary of Evaluation of *In Situ* Treatment Technologies for Sediment

Based on the above evaluation, none of the *in situ* treatment technologies that were evaluated is considered a potentially viable remedial option for the Rest of River sediments at the present time. Although several of the technologies have been, in part, demonstrated at a bench- or pilot-scale level, none of the technologies has been successfully demonstrated full-scale with PCBs in sediment. The lack of success of these technologies in reducing PCB concentrations is governed in part by the fact that, by their nature, PCBs are persistent compounds.

Although each technology presents its own individual challenges, in general adding media (e.g., stabilization agent, chemical reagent, microorganisms, etc.) to sediment through the water column is difficult at best. According to the EPA, "developing an effective in-situ delivery system to add and mix the needed levels of reagents to contaminated sediment is more problematic" (EPA, 2005a). Delivery systems are affected by the depth of water and river bottom substrate; a layer of cobble and/or gravel at the sediment surface will likely be difficult to penetrate in these application situations. Many of these technologies may require multiple on-shore staging areas to promote application. Further, once the added media are introduced into a dynamic river system, it is difficult to control the endpoint of the application. Several of these technologies require significant mixing of sediment in order to promote success, and resuspension created by the mixing process may be difficult to control or manage in areas of variable river conditions (e.g., increased river velocities, uneven river bottom, deep water, etc.) There is a need for more successful bench/pilot-scale testing showing some promise at overcoming the challenges noted above before full-scale implementation is considered. However, GE will re-evaluate these technologies during the CMS if future information or test results become available indicating that any of them may prove to be a potentially effective and implementable option for application to the Rest of River sediments.

3.5 Evaluation of Identified *In Situ* Treatment Technologies for Soil

In the CMS Proposal, *in situ* physical treatment of floodplain soil was carried forward for secondary screening because it has been used at a limited number of sites with PCB-impacted soils. However, that process option was not retained for further evaluation in the CMS due a number of issues relating to its effectiveness and implementability. *In situ* chemical and thermal treatment processes for soil were screened out in the initial screening step because such process have not been successfully demonstrated full-scale to address PCBs in soil. Similarly, although aerobic and anaerobic biodegradation of PCBs are known to occur both naturally and through enrichment, *in situ* biological treatment for soil was also screened out in the initial screening step because no *in situ* biological processes or sites were identified in the literature where significant reductions in PCB concentrations have been documented. Additional information and justification for the screening of each of these *in situ* treatment process options for floodplain soil are provided in the following subsections.

3.5.1 *In Situ* Physical Treatment

In situ physical treatment (via immobilization) has been applied at a number of sites employing a variety of deep and shallow mixing techniques using Portland cement or some other stabilization agent to reduce the potential mobility of contaminants in soils through physical and/or chemical fixation of the contaminants (Lehr, 2004). Most of the documented *in situ* applications have been at sites containing a variety of PAHs and metals, and were done to address deep soils that would be difficult to excavate and/or performed in part to improve the geotechnical characteristics of the soil for subsequent redevelopment (Carleo et. al, 2006; Wilk, 2005; Wilk and DeLisio, 2002). The use of *in situ* physical treatment to address soils containing PCBs appears to be very limited, with only one site demonstration and one full-scale project identified through a literature search and discussions with vendors. A summary of those projects is provided below..

Physical immobilization was evaluated in 1988 through EPA’s SITE Demonstration Program at a GE service shop in Hialeah, FL. Contaminants of concern included PCBs at concentrations ranging up to 950 mg/kg, as well as a variety of volatile organic compounds (VOCs) and metals. The demonstration process involved deep soil mixing using Geo-Con equipment and International Waste Technologies (IWT) HWT-20 cementitious additive. The mixing process was based on a combination of an auger and caisson, which operated in the waste. The stabilization/solidification agent was fed into the auger and then into the waste through a hollow stem. Inside the caisson, the auger mixed the agent with the waste by a lifting and turning action (EPA, 1989). The test was performed on two 10x20 ft areas to depths up to 18 feet. Among the objectives, the study was designed to evaluate the extent to which the Geo-Con process could immobilize (i.e., reduce the leachability of) the PCBs in the soil, evaluate the performance and effectiveness of the mixing process, and assess the potential long term durability of the solidified mass. The conclusions drawn (EPA, 1990) were that:

(a) immobilization of PCBs appeared likely, although this could not be confirmed due to low PCB concentrations in the mixed soil (due to dilution through mixing with lower concentration soils and some dilution from the additive) and in the leachate from the treated and untreated soils;

(b) a modest volume increase of 8.5% occurred, which could provide land contouring difficulties in many locations;

(c) the solidified material showed satisfactory physical properties (e.g., unconfined compressive strengths, permeability, and integrity) indicating a potential for long-term durability, but unsatisfactory integrity for the freeze/thaw samples, with cumulative relative weight losses ranging from 0.5% to 30 % and averaging 6.3%; and

(d) a dense, low-porosity, monolithic block of treated waste was produced, which groundwater would flow around, not through.

In situ stabilization was also implemented as a final remedial component to address in-place soils at the Caldwell Trucking Site (NJ) (EPA, 2006a). The primary constituents of concern at the Caldwell site were lead, cadmium, and VOCs. PCBs were also detected in soil stabilized at the site at concentrations below 50 mg/kg. In total, approximately 40,000 cubic yards of soil were stabilized in place using an excavator, to depths up to 35 feet, using Portland cement. The stabilization process was suspended for 17 months due to high levels of odors and emissions coming from the soils, which were addressed through construction of a soil vapor extraction system. The treatment process created a large monolithic block of concrete/soil, which was bulked by approximately 20% (protruding above grade) due to the addition of concrete slurry. Once complete, a 2-foot soil cover was placed over the treatment area and seeded (Hebert, 2007). Although no specific data were found, review of a 5-year review report by EPA indicated that the stabilization of contaminated soil was "intact and in good repair," and that it "has greatly reduced the potential for exposure and mobility of site related contaminants" (EPA, 2002b).

Given its prior use at these sites (despite the considerations discussed above), *in situ* physical treatment of soils (via immobilization) was retained for secondary screening under the effectiveness and implementability criteria, as discussed below.

If applied to the Housatonic River floodplain soils, physical immobilization would involve mixing the floodplain soils *in situ* with Portland cement or some other stabilization agent to reduce the bioavailability of PCBs in the soils. For areas with extensive vegetation, clearing, grubbing, and site grading would be required prior to implementation. This option could be implemented alone or may need to be combined with other technologies/process options. For example, to maintain flood storage capacity in the area, soil removal might be required prior to soil stabilization so as to accommodate the increased volume that would be caused by the addition of the stabilization agent and/or to accommodate a soil cover, which may need to be placed over the stabilized soils to support vegetative growth. The impact of using certain stabilization agents on surface water/groundwater movement and interaction would also need to be considered.

Effectiveness – Physical immobilization could reduce the bioavailability of PCBs in floodplain soils, thereby reducing the potential for human or ecological exposure. For those sites noted above where *in situ* physical treatment has been implemented, the bioavailability was essentially reduced by converting the soils into a cement-like monolithic block. While a cement-like product may be acceptable at an industrial site where the potential for leaching to groundwater is the primary driver, use of such a product in the Housatonic floodplain would greatly inhibit the functional value of the soils, requiring a new soil cover to be placed over the top of the solidified material to sustain vegetation and provide habitat for floodplain organisms. Since the concentration of PCBs in the soil matrix is not significantly reduced through the physical immobilization process, the effectiveness of this technology using non-cement additives (if one were identified) at reducing the bioavailability to organisms which ingest soil is questionable, and would likely also require placement of a clean soil cover. Additional problems and challenges noted at the Hialeah site, which would also need to be considered for the Housatonic River floodplain soils, include volume increase and freeze/thaw integrity issues.

Implementability – It is currently assumed that the equipment, materials, and operating personnel needed to implement *in situ* physical treatment in the Housatonic River floodplain would be readily available. However, there could be some technical and administrative issues, such as incompatibility with future uses of floodplain soils and restoration options (i.e., may not be able to support vegetative growth), flood storage issues due to volume expansion during implementation of this option, and potential difficulty obtaining permission from property owners to carry out the immobilization on their properties. None of these were issues at the Hialeah, FL. and Caldwell, NJ sites, because both are industrial sites, and physical treatment was performed to support future site use without consideration for use and inhabitance by wildlife or potential wetlands restoration. Also, this option is best suited for deeper applications within a relatively small footprint, rather than a potentially large, shallow-depth application such as the floodplain soils of the Housatonic River. Unlike the Housatonic River floodplain soils, the use of *in situ* physical treatment at the Hialeah, FL. and Caldwell, NJ sites was driven by the presence of deep soils requiring remediation (up to 35 feet deep) and the fact that excavation to such depths was deemed impracticable. Finally, this option would be costly to implement given the relatively shallow vertical distribution of PCBs in the floodplain soil (which would make this an expensive remedy per unit area applied) and the likely need to remove material prior to or following implementation to accommodate flood storage capacity.

Due to potential effectiveness and implementation issues noted above and the relatively high implementation costs compared to other more proven and effective floodplain soil remedial options, physical immobilization has not been retained for further evaluation as a floodplain soil remedial option at this time.

3.5.2 *In Situ* Chemical Treatment

In situ chemical treatment processes have not been successfully demonstrated full-scale for PCBs in soil. EPA has noted that while injecting chemical surfactants/solvents to treat soils is common in oil field applications, “it has found limited application in the environmental arena” (EPA, 2006b).

Several chemicals that are known to break down PCBs have been identified in the laboratory. Fenton’s reagent, a form of chemical oxidation, has been found to be an effective method of remediating PCB-impacted soils through oxidation by hydroxyl radicals. The toxicity of the parent PCB, potential Fenton’s remediation byproducts, and the byproduct mixture may require further evaluation (Satoh et al., 2003). As another example, nanoscale zero-valent iron has been shown to dechlorinate PCB; however, a study reporting this noted that pilot and full-scale field tests are ultimately needed to further assess the appropriateness of these technologies (Mikszewski, 2004).

In addition, Oil-Free Technologies, Inc. has developed a proprietary enzyme mixture (Enzymmix) which is reported to be able to break down PCBs and which has been demonstrated in laboratory tests on soils. That technology was discussed in Section 3.4.2. As explained in that section, the effectiveness of this technology is uncertain since the tests were not conducted under air-tight conditions and hence the faction of PCBs lost to volatilization is unknown (EPA, 2005b). In addition, there is no documentation regarding the toxicological effects of the enzyme mixture, and it is unclear how its migration would be controlled or how it would be recovered from the subsurface. As noted above, in response to a request from HRI to evaluate Enzymmix for possible application at the Housatonic River site, EPA concluded that this process would not be evaluated under the SITE Demonstration Program due to incomplete data from previous studies and an absence of demonstrated performance (EPA, 2005c).

General problems associated with the implementation of *in situ* chemical treatment processes in soils include the following:

- Effectiveness can be greatly affected by site stratigraphy, soil oxidant demand, and pH;
- Multiple applications are needed when using chemical oxidants; some unreacted oxidants may remain in the subsurface (EPA, 2006b);

- Land disposal restrictions and underground injection-related regulations may limit the viability of using chemical treatment (EPA, 2006b); and
- Byproducts from oxidation may present additional toxicity issues that would need to be further evaluated as part of a bench scale and/or pilot study.

Given these problems, *in situ* chemical treatment is not considered a potentially viable remedial option for the Housatonic River floodplain soils at this time.

3.5.3 *In Situ* Biological Treatment

In situ biological treatment processes have not been successfully demonstrated full-scale for PCBs in soil. While aerobic and anaerobic biodegradation of PCBs are known to occur both naturally and through enrichment (e.g., through addition of nutrients and/or microbes which are know to degrade PCBs), no processes or sites were identified in the literature where significant reductions in PCB concentrations have been documented.

One study (Mikszewski, 2004) assessed the potential for anaerobic and aerobic biodegradation of PCBs. The study concluded that, despite years of research and many promising leads, an effective biodegradation *in situ* remediation technique for PCB-contaminated soils and sediments does not exist. It was also recognized by the author that the controversial use of genetically modified organisms (such as used in this research) must be carefully monitored.

In 1998, Green Mountain Laboratories, Inc. (GML) and the EPA conducted a SITE project to evaluate the effectiveness of a bioremediation process for the treatment of PCB contaminated soils at the Beede Waste Oil/Cash Energy Superfund site in Plaistow, NH. The treatment process involved inoculation/augmenting of the PCB contaminated soils with bulk microbial inoculum and nutrients, allowing the microbes to aerobically degrade the PCBs. The bulk inoculum was produced on-site by the developer using animal feed-grade oatmeal as the substrate, shredded pine needles that provided certain specific co-metabolite compounds, nutrients and a proprietary consortium of microorganisms believed capable of degrading the PCBs to their eventual endpoints (carbon dioxide and mineral halides). The results of the field evaluation of the technology, which are based on the data collected from the treatability study conducted in the third quarter of 1998, indicated no removal/degradation of the PCBs (EPA, 2005a).

In general, the problems associated with implementation of *in situ* biological treatment processes in soils include:

- Lack of an effective nutrient/chemical delivery and containment system for materials injected or mixed into the soils to promote degradation (Renholds, 1998);
- Difficulty in identifying the microbes responsible for PCB biodegradation/dechlorination;
- Inability to achieve low ppm residual PCB concentrations;
- Inability to establish/enhance variable sediment conditions (e.g., aerobic versus anaerobic, pH, etc.) to a sufficient degree to effectively support microbial degradation and/or dechlorination; and
- Overall resistance of PCBs to microbial degradation.

Given these problems, *in situ* biological treatment of soils has not been retained as a potentially viable remedial option for the Housatonic River floodplain soils at this time.

3.5.4 *In Situ* Thermal Treatment

In situ thermal treatment has been pilot tested at several sites containing PCBs. The technology was applied in a field application in Glens Falls (NY), where near-surface PCBs were detected at concentrations up to 5,000 ppm. Following treatment, PCB concentrations were reportedly reduced to less than 2 ppm (TerraTherm Environmental Services, 1997). In another case study, *in situ* thermal treatment was tested at a 30-acre Naval facility in Ferndale, CA, which contained PCBs in soils at concentrations up to 860 ppm. From September 1998 to February 1999, approximately 1,000 cubic yards (cy) of PCB-impacted soils were treated using *in situ* thermal treatment. Treatment goals were met in the bulk of the treatment area with the exception of one portion (178 cy) where elevated PCB concentrations remained (EPA, 2007b).

Despite these pilot tests, *in situ* thermal treatment processes have not been implemented full-scale to address PCBs in floodplain soils similar to those in the Rest of River. The problems with such application of *in situ* thermal treatment processes include the following:

- The process boils off water in the soil before it boils off the contaminants (the maximum achievable temperature is 212 degrees Fahrenheit (°F) until all of the water is boiled off). In locations where the control of soil moisture would be difficult (e.g., such as in soils that are saturated by surface waters), this technology cannot be used effectively unless the soils are excavated and treated above ground. Therefore, the high temperatures would likely need to be applied over a period of days depending on the water content of the soils being treated (Iben et al., 1996).

- *In situ* thermal treatment would require the installation of numerous electrodes and/or injection/extraction wells to allow for sufficient coverage. If thermal treatment were applied to the floodplain soils at temperatures sufficient to volatilize or destroy the PCBs (700 to 900 degrees Celsius [°C]), the soils would need to be amended with nutrients or removed/covered with new soil (if vitrified) following treatment to support vegetative growth.

- The effectiveness of *in situ* thermal treatment can be limited by the presence of large inclusions in the area to be treated. Inclusions are highly concentrated contaminant layers, void volumes, containers, metal scrap, general refuse, demolition debris, rock, or other heterogeneous materials within the treatment volume.

- Thermal treatment could vitrify the soils, which would form a glass-like monolithic product. The treated material may not readily support vegetative growth following treatment. If needed, the addition of soil on top of the treated material to support vegetative growth would reduce the available floodplain storage capacity.

Given these problems and potential drawbacks with applying *in situ* thermal treatment to floodplain soils, coupled with the lack of use of this technology full-scale at a similar site, *in situ* thermal treatment of soil has not been retained at this time as a potentially viable remedial option for the Rest of River floodplain soils.

3.5.5 Summary of Evaluation of *In Situ* Treatment Technologies for Soil

Since *in situ* physical treatment (immobilization) has been applied at a limited number of PCB sites, it was subject to secondary screening. However, it was eliminated during the secondary screening because it may be incompatabile with future floodplain uses and vegetative restoration options, may cause flood storage or freeze/thaw issues due to volume expansion during implementation, and is best suited for deeper applications within a relatively small footprint, rather than a potentially large, shallow-depth application such as the Rest of River floodplain soils. *In situ* biological, chemical, and thermal treatment processes were eliminated during initial screening because none of these technologies has been applied full-scale for soils containing PCBs at a site similar to the Housatonic River floodplain and because each has additional implementation issues as described above. Nevertheless, GE will re-evaluate these technologies during the CMS if future information or analyses become available indicating that any of them may prove to be a potentially effective and implementable option for application to the Rest of River floodplain soils.

4. Plan for Conducting Phase I Cultural Resource Evaluation

EPA's Conditional Approval Letter contains the following comment:

- **General Condition 3.** *GE shall submit (in the Supplement) a plan for conducting a Phase I Cultural Resource Evaluation as required for compliance with Section 106 of the National Historic Preservation Act (NHPA).*

In response to this comment, GE has retained URS Corporation to prepare a Phase I Cultural Resources Assessment Work Plan. That Work Plan is provided as Appendix A to this Supplement. It calls for a detailed literature review and collection of available background information on potential archaeological or historic resources that may be present within the area where active remediation is being considered – i.e., the Housatonic River and floodplain from the Confluence to Rising Pond Dam. It also provides for an on-site reconnaissance of that area and preparation of GIS-based sensitivity maps of the area, showing locations that contain or have a high potential to contain archaeological or historic resources.

As described in the Work Plan, the information resulting from these activities will be presented in a Phase I Cultural Resources Assessment Report, to be submitted concurrently with the CMS Report. That Report will also identify additional data needs and will include a plan for conducting further investigations and evaluations, once the scope and extent of remediation is known, to determine whether any archaeological or historic resources are actually present in the areas targeted for remediation, whether such resources are potentially eligible for inclusion in the National Register of Historic Places, and whether the remediation could have an adverse impact on such resources.

5. Methodology for Developing Target Floodplain Soil Concentrations Associated with the IMPGs for Mink

5.1 Introduction

This section of the Supplement addresses the following EPA comment:

- **General Condition 14.** *Reasonable assumptions can be made regarding the items in the mink diet using the assumptions made in the ERA. GE shall provide an evaluation of protection of mink (by comparison to the IMPG) in the CMS. GE shall submit (in the Supplement) a proposed methodology (similar to that proposed for Insectivorous Birds in Appendix B) using the assumptions in the ERA for determining floodplain soil PCB concentrations consistent with the IMPGs for mink.*

The IMPGs approved by EPA for piscivorous mammals (mink and otter) include a range of 0.984 to 2.43 mg/kg for PCBs, applicable to the dietary items of those mammals (GE, 2006a). These IMPGs were based on an assessment of potential risks to the American mink (*Mustela vison*), as described in EPA's Ecological Risk Assessment (ERA; EPA, 2004). In the CMS Proposal, GE noted that the components of the mink's diet are so diverse and unspecified that it would be difficult to convert the IMPGs for mink into concentrations in a medium that will be evaluated in the CMS; and thus GE proposed to use the assumed diet of a river otter (which consists primarily of fish) for application of the IMPGs for piscivorous mammals. However, as noted above, EPA has directed GE to use the IMPGs for mink in the CMS evaluations, and to develop a proposed methodology for determining target floodplain soil levels consistent with those IMPGs, using assumptions in the ERA. This section describes that methodology.[9]

Since the mink IMPGs are based on diet, they apply to PCB concentrations in mink prey, which consist of both aquatic and terrestrial organisms. The proposed approach converts these tissue concentrations into floodplain soil concentrations by first selecting a range of target sediment PCB concentrations that fall within the range of other sediment IMPGs (e.g., based on human direct contact and other ecological receptors), and then by

---

[9] The methodology described in this section is based on PCB concentrations and pertains to the IMPGs for PCBs. Although IMPGs for piscivorous mammals were also derived for dioxin toxicity equivalents (TEQs), EPA's Conditional Approval Letter indicated that, for the purposes of evaluating remedial alternatives in the CMS, the use of total PCBs is acceptable (General Condition 27).

calculating target floodplain soil concentrations associated with achieving the high and low ends of the dietary IMPG range (rounded to 0.98 and 2.4 mg/kg PCBs) in mink prey, assuming that the sediment PCB concentrations are at the selected target values. The selected target sediment PCB concentrations are 1, 3, 5, and 10 mg/kg.

The underlying equations, assumptions, and results of this analysis are detailed below. The target PCB concentrations have been developed for the Housatonic River floodplain from data obtained in the PSA, which consists of Reaches 5 and 6. The target concentrations assume conservatively that the mink forage exclusively within the Rest of River floodplain, rather than also in areas outside the floodplain (i.e., outside the 1 mg/kg PCB isopleth), even though foraging in tributaries and uncontaminated areas is in fact likely. The resulting target concentrations will thus be adjusted in the CMS, as appropriate, to account for the proportion of the mink's foraging range within the floodplain, and, with such adjustments, can be used not only in the PSA but also for evaluating remedial alternatives in further downstream reaches.

5.2 Derivation of Equation for Target Soil PCB Concentrations

The objective was to derive an equation that estimates target soil PCB concentrations protective of mink at a given target sediment PCB concentration. Such an equation must account for the uptake of PCBs by mink from both the river sediments and floodplain soils. The equation must subtract the mink's uptake of PCBs from aquatic prey items (after remediation of the sediments to 1, 3, 5, or 10 mg/kg) from the allowable oncentration in the prey (based on the IMPGs) to determine the allowable uptake of PCBs from terrestrial prey items. The derivation of such an equation requires first quantifying the fraction of each prey item in the mink's diet and the associated PCB tissue concentration to estimate the total PCB concentration in the prey.

The diet-based IMPG is related to PCB concentrations in the aquatic and terrestrial prey of mink as follows:

$$C_p = (P_i \times C_i) + (P_f \times C_f) + (P_a \times C_a) + (P_{ab} \times C_{ab}) + (P_{tb} \times C_{tb}) + (P_{am} \times C_{am}) + (P_{tm} \times C_{tm}) \qquad \text{Eqn. 1}$$

where

C_p = target PCB concentration in mink prey, set equal to the EPA-approved IMPG values (mg/kg)
P_i = proportion of diet from aquatic invertebrates
P_f = proportion of diet from fish

P_a= proportion of diet from amphibians and reptiles
P_{ab}= proportion of diet from aquatic birds
P_{tb}= proportion of diet from terrestrial birds
P_{am}= proportion of diet from aquatic mammals
P_{tm}= proportion of diet from terrestrial mammals

C_i= PCB concentration in aquatic invertebrates (mg/kg)
C_f= PCB concentration in fish (mg/kg)
C_a= PCB concentration in amphibians and reptiles (mg/kg)
C_{ab}= PCB concentration in aquatic birds (mg/kg)
C_{tb}= PCB concentration in terrestrial birds (mg/kg)
C_{am}= PCB concentration in aquatic mammals (mg/kg)
C_{tm}= PCB concentration in terrestrial mammals (mg/kg)

This equation is similar to the one used in Section 3.7 of the revised IMPG Proposal (GE, 2006a), except that birds and mammals are split into aquatic and terrestrial components to account for the separate source of PCBs for these groups. Because the aquatic birds in the diet (mainly waterfowl) feed partially on terrestrial invertebrates and partially on aquatic invertebrates, the aquatic birds were further divided and the equation becomes:

$$C_p = (P_i x\, C_i) + (P_f\, x\, C_f) + (P_a\, x\, C_a) + P_{ab}[(P_{aba}\, x\, C_{aba}) + (P_{abt}\, x\, C_{abt})] + (P_{tb}\, x\, C_{tb}) + (P_{am}\, x\, C_{am}) + (P_{tm}\, x\, C_{tm}) \quad \text{Eqn 2}$$

where

P_{aba} = proportion of aquatic bird diet that is from aquatic invertebrates
P_{abt} = proportion of aquatic bird diet that is from terrestrial invertebrates
C_{aba}= PCB concentration in aquatic bird diet that is from aquatic invertebrates (mg/kg)
C_{abt} = PCB concentration in aquatic bird diet that is from terrestrial invertebrates (mg/kg)

The portion of the wood duck's diet that is vegetation (24%) is not included because it is assumed PCB accumulation through that route is minimal compared to bioaccumulation from the invertebrates.

The uptake equation was reversed (back-calculated) to derive protective PCB concentrations for both sediment and soil. Bioaccumulation factors were used to accomplish this back-calculation. For the sediment, these factors represent the relationship between lipid-normalized concentration of PCBs in aquatic prey and organic carbon-normalized concentration of PCBs in sediment (Ankley et al., 1992). Using invertebrate prey of the mink as an example, the biota-sediment accumulation factor (BSAF) is as follows:

$$BSAF_i = (C_i / LIPID_i) / (C_{sed} / FOC) \qquad \text{Eqn. 3}$$

Where

$BSAF_i$= biota-sediment accumulation factor for invertebrates (kg organic carbon/kg lipid)
C_i= PCB concentration in invertebrate tissue (mg/kg)
$LIPID_i$= fraction of body weight in lipids for invertebrates
C_{sed}= concentration of PCBs in sediment (mg/kg)
FOC= fraction of total organic carbon in sediment

Solving Equation 3 for invertebrate prey PCB concentration, C_i , yields:

$$C_i = BSAF_i \times C_{sed} \times 1/FOC \times LIPID_i \qquad \text{Eqn. 4}$$

Unlike bioaccumulation factors for sediment (BSAFs), typically bioaccumulation factors (BAFs) for soil are not based on normalized tissue and soil concentrations. Using terrestrial mammal prey as an example, the BAF is calculated as follows:

$$BAF_{tm} = C_{tm}/C_{soil} \qquad \text{Eqn. 5}$$

where

C_{tm} = concentration in terrestrial mammal tissue
BAF_{tm} = soil-to-terrestrial mammal bioaccumulation factor (kg organic carbon/kg lipid)
C_{soil} = concentration of PCBs in floodplain soil (mg/kg)

Solving Equation 5 for concentration of PCBs in terrestrial mammal prey yields

$C_{tm} = BAF_{tm} \times C_{soil}$ Eqn. 6

Equations 4 and 6 can be developed for each prey item in the same way. The prey concentration equations for each prey item are then substituted into Equation 2, which is an intermediate step required before developing the target soil concentration:

$$C_p = [(P_i \times BSAF_i \times C_{sed} \times 1/FOC \times LIPID_i) + (P_f \times BSAF_f \times C_{sed} \times 1/FOC \times LIPID_f) + (P_a \times BSAF_a \times C_{sed} \times 1/FOC \times LIPID_a) + (P_{ab} \times P_{aba} \times BSAF_{ab} \times C_{sed} \times 1/FOC \times LIPID_{ab}) + (P_{ab} \times P_{abt} \times BAF_{ab} \times C_{soil}) + (P_{tb} \times BAF_{tb} \times C_{soil}) + (P_{am} \times BSAF_{am} \times C_{sed} \times 1/FOC \times LIPID_{am}) + (P_{tm} \times BAF_{tm} \times C_{soil})]$$

Eqn. 7

where

$BSAF_f$ = biota-sediment accumulation factor for fish
$BSAF_a$= biota-sediment accumulation factor for amphibians
$BSAF_{ab}$= biota-sediment accumulation factor for aquatic birds
$BSAF_{am}$= biota-sediment accumulation factor for aquatic mammals
BAF_{tb}= bioaccumulation factor for terrestrial birds
$BAFt_m$= bioaccumulation factor for terrestrial mammals

$LIPID_f$ = lipid content for fish (proportion)
$LIPID_a$= lipid content for amphibians (proportion)
$LIPID_{ab}$= lipid content for aquatic birds (proportion)
$LIPID_{am}$= lipid content for aquatic mammals (proportion)

Solving Equation 7 for C_{soil} yields:

$$C_{soil} = \{C_p - C_{sed} \times 1/FOC \times [(P_i \times BSAF_i \times LIPID_i) + (P_f \times BSAF_f \times LIPID_f) + (P_a \times BSAF_a \times LIPID_a) + (P_{ab} \times P_{aba} \times BSAF_{ab} \times LIPID_{ab}) + (P_{am} \times BSAF_{am} \times LIPID_{am})]\} / [(P_{ab} \times P_{abt} \times BAF_{ab}) + (P_{tb} \times BAF_{tb}) + (P_{tm} \times BAF_{tm})]$$

Eqn. 8

Equation 8 was then used to calculate the target soil concentration associated with the high and low IMPG values of 0.98 and 2.4 mg/kg for the prey of mink, based on the following input data and assumptions regarding each of the equation's variables.

5.3 Input Data and Assumptions

Input values were preferentially selected based on site-specific data from Reaches 5 and 6, as presented in the ERA, the RFI Report (BBL and QEA, 2003), and supporting studies and datasets. In a few cases, where site-specific data were not available, data from another PCB river/floodplain site, the Kalamazoo River in Michigan, were used. The input values used in the analysis are listed in Table 5-1, with backup supporting information provided in Tables 5-2 through 5-8. The input data and assumptions are detailed below.

Foraging Range of Mink

The method conservatively assumes that 100% of the foraging range of mink is contained within the floodplain, even though the percentage mostly likely is less.

Acceptable PCB Concentration in Diet

C_p – The target PCB concentrations in the mink diet were set equal to the high and low ends of the EPA-approved IMPG range, 0.98 and 2.4 mg/kg, as described in the revised IMPG Proposal (GE, 2006a).

Dietary Composition

P - The proportion of each prey type in the diet was based on the values used in the ERA (Vol. 6, Table I.2-2). Representative species for each prey type were chosen in order to develop bioaccumulation factors. The selection of representative species was based on the data available and presented in ERA Appendix I (Table I.2-1).

The mink diet data provided in the ERA indicated that mink could consume both aquatic and terrestrial birds and mammals. The muskrat (*Ondatra zibethicus*), a primary aquatic mammal in the mink diet (based on volumetric data in Table I.2-2 in ERA), was used to represent the aquatic mammals. The short-tailed shrew (*Blarina brevicauda*) and white-footed mouse (*Peromyscus leucopus*) represented the terrestrial mammals in the diet. The wood duck (*Aix sponsa*) represented the aquatic-feeding birds, and the house wren (*Troglodytes aedon*), black-capped chickadee (*Poecille atricapilla*), and American robin (*Turdus migratorius*) represented the terrestrial-feeding birds. Tissue PCB concentration data were available for each of those species. The percentages of aquatic and terrestrial birds in the mink diet were based on mean percentages averaged across diet studies in Table I.2-1 of the ERA.

The specific species and proportions of each dietary item were set as follows:

P_i – the proportion of the mink diet consisting of aquatic invertebrates represented by crayfish = 0.36
P_f – the proportion of the mink diet consisting of fish represented by fish in the size class of 7 to 20 cm = 0.23
P_a – the proportion of the mink diet consisting of amphibians and reptiles represented by wood frogs, leopard frogs, and bullfrogs = 0.15
P_{ab} – the proportion of the mink diet consisting of aquatic-feeding birds represented by the wood duck = 0.08
P_{tb} – the proportion of the mink diet consisting of terrestrial-feeding birds = 0.03
P_{am} – the proportion of the mink diet consisting of aquatic mammals represented by the muskrat = 0.07
P_{tm} – the proportion of the mink diet consisting of terrestrial mammals represented by shrews and mice = 0.08

Additionally, a proportion of the wood duck invertebrate diet is aquatic (0.74) and a proportion is terrestrial (0.26) (Vol. 5, Table G.2-33 in ERA), requiring splitting of the aquatic bird percentage into a terrestrial and aquatic component:

P_{aba} – the proportion of the wood duck invertebrate diet consisting of aquatic invertebrates = 0.74
P_{abt} – the proportion of the wood duck invertebrate diet consisting of terrestrial invertebrates = 0.26

Biota Accumulation Factors for Sediment

For aquatic-feeding prey items except fish and birds (i.e., invertebrates, amphibians, and mammals), bioaccumulation was estimated based on the median BSAFs. The median was used because the BSAFs were not normally distributed, and hence use of the median avoids the undue influence of high and low outlying values on the mean. For fish, a regression-based approach using the predictions from the EPA bioaccumulation model, which computes concentrations for an average fish, was used. For aquatic birds, which have large foraging ranges, the BSAF was based on spatially-weighted averages of concentrations in sediment and soil. The derivation of BSAFs for each prey item is discussed below.

$BSAF_i$ - The BSAF for aquatic invertebrates was derived from the values computed in the RFI Report (Figure 8.34), developed using PCB concentrations and lipid measurements in site-specific crayfish tissue. River sediment total PCBs and FOC were averaged and co-located with crayfish tissue concentrations by river mile to calculate a median BSAF. Crayfish were used because they are listed as the primary aquatic invertebrate in the mink diet for many studies (Table I-2.1 in ERA). In all analyses, half of the Method Detection Limit was used for non-detects of analytes.

$BSAF_f$ –The food chain model (FCM) developed by EPA for the Rest of River modeling (Weston, 2006) was used to estimate uptake of PCBs from sediment to fish. That model accounts for many factors including both the lipid content in fish and FOC in the sediments. To estimate the BSAF for fish from the FCM, regressions of lipid-normalized fish PCB concentrations and OC-normalized sediment PCB concentrations were developed. Sediment exposure concentrations and model-predicted fish concentrations were averaged over the autumn period for each year of the 26-year model validation period. The individual species simulated by the FCM were averaged to produce a composite exposure concentration based on an assumed mink fish diet of 2/3 predatory fish (largemouth bass in the model) and 1/3 bottom and forage fish (average of model results for brown bullhead, sunfish, white sucker, and cyprinids), based on Alexander (1977).

Fish sizes were limited to age classes that correspond to the sizes eaten by mink, 7 to 20 cm. The FCM outputs from Reaches 5A, 5B, 5C, and 6 for these fish age classes were averaged into a river-length weighted $BSAF_f$. Fish tissue PCB concentrations calculated were lipid-normalized and divided by organic-carbon normalized PCBs (mg PCB/kg OC) in the main channel in Reaches 5 and 6 based on the assumption of sediment concentrations of 1, 3, 5, and 10 mg/kg. In addition, since mink feed frequently in backwater areas, PCBs and FOC in the backwater areas adjacent to the lower portion of Reach 5 were included when calculating predicted concentrations in the fish tissue.

$BSAF_a$ – It is assumed most of the amphibians and reptiles in the diet originated from aquatic sources. The BSAF for amphibians was developed using site-specific wood frog, leopard frog, and bullfrog tissue PCB concentrations and percent lipid co-located with pond-specific and/or location-specific (in Woods Pond) sediment data (from samples collected at depths of 0 to 6 inches). Pooling the data for all frogs, the percent lipid values were averaged, and the median BSAF was calculated.

$BSAF_{am}$ – Given the absence of site-specific data on aquatic mammals, the BSAF for aquatic mammals was obtained from data collected for the Kalamazoo River, Michigan, in an area that has PCBs in the sediments and floodplain soils (see Table 5-6). Data used for the calculation of the BSAF came from muskrat tissue and sediment (top 6 inches) located within the foraging range of each muskrat trapping location. The median BSAF was used.

$BSAF_{ab}$ – The $BSAF_{ab}$ represents the bioaccumulation of PCBs by the wood duck based on consuming aquatic invertebrates, whereas the BAF_{ab} represents the bioaccumulation by the wood duck based on consuming

terrestrial invertebrates. To derive the equation to calculate the $BSAF_{ab}$ required two steps. First, to treat terrestrial and aquatic uptake of PCBs in the same manner when estimating bioaccumulation in an individual duck, the terrestrial BAF ($BAF_{ab}*$) of the wood duck was normalized for lipid content and FOC in the soil as follows:

$$BAF_{ab}* = (C_{ab}/LIPID_{ab}) / (C_{soil} / FOC_{soil}) \qquad \text{Eqn. 10}$$

where

FOC_{soil} = fraction of total organic carbon in soil
$BAF_{ab}*$ = lipid and organic carbon-normalized bioaccumulation factor from soil to wood duck

The uptake of PCBs into the duck from PCBs originating in the soil is assumed to be affected by lipid content and soil FOC for consistency.

Second, the lipid- and organic carbon-normalized BAF for the soil ($BAF_{ab}*$) is assumed to equal the $BSAF_{ab}$ for the sediment because invertebrates are used as the prey of the wood duck for both soil and sediment and the normalization is assumed to account for most of the factors that affect PCB uptake.

The derivation of the equation for $BSAF_{ab}$ is as follows:

$$C_{ab} = C_{abt} + C_{aba}$$

By substitution, this becomes:

$$C_{ab} = [P_{abt} \text{ x } C_{soil} \text{ x } (LIPID_{ab}/FOC_{soil}) \text{ x } BAF_{ab}*] + [P_{aba} \text{ x } C_{sed} \text{ x } (LIPID_{ab}/FOC_{sed}) \text{ x } BSAF_{ab}] \qquad \text{Eqn. 11}$$

where

FOC_{sed} = fraction of total organic carbon in sediment
FOC_{soil} = fraction of total organic carbon in soil

Solving for $BSAF_{ab}$ yields

$$BSAF_{ab} = BAF_{ab}^* = C_{ab}/\{LIPID_{ab} \times [(P_{abt} \times C_{soil}/FOC_{soil}) + (P_{aba} \times C_{sed}/FOC_{sed})]\} \qquad \text{Eqn. 12}$$

The derivation of the equation for the terrestrial component of the wood duck, $BAF_{ab,}$ is as follows:

$$BAF_{ab}^* = BAF_{ab} \times (FOC_{soil}/LIPID_{ab}) \qquad \text{Eqn. 13}$$

Thus

$$BAF_{ab} = BAF_{ab}^* \times (LIPID_{ab}/FOC_{soil}) \qquad \text{Eqn. 14}$$

The $BSAF_{ab}$ for aquatic birds feeding on aquatic invertebrates was developed using (1) the average of PCB concentrations divided by the average lipid content of wood ducks and (2) the spatially-weighted average PCB and FOC concentrations in the sediment (top 0 to 6 inches) from Thiessen polygons (see Appendix B, Table B-4 of the CMS Proposal for TOC data). Because only breast and liver tissue data were available, whole-body PCB estimates were calculated using the equation in the ERA (Appendix I, Section I.2.1.5.3). It was assumed the lipid-normalized breast tissue PCB concentrations are the same as the lipid-normalized offal concentrations.

Concentrations in Sediment

C_{sed} - The target concentrations, C_{sed} and C_{soil}, are inter-related, creating two unknowns in a single formula. Therefore, C_{sed} was fixed at 1, 3, 5, and 10 mg/kg and Equation 8 was solved for corresponding C_{soil} values.

Lipid Estimation

The lipid content of aquatic prey species described above to calculate BSAFs were averaged across individuals of each species to obtain the species-specific lipid content. The lipid data for each species are presented in Tables 5-2 to 5-8.

Fraction Organic Carbon Estimation

FOC in sediments of ponds, the river, and backwaters was estimated using the spatially-weighted averages of the FOC data from Reach 5 and Reach 6 (0.066 and 0.085, respectively).

Bioaccumulation Factors for Soil

BAFs are used to estimate uptake between soil and terrestrial receptors. BAFs were calculated for terrestrial-feeding birds and mammals. For example, the bioaccumulation factors for terrestrial-feeding birds (BAF_{tb}) and mammals (BAF_{tm}) were based on the following equations and are then described:

$$BAF_{tb} = C_{tb}/C_{sed} \qquad \text{Eqn. 15}$$

$$BAF_{tm} = C_{tm}/C_{sed} \qquad \text{Eqn. 16}$$

BAF_{tb} - The bioaccumulation factor for adult terrestrial birds could not be calculated entirely from site-specific data because adult tissue PCB concentrations were unavailable. However, PCB concentrations were available for eggs of three species: American robins, house wrens, and black-capped chickadees. The house wren and black-capped chickadee eggs were obtained in tree swallow boxes in three main nest box locations described in the ERA, and the robin eggs were obtained during a robin productivity study (Arcadis G&M, 2003). To estimate PCB concentrations in the adults, the ratio of PCBs in house wren adults relative to house wren eggs observed in the Kalamazoo River (0.51; Neigh et al., 2006) was applied to the egg PCB estimates for the Housatonic River floodplain. Map coordinates of the wren and chickadee eggs were not recorded but coordinates for the tree swallow boxes were known. Thus, to co-locate soil PCB concentrations (top 0 to 6 inches) with tissue concentrations for these species, the soil PCB data were spatially-weighted and averaged in a 1-ha area buffered around all nest boxes in each of the three main nest box locations (Table 5-7). For robins, the average soil PCB concentration within 25 m of the nest was used.

BAF_{tm} - The bioaccumulation factor for terrestrial mammals (BAF_{tm}) was based on short-tailed shrew and white-footed mouse tissue co-located with floodplain soil. The median BAF of the combined dataset for shrews and mice was used.

In addition, as stated above, the bioaccumulation factor for the wood duck (BAF_{ab}) based on consuming terrestrial invertebrates was calculated using Equation 14. Within the floodplain, the soil concentration of PCBs and FOC used for the wood duck BAF was a spatially-weighted average. The wood duck tissue PCB concentrations and lipid content were averaged across the floodplain.

5.4 Results

Based on the inputs and equations described in Section 5.3, the estimated target floodplain soil PCB concentrations associated with the four target sediment concentrations range from 0 to 10 mg/kg for the low-end IMPG of 0.98 mg/kg and from 1 to 27 mg/kg for the high-end IMPG of 2.4 mg/kg, depending on the target sediment concentration (Table 5-9).

Table 5-9. Estimated Target Floodplain Soil PCB Concentrations.

Target Sediment PCB Concentration (mg/kg)	Target Soil PCB Concentration (mg/kg) for IMPG = 0.98 mg/kg	Target Soil PCB Concentration (mg/kg) for IMPG = 2.4 mg/kg
1	9.6	27.4
3	3.9	21.7
5	0.0	16.0
10	0.0	1.7

5.5 Discussion

The dietary IMPG range of 0.98 to 2.4 mg/kg was based on results from EPA's survival study of 6-week old mink kits, as presented in the ERA. The lower end of this range corresponds to the LC_{20} and the higher end of the range was based on the geometric mean of the no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL) (GE, 2006a). The results of the present analysis show that for target concentrations of PCBs in sediment in the 1 to 3 mg/kg range, the lower bound of the dietary IMPG can be achieved with floodplain soil concentrations in the 4 to 10 mg/kg range. However, the model predicts that the low dietary IMPG cannot be achieved in the floodplain where sediment concentrations of PCBs are 5 mg/kg or higher. The high bound of the dietary IMPG range can be achieved by floodplain soil concentrations in the 16 to 27 mg/kg range when sediment concentrations are 1 to 5 mg/kg, and by a soil concentration of 1.7 mg/kg when the sediment concentration is at 10 mg/kg. For both IMPGs, the targets become negative at concentrations above 10 mg/kg and actually are negative at 5 and 10 mg/kg for the low IMPG (-1.9 and -15.1, respectively, which were replaced with 0).

The model is sensitive to changes in the BAFs and BSAFs. At low target sediment concentrations, the model output is more sensitive to estimates of the terrestrial BAFs than the aquatic BSAFs, particularly considering that tissue concentrations of PCBs in terrestrial birds and mammals are higher on average than for aquatic animals (Tables 5-2 to 5-8). However, at higher sediment concentrations, the aquatic animals, particularly the fish, have a stronger influence. The model is also sensitive to large changes in the sediment FOC, which varies greatly between the river and backwaters. For this reason, it is important to include the backwater habitat of the mink in the model. Uncertainty exists with the terrestrial passerine data, because only nest (eggs and chicks) data were available, and the ratio applied to the egg concentrations to obtain adult concentrations was obtained from data from the Kalamazoo floodplain (Neigh et al., 2006). Similarly, BSAFs for muskrat were based on data from the Kalamazoo River.

Use of the FCM to obtain fish tissue concentrations of PCBs has some limitations. First, for many of the fish species included in the analysis (e.g., sunfish), tissue concentrations are more closely correlated with PCB concentrations in the water column than with those in sediment. As a result, PCB concentrations in tissue samples from these species may be lower than those predicted by the linear relationship with sediment in the predictive model. Second, the range of Reach 5 and 6 sediment exposure concentrations for which the FSM was calibrated is much higher than the target sediment concentrations of 1 to 10 mg/kg. Supplemental analyses suggest the model could underestimate bottom-fish concentrations (e.g., suckers, bullheads) at low sediment concentrations by up to a factor of two. Third, the accuracy of the model in predicting fish tissue concentrations in the backwaters is unknown because no fish have been collected in those areas to compare to model results.

As noted above, the model assumes that mink forage exclusively within the Rest of River floodplain. In fact, however, very few mink likely forage entirely within the floodplain (i.e., within the 1 mg/kg isopleth) without also foraging within tributaries and other areas outside the Rest of River. Thus, in applying this model in the CMS, adjustments will be made to account for proportion of the mink's foraging range within the contaminated floodplain, considering factors such as the size of the watersheds of uncontaminated tributaries and floodplain width.

In conclusion, the estimated target floodplain soil PCB concentrations that are associated with the four selected target sediment concentrations range from 0 to ~ 10 mg/kg based on the low-end dietary IMPG and from ~ 1 to 27 mg/kg based on the high-end dietary IMPG. These results are based mainly on site-specific data and assumptions presented in the ERA and supporting studies, and are conservative given the assumption that the mink forage entirely within the contaminated floodplain. With appropriate adjustments to account for the proportion of the mink's foraging range within the floodplain, the target soil concentration estimates will be used both in the PSA and, where relevant, in further downstream reaches as comparison points for evaluating floodplain remedial alternatives. Additionally, the model equation discussed herein may be rearranged to calculate target sediment concentrations of PCBs given assumed target floodplain soil PCB levels. This may be useful for other applications in the CMS.

6. Revised Sediment Remediation Alternatives

EPA's Conditional Approval Letter contains the following comments:

- **General Condition 21.** *The depth of sediment removal evaluated in the alternatives shall not be limited to the bare minimum required for engineering considerations, but must include a safety factor. In general the depth of sediment removal shall be a minimum of 2 to 3 feet. In the Supplement, GE shall revise the depths of removal, note the depths in the revised Table 5-1, and provide a rationale for the depths.*

- **General Condition 23**. *Sediment Alternative 7 shall be revised to evaluate removal in Reaches 7 and 8 to 3 mg/kg, the IMPG for benthic invertebrates. GE shall reflect this change in the revised Table 5-1 in the Supplement.*

As noted above, GE invoked dispute resolution under the Permit on April 27, 2007, on EPA's General Condition 21. Once that dispute is resolved, GE will provide information on revised depths of removal for the sediment remediation alternatives (if applicable) in accordance with the resolution of that dispute, and will provide a revised Table 5-1.

To address EPA's General Condition 23, Sediment Alternative 7 will be revised to include the following component for the impoundments in Reach 7 and for the shallower portion of Reach 8: removal of sediments in the uppermost depth increment (based on the depth determined as a result of the dispute resolution) that contain higher PCB concentrations, defined for evaluation purposes as those sediments containing PCB concentrations greater than 3 mg/kg, followed by replacement with an engineered cap or backfill. We note that that PCB concentration is not the only IMPG for benthic invertebrates, but is the lower bound of the IMPG range of 3 to 10 mg/kg. This component of Sediment Alternative 7 will be reflected in the revised Table 5-1.

7. Corrective Measure Evaluation Process

7.1 Introduction

This section summarizes the sequence of steps that will be undertaken to evaluate corrective measures for the Rest of River and presents an overall flow chart to illustrate the process. This section addresses the following EPA comment:

- **Specific Condition 47.** *GE shall include a flow chart of the overall Corrective Measures evaluation process in the Supplement. GE shall include more detailed flow charts of the alternatives analysis in the CMS.*

7.2 Overview of Evaluation Process

Section 5 of the CMS Proposal describes the methodology that will be used in the CMS to evaluate potential corrective measures for the Rest of River. In summary, the specific remedial alternatives identified in the CMS Proposal for addressing in-sediment/riverbanks and floodplain soil, as modified based on EPA's comments, will be evaluated based on the evaluation criteria specified in the Permit, which consist of three "General Standards" and six "Selection Decision Factors." These criteria will be used to conduct a detailed and comparative evaluation of each remedial alternative. The CMS evaluation process specific to the in-sediment/riverbank soils will include use of the EPA model to predict future sediment, surface water, and fish tissue PCB concentrations resulting from those alternatives. As also noted in the CMS Proposal, the performance of the CMS may lead to the identification of other in-sediment/riverbank soils and/ or floodplain soil alternatives for inclusion in the CMS evaluations.

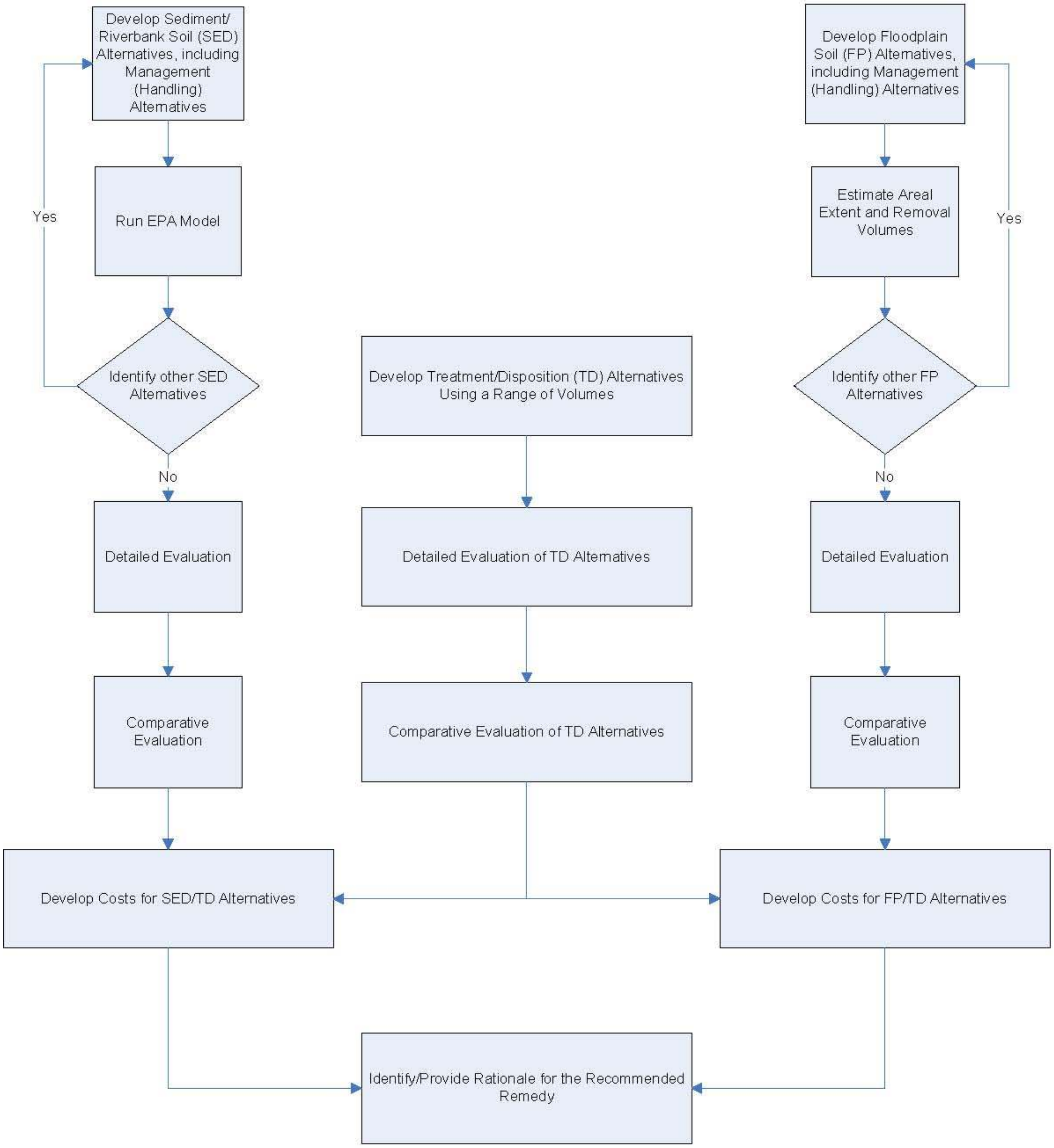
The evaluation criteria defined in the CMS Proposal will first be applied separately to the in-river sediment/riverbank soil remediation alternatives and then to the in-place floodplain soil remediation alternatives. For those alternatives that involve removal, the alternatives will include the appropriate interim sediment/soil dewatering and other handling procedures that are logically associated with them. In addition, a number of sediment/soil treatment/disposition alternatives (e.g., chemical or thermal treatment, local disposal, off-site disposal) will be developed to support the alternatives that involve removal, and these treatment/disposition alternatives will be evaluated using the relevant standards and factors, considering the range of volumes collectively generated by the in-river sediment/riverbank and floodplain soil alternatives. As noted in the CMS

Proposal, in applying the cost factor, a cost estimate will be developed for each relevant combination of such “front-end” and “back-end” alternatives.

The CMS Report will conclude with a recommendation as to which remedial alternatives for sediments and floodplain soils, including sediment/soil management/disposition alternative(s) if pertinent, would, in GE’s opinion, be best suited to meet the General Standards in the Permit, in consideration of the Selection Decision Factors and the balancing of those factors against one another.

A flow chart depicting the overall corrective measures evaluation process is included as Figure 7-1 below.

Figure 7-1. Process for Conducting CMS Evaluation



8. Additional Justification of Production Rates

8.1 Introduction

This section provides further justification for the dredging production rates provided in the CMS Proposal and specifically addresses the following EPA comment:

- **Specific Condition 66**. *Page 5-24 and Table 5-2 – Production Rates – The text states that the production rates in Table 5-2 are based on rates from similar projects where remedies have been completed and for the upper two miles of the Housatonic. The annualized production rates for hydraulic dredging in the table are very low, from 70 to 220 cy/day (9 to 28 cy/hr for an 8 hour day). The mechanical dredging rates also are low, from 60 to 240 cy/day (8 to 30 cy/hr for an 8 hour day). EPA believes that a more realistic low-end production rate for wet mechanical dredging is 282 cy/day (assuming the smallest bucket size listed in the EPA 2005 guidance). This rate would increase with an increase in bucket size or use of multiple buckets. Similarly, a more realistic low-end production rate for hydraulic dredging is 397 cy/day. This rate assumes the smallest diameter pipe/dredge (15 cm) used in the EPA 2005 guidance. These annual average estimates assume dredging for 8 hours per day, 22 days per month, and 9 months of the year.*

  Production can be defined in terms of the operating production rate (the rate during time periods of active dredge operation) or effective production rate (the rate considering effective hours per day, days per week, and weeks per dredging season). The text states the rates in Table 5-2 are based on an annual production rate, converted to a daily rate. This wording implies the table values are considering the effective time, but may be a rate spread over an entire year (which would be inappropriate considering a possible winter shutdown or other shutdowns, e.g. high flows). EPA believes that it is better to evaluate effective time, to include a seasonal shutdown, and calculate the required dredging seasons to do the job. GE shall estimate removal over dredging seasons rather than full years in the modeling exercise as well as for evaluations of schedule and costs.

  GE shall provide in the Supplement specifics on the assumptions of operating production rates, projects from which rates have been estimated, and effective time in hours, days, and weeks used to calculate the effective production rate over a season.

8.2 Justification for Production Rates

The daily production rates presented in Table 5-2 of the CMS Proposal represent annualized daily production rates assuming operation 8 hours per day, 365 days per year (i.e., total annual production spread out over one year) to simplify their use in the model to simulate the time required for various remedial activities.). GE recognizes that the effective dredge time may be less – perhaps as EPA suggests, 8 hours per day, 22 days per month, and 9 months of the year. However, the total cubic yards dredged per year would remain the same whether it is represented as a daily rate or as an effective rate. For its use in the model, changing the annualized daily production rate to an effective daily production rate (i.e., dredging over 12 months versus 9 months) would have no practical effect on the model because the total volume of sediment dredged per year would remain unchanged. Representing the annualized daily production rates as effective daily production rates, Table 5-2 would be revised as the following Table 8-1:

Table 8-1
Production Rates to be used in CMS Model Simulations

Technology	Effective Areal Production Rate (m^2/day) [used in model][1]	Effective Equivalent Volumetric Production Rate (cy/day)[1]
Mechanical/Hydraulic Dredging in the Wet (≤ 2-ft removal)[2]	325	130 - 260
Mechanical/Hydraulic Dredging in the Wet (> 2-ft removal)[2]	165	200 - 405
Mechanical Dredging in the Dry (≤ 2-ft removal)[2]	260	110 - 200
Mechanical Dredging in the Dry (> 2-ft removal)[2]	130	150 - 310
Thin-Layer Capping	1,100	110 - 220
Engineered Capping	550	220 - 440

Notes:
[1] *Effective production rates based on dredging operation 8 hours/day, 22 days/month, and 9 months/year.*
[2] *Assumes placement of an engineered cap or backfill after removal consistent with scenario descriptions provided in Section 5.2.1 of the CMS Proposal.*
m^2/day = square meters per day
cy/day = cubic yards per day

Additionally, EPA has suggested that more realistic low end effective dredging rates would be approximately 300 cy/day for wet mechanical dredging and 400 cy/day for hydraulic dredging (approximately 60,000 cy or 80,000 cy on an annual basis using the effective dredge time). However, effective dredge production rates this high have not been consistently achieved at other dredging sites without the use of multiple dredges. Tables 8-2 and 8-3 provide supporting information for both dredging and capping production rates based on a single dredge/capping crew. These tables support the production rates used by GE in the CMS Proposal. For example, the effective dredge production rates in Table 8-2 for both hydraulic and bucket dredges range from 65 to 500 cy/day, with an average of approximately 290 cy/day. GE rates represented as effective daily dredge production rates are 130 to 405 cy/day, which are consistent with what has been achieved on other projects, as illustrated in Table 8-2. It should also be recognized that production rates are very site-specific and that higher or lower production rates could be achieved based on site-specific considerations such as river hydraulic conditions, river geometry, equipment used, etc. In addition, higher production rates may be achieved by using multiple dredges. However, for the purposes of the CMS, given the conditions in the Housatonic River (e.g., limited access, variable water depths and velocities, presence of steep banks, presence of debris and cobbles in the river, variable sediment types) and the current level of understanding of the implementation methods (i.e., CMS-level as opposed to design-level estimates), GE does not believe that it should be assumed at this time that use of multiple dredges will be feasible. Accordingly, GE has assumed production rates commensurate with the use of one dredge.

With regard to dry excavation, GE assumed a range of effective daily production rates of approximately 100 to 300 cy/day. Considering that EPA achieved an effective production rate of 60 cy/day (Table 8-2) for the 1½ Mile Reach, this assumption is already optimistic.

Based on the information presented above and in Tables 8-2 and 8-3, GE does not propose to make any changes to the dredging or capping production rates for use by the model in the CMS.

9. Clarification of Model Assumptions for Post-Remediation and Resuspension Concentrations

9.1 Introduction

This section clarifies the spatial scale at which post-remediation (residual) and resuspension concentrations will be specified in the model, specifically addressing the following EPA comment:

- **Specific Condition 68.** *Page 5-26/5-27 – It is unclear if residual and resuspension concentrations are based on model grid cell-specific simulated PCB concentrations or those calculated at the level of a spatial bin. GE shall indicate in the Supplement the scale at which these concentrations will be determined and/or applied.*

9.2 Spatial Scale for Modeling Post-Remediation Concentrations and Resuspension Rates during Dredging

The CMS Proposal notes that the EPA “spatial bins” formed the basis for the sediment PCB data averaging scheme used to develop model initial conditions and were the reaches over which the model predictions of sediment PCB concentrations were calibrated. Therefore, the spatial bins represent the finest scale at which the model can be used to evaluate sediment processes and, consequently, the smallest remedial units reasonably simulated by the model. However, during simulation of the proposed remedial alternatives, post-remediation (as well as residual) concentrations and dredging-associated resuspension fluxes will be calculated and applied at the level of an individual model grid cell. As discussed below, this procedure allows for a more efficient modification in the model code and will result in spatial-bin averages that are equivalent to making these changes on the scale of a spatial bin, thus allowing the results to be used in modeling the impacts of remedial alternatives at the spatial-bin level.

In the CMS Proposal, GE proposed developing additional computer code and model pre-processors to represent “active” remediation technologies in the model simulations. The model code will be modified to calculate post-remediation concentrations for each individual grid cell using the relevant method specified in the Model Input Addendum (e.g., for dredging or capping through the water, the vertical average of the sediments removed times a 99% reduction efficiency). Simulation of resuspension rates for alternatives involving hydraulic or mechanical dredging in the wet will be calculated in the model at the same spatial scale. The calculation of post-remediation concentrations and resuspension fluxes at the grid-cell level is a more efficient means of effecting the change in the model code and will produce results that are mathematically equivalent to the intended simulation of remedial alternatives on the scale of a spatial bin. Specifically, post-remediation concentrations and resuspension fluxes applied at the grid cell scale will result in averages over the corresponding spatial bin that are equivalent to making these changes at the spatial bin level since 1) the proposed remedial alternatives do not vary on scales smaller than a spatial bin, and 2) changes in sediment concentrations occur very slowly in the model relative to the time-scale associated with remediation of a single spatial bin.

10. References

Alexander, G.R. 1977. Food of vertebrate predators on trout waters of north central lower Michigan. *Michigan Academician* 10:187-195.

Ankley, G.T. P.M. Cook, A.R. Carlson, D.J. Call, J.A. Sorensen, H.F. Corcoran, R.A. Hoke. 1992. Bioaccumulation of PCBs from sediments by oligochaetes and fishes: Comparison of laboratory and field studies. *Can. J. Fish. Aquat. Sci.* 49:2080-2085.

ANSP. 2005. *PCB Concentrations in Fishes from the Housatonic River, Connecticut, 1984-2004, and in Benthic Invertebrates, 1978-2005.* Prepared by the Academy of Natural Sciences of Philadelphia for the General Electric Company. September 2005.

ARCADIS BBL and QEA. 2007. *Corrective Measures Study Proposal – Housatonic River – Rest of River* (CMS Proposal). Prepared for the General Electric Company, Pittsfield, MA. Submitted February 27, 2007.

ARCADIS G&M, Inc. 2002. *Robin Productivity in the Housatonic River Watershed, Berkshire County, Massachusetts.* Prepared for General Electric Company.

BBL and QEA. 2003. *RCRA Facility Investigation Report – Rest of River (RFI Report).* Prepared for the General Electric Company, Pittsfield, MA.

Bedard, D.L., L.A. Smullen, K.A. DeWeerd, D.K. Dietrich, G.M. Frame, R.J. May, J.M. Principe, T.O. Rouse, W.A. Fessler, and J.S. Nicholson. 1995. Chemical activation of microbially-mediated PCB dechlorination: A field study. *Organohalogen Compounds* 24: 23-8.

Bedard, D.L., H. Van Dort, and K. A. Deweerd. 1998. Brominated biphenyls prime extensive reductive dehalogenation of Aroclor 1260 in Housatonic River sediment. *Applied and Environmental Microbiology* 64(5): 1786-1795.

Bedard, D.L., K.M. Ritalahti, and F.E. Loffler. 2007. Dehalococcoides in a sediment-free, mixed culture metabolically dechlorinate the commercial polychlorinated biphenyl mixture Aroclor 1260. *Applied Environmental Microbiology.* Published online ahead of print on February 16, 2007.

Board on Environmental Studies and Toxicology. 2001. *A Risk Management Strategy for PCB-Contaminated Sediments*. Web site retrieved November 13, 2006 from www.nap.edu/catalog/10041.html#toc

Carleo, C., T. Clark, and C.M. Wilk. 2006. *Phoenix-Award Winning Kendall Square Rises from Cement-Treated Brownfield Site.* PCA Project Information Sheet prepared for "Waste Treatment Cement-Based Solidification/Stablization." Skokie, IL: Portland Cement Association.

Conner, J.R. 1997. *Guide to Improving the Effectiveness of Cement-Based Stabilization/Solidification*. Engineering Bulletin Published by the Portland Cement Association.

EPA. 1986. *Handbook for Stabilization/Solidification of Hazardous Wastes*. EPA/540/2-86/001. p. 6-17.

EPA. 1989. *Stabilization/Solidification of CERCLA and RCRA Wastes: Physical Tests, Chemical Testing Procedures, Technology Screening, and Field Activities*. EPA/625/6-89/022. p. 7-7 – 7-8.

EPA. 1990. *International Waste Technologies/Geo-Con In Situ Stabilization /Solidification Applications Analysis Report.* EPA/540/A5-90/004. p. 4-16, 4-41.

EPA. 1994. *ARCS Remediation Guidance Document*. EPA 905-B94-003. Chicago, Il.: Great Lakes National Program Office.

EPA. 1995. *Cost and Performance Report: Slurry-Phase Bioremediation at the French Limited Superfund Site Crosby, TX.* March 1995.

EPA. 1996. *PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures*. National Center for Environmental Assessment, Office of Research and Development. EPA/600/P-96/001F. September 1996.

EPA. 2000. *Final Supplemental Investigation Work Plan for the Lower Housatonic River (SI Work Plan)*. Prepared by Weston Solutions, Inc., West Chester, PA, for the United States Army Corps of Engineers, New England District, and the United States Environmental Protection Agency, New England Region.

EPA. 2002a. *National Recommended Water Quality Criteria: 2002.* Office of Water, Office of Science and Technology. EPA-822-R-02-047. November 2002.

EPA. 2002b. *Five-Year Review Report for Caldwell Trucking Company Superfund Site.* September 2002.

EPA. 2004. *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 2004.

EPA. 2005a. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, DC. EPA-540-R-05-012. December 2005.

EPA. 2005b. E-mail correspondence from C. Acheson (EPA) to J. DiLorenzo (EPA) Re: Oil Free Technologies. February 1, 2005.

EPA. 2005c. Letter from J. DiLorenzo (EPA) to T. Gray (HRI, Inc.) Re: Review of the Oil Free Technologies, Inc. Enzyme Process by EPA's Superfund Innovative Technology Evaluation (SITE) Program. May 24, 2005.

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

EPA. 2006a. Caldwell Trucking NPL Listing History. EPA Region 2.

EPA. 2006b. *In Situ Treatment Technologies for Contaminated Soil*. Engineering Forum Issue Paper. EPA 542/F-06/13. November 2006.

EPA. 2006c. *In-Situ Chemical Oxidation.* Engineering Forum Issue Paper. EPA/600/R-06/072. August 2006.

EPA. 2007a. EPA's SITE Program web site retrieved from: http://www.epa.gov/ORD/SITE/.

EPA. 2007b. In Situ Thermal Desorption for Treatment of POPs in Soils and Sediments. Retrieved from: http://www.clu-in.org/download/remed/542r05006/in_situ_thermal.pdf.

Frink, C.R., B.L. Sawhney, K.P. Kulp, and C.G. Fredette. 1982. *Polychlorinated Biphenyls in Housatonic River Sediments in Massachusetts and Connecticut: Determination, Distribution, and Transport*. A Cooperative Study by CAES, CDEP, and USGS.

GE. 2006a. *Interim Media Protection Goal Proposal – Rest of River* (IMPG Proposal). Prepared by General Electric Company. Revised March 2006.

GE. 2006b. *General Electric's Statement of Position on Objections to EPA's Disapproval of Interim Media Protection Goals Proposal.* Attachment to Letter from Andrew Silfer of the General Electric Company to Susan Svirsky of the United States Environmental Protection Agency. Dated January 23, 2006.

Hebert, A. 2007. Personal communication with Alain Hebert, ARCADIS BBL. May 10, 2007.

Hong, A., and D. Hayes. 2006. *Ongoing Project: In Situ Sediment Ozonator for Remediation of PCB, PAH, DDT and Other Recalcitrant Chemicals. Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET).* Web site retrieved November 13, 2006 from http://ciceet.unh.edu/progressreports/2006/3_2006/hong04/.

Iben, I. E. T., W. A. Edelstein, R. B. Sheldon, A. P. Shapiro, E. E. Uzgiris, C. R. Scatena, S. R. Blaha, W. B. Silverstein, G. R. Brown, G. L. Stegemeier, and H. J. Vinegar. 1996. Thermal blanket for in-situ remediation of surficial contamination: A pilot test. *Environ. Sci. Technol.*, 30 (11): 3144 -3154. June 1996.

Kita, D., and Kubo, H. 1983. Several solidified sediment examples. Proceedings of the 7th U.S./Japan Experts Meeting: Management of Bottom Sediments Containing Toxic Substances, 2-4 November 1981, New York City. United States Army Corps of Engineers, Water Resource Support Center (ed.), pp. 192-210.

Kulp, K.P. 1991. *Concentration and Transport of Polychlorinated Biphenyls in the Housatonic River Between Great Barrington, Massachusettes and Kent, Connecticut.* Prepared by United States Geological Survey (USGS) in Cooperation with the Connecticut Department of Environmental Protection. USGS Water Resources Investigation Report 91-4014.

LMS. 1991. *Ambient Trend Monitoring and PCB Fate and Transport Model.* Report to CDEP pursuant to the Housatonic Cooperative Agreement. Prepared by Lawler, Matusky, & Skelly Engineers (LMS) for the General Electric Company, Pittsfield, MA.

LMS. 1994. *PCB Fate and Transport Model: Additional Monitoring and Model Verification*. Report to Connecticut Department of Environmental Protection pursuant to the Housatonic Cooperative Agreement. Prepared by Lawler, Matusky, & Skelly Engineers (LMS) for the General Electric Company, Pittsfield, MA.

Lehr, J.H. 2004. *Wiley's Remediation Technologies Handbook. Major Contaminant Chemicals and Chemical Groups*. John Wiley & Sons, Inc. ISBN: 0-471-45599-7.

Michigan State University. 2004. Michigan State University Kalamazoo River Area of Concern Biological Database.

Mikszewski, A. 2004. *Emerging Technologies for the In Situ Remediation of Contaminated Soils and Sediments: Bioremediation and Nanoscale Zero-Valent Iron*. Prepared for EPA.

Murphy, T.P., A. Moller, R. Pandey, H. Brouwer, M. Fox, J. Babin, and K. Gray. 1995 . St. Mary's River - Chemical Treatment of contaminated sediments by iron injection. In: *The Lake Huron Ecosystem: Ecology, Fisheries and Management*, pp. 397-412. Edited by Munawar, M., Edsall, T., and Leach, J. SBP Academic Publishing, Amsterdam, The Netherlands.

Neigh, A.A., M. J. Zwiernik, P.W. Bradley, D.P. Kay, P.D. Jones, R.R.Holem, A.L. Blankenship, K.D. Strause, J.L. Newsted, and J. P. Giesy. 2006. Accumulation of polychlorinated biphenyls from floodplain soils by passerine birds. *Environmental Toxicology and Chemistry* 25(6):1503-1511.

Parr, D.E., M.D. Scott, and D.D. Kennedy. 1979. Autumn movements and habitat use by wood ducks in southern Illinois. *Journal of Wildlife Management* 42:102-108.

Renholds, J. 1998. *In Situ Treatment of Contaminated Sediments*. Report prepared for EPA. Web site retrieved November 13, 2006 from www.clu-in.org/products/intern/renhold.htm.

Satoh, A. Y.; J.E. Trosko, and S.J. Masten. 2003. Epigenetic toxicity of hydroxylated biphenyls and hydroxylated polychlorinated biphenyls on normal rat liver epithelial cells. *Environ. Sci. Technol.*, 37(12): 2727-2733.

Stewart Laboratories, Inc. 1982. *Housatonic River Study -1980 and 1982 Investigations.* Prepared for the General Electric Company. December 1982.

TerraTherm Environmental Services, Inc. 1997. *Project Profile: Remediation of PCBs at State Superfund Site, Glens Falls, NY.* Received from TerraTherm Environmental Services, Inc., An Affiliate of Shell Technology Ventures, Inc., 10077 Grogan's Mill Rd, The Woodlands, TX, 77380.

University at Albany. 2006. *Congener-Specific PCB Analysis of Control and Enzyme Treated Soil.* Prepared for Oil-Free Technologies Inc. March 10, 2006.

Weston. 2006. *Final Model Documentation Report: Modeling Study of PCB Contamination in the Housatonic River*. Prepared by Weston Solutions, Inc. for the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency.

Wilk, C.M. and R. DeLisio. 2002. *Solidification/Stabilization Treatment of Arsenic- and Creosote-Impacted Soil at a Former Wood-Treating Site.* PCA Project Information Sheet prepared for "Waste Treatment Cement-Based Solidification/Stablization." Skokie, IL: Portland Cement Association.

Wilk, C.M. 2003. *Augusta Manufactured Gas Plant Cleanup Using Cement-based Solidification/Stabilization.* PCA Project Information Sheet prepared for "Waste Treatment Cement-Based Solidification/Stablization." Skokie, IL: Portland Cement Association.

Wilk, C.M. 2005. *In-Situ Solidification/Stabilization of a Former Wood Treatment Site.* PCA Project Information Sheet prepared for "Waste Treatment Cement-Based Solidification/Stablization." Skokie, IL: Portland Cement Association.

Tables

Table 2-1.
Summary of surface water total PCB data from Reaches 9-16 of the Housatonic River.

Year	Sampler	Location	Number of Samples	Detection Limit (ug/L)	Frequency of Detection (%)	Median (ug/L)	Arithmetic Mean (ug/L)	S.E.M. (ug/L)	Minimum (ug/L)	Maximum (ug/L)
CAES, CDEP, and USGS -- Cooperative PCB Investigation										
1978-80	CAES/CDEP/USGS	Near Great Barrington	14	NA	100	0.20	0.25	0.044	0.10	0.60
		Falls Village	13	NA	46	0.00	0.062	0.021	ND	0.20
		Gaylordsville	13	NA	15	0.00	0.015	0.010	ND	0.10
Stewart Investigation										
1982	Stewart	Division Street Bridge	13	0.030	62	0.040	0.043	0.0083	ND	0.10
		Andrus Road Bridge	16	0.030	88	0.070	0.062	0.010	ND	0.15
USGS and CDEP Water Column PCB Investigation										
1984-88	USGS/CDEP	Near Great Barrington	5	0.1	100	0.20	0.280	0.058	0.20	0.50
		Ashley Falls	4	0.10	75	0.10	0.088	0.013	ND	0.10
		Near Canaan	3	0.10	33	0.050	0.067	0.017	ND	0.10
		Near Falls Village	4	0.10	25	0.050	0.063	0.013	ND	0.10
		Kent	16	0.10	25	0.050	0.069	0.010	ND	0.20
MCP Phase II Investigation										
1989-92	BBL	Division Street Bridge	21	0.030-0.065	67	0.080	1.102	1.00	ND	21
LMS Fate and Transport Model										
1991-93	LMS	Division Street Bridge	55	0.065	71	0.10	0.231	0.041	ND	1.1
		Falls Village	32	0.065	16	0.033	0.042	0.0043	ND	0.15
MCP Supplemental Phase II/RFI										
1995-06	BBL	Division Street Bridge	139	0.022-0.98	31	0.013	0.046	0.0091	ND	1.0
		Andrus Road Bridge	4	0.022	25	0.011	0.014	0.0033	ND	0.024
		Bulls Bridge Dam	4	0.022	0	NA	ND	NA	NA	NA

Notes:
(1) Non-detect data set to 1/2 method detection limit.
(2) S.E.M. = Standard Error of the Mean.
(3) ND = Non detect.
(4) NA = Not Available.
(5) Duplicate samples were included.
(6) Locations with no PCBs analyzed were not included.

Table 2-2a.
Summary of sediment total PCB data from Reach 9 of the Housatonic River.

Year	Sampler	Depth Interval (inch)	Number of Samples	Detection Limit (mg/kg)	Frequency of Detection (%)	Median (mg/kg)	Arithmetic Mean (mg/kg)	S.E.M. (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
CAES, CDEP, and USGS -- Cooperative PCB Investigation										
1979-82	CAES/CDEP/USGS	0-6	29	NA	100	0.77	0.97	0.13	0.030	3.9
		6-12	4	NA	75	0.59	0.94	0.58	ND	2.6
		12-18	3	NA	100	0.53	0.81	0.56	0.010	1.9
		18-24	2	NA	100	0.76	0.76	0.54	0.22	1.3
Stewart Investigation										
1980	Stewart	0-6	13	0.05	92	0.32	0.70	0.19	ND	2.3
		6-12	12	0.05	83	0.43	0.61	0.17	ND	1.7
		12-18	12	0.05	92	0.18	0.36	0.15	ND	1.6
		18-24	5	0.05	60	0.040	0.070	0.033	ND	0.20
1982	Stewart	0-6	4	0.05	100	0.28	0.49	0.28	0.080	1.3
		6-12	3	0.05	100	0.32	0.52	0.29	0.15	1.1
		12-14	1	0.05	0	NA	ND	NA	NA	NA
		12-18	2	0.05	100	0.79	0.79	0.41	0.38	1.2
LMS Fate and Transport Model										
1992	LMS	0-1	4	0.05	100	0.67	0.66	0.15	0.32	0.96
		1-2	3	0.05	100	0.43	1.1	0.70	0.40	2.50
		2-3	4	0.05	100	0.49	0.84	0.43	0.28	2.10
		0-3	8	0.05	75	0.22	0.34	0.13	ND	0.90
MCP Phase II Investigation										
1994	BBL	0-6	3	NA	100	0.29	0.26	0.050	0.17	0.32
MCP Supplemental Phase II/RFI										
1997-98	BBL	0-1	7	0.13-0.15	0	NA	ND	NA	NA	NA
		1-6	9	0.13-0.15	11	0.068	0.078	0.010	ND	0.16
1998-02	USEPA	0-6	60	0.02-0.53	32	0.25	0.30	0.022	ND	1.2
		12-18	2	0.5	0	NA	ND	NA	NA	NA
		24-30	1	0.5	0	NA	ND	NA	NA	NA

Notes:
(1) Non-detect data set to 1/2 method detection limit.
(2) S.E.M. = Standard Error of the Mean.
(3) ND = Non detect.
(4) NA = Not Available.
(5) Duplicate samples were included.
(6) High resolution core data were not included.

Table 2-2b.
Summary of sediment total PCB data from Reach 10 of the Housatonic River.

Year	Sampler	Depth Interval (inch)	Number of Samples	Detection Limit (mg/kg)	Frequency of Detection (%)	Median (mg/kg)	Arithmetic Mean (mg/kg)	S.E.M. (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
CAES, CDEP, and USGS -- Cooperative PCB Investigation										
1979-82	CAES/CDEP/USGS	0-6	11	NA	100	0.72	0.68	0.090	0.19	1.2
LMS Fate and Transport Model										
1992	LMS	0-1	1	NA	100	0.063	0.10	NA	0.10	0.10
		1-2	1	NA	100	0.51	0.070	NA	0.070	0.070
		2-3	1	NA	100	0.065	1.0	NA	1.0	1.0
		0-3	6	NA	100	0.39	0.48	0.13	0.25	1.1
MCP Supplemental Phase II/RFI										
1997-98	BBL	0-1	11	0.13-0.16	9	0.070	0.077	0.0075	ND	0.15
		1-6	12	0.13-0.15	17	0.071	0.085	0.011	ND	0.19
1998-02	USEPA	0-6	3	0.02	0	NA	ND	NA	NA	NA
		6-9	1	0.02	0	NA	ND	NA	NA	NA
		6-12	1	0.02	0	NA	ND	NA	NA	NA
		12-18	1	0.02	0	NA	ND	NA	NA	NA
PCBs in Sediment Cores Collected during Falls Village Dam Repair										
2005	NGS	0-6	5	0.11	40	0.057	0.11	0.035	ND	0.22
		6-12	5	0.10-0.16	40	0.080	0.17	0.065	ND	0.35
		12-24	4	0.123	75	0.185	0.25	0.11	ND	0.58
		24	1	0.11	0	NA	ND	NA	NA	NA
		36	1	0.16	0	NA	ND	NA	NA	NA
		48	1	0.19	0	NA	ND	NA	NA	NA
Sediment Samples from the Housatonic River Commission										
2005	Hydro Technologies	NA	3	0.005	100	0.19	0.16	0.064	0.035	0.25

Notes:
(1) Non-detect data set to 1/2 method detection limit.
(2) S.E.M. = Standard Error of the Mean.
(3) ND = Non detect.
(4) NA = Not Available.
(5) Duplicate samples were included.
(6) High resolution core data were not included.
(7) NGS = Northeast Generation Services
(8) Depth intervals were not clearly indicated for the 2005 samples collected by Hydro Technologies.

Table 2-2c.
Summary of sediment total PCB data from Reach 11 of the Housatonic River.

Year	Sampler	Depth Interval (inch)	Number of Samples	Detection Limit (mg/kg)	Frequency of Detection (%)	Median (mg/kg)	Arithmetic Mean (mg/kg)	S.E.M. (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
CAES, CDEP, and USGS -- Cooperative PCB Investigation										
1979-82	CAES/CDEP/USGS	0-6	4	NA	100	0.14	0.15	0.06	0.04	0.26
LMS Fate and Transport Model										
1992	LMS	0-3	3	0.05	33	0.025	0.037	0.012	ND	0.06
MCP Supplemental Phase II/RFI										
1998-02	USEPA	0-6	2	0.02	0	NA	ND	NA	NA	NA

Notes:
(1) Non-detect data set to 1/2 method detection limit.
(2) S.E.M. = Standard Error of the Mean.
(3) ND = Non detect.
(4) NA = Not Available.
(5) Duplicate samples were included.
(6) High resolution core data were not included.

Table 2-2d.
Summary of sediment total PCB data from Reach 12 of the Housatonic River.

Year	Sampler	Depth Interval (inch)	Number of Samples	Detection Limit (mg/kg)	Frequency of Detection (%)	Median (mg/kg)	Arithmetic Mean (mg/kg)	S.E.M. (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
CAES, CDEP, and USGS -- Cooperative PCB Investigation										
1979-82	CAES/CDEP/USGS	0-6	5	NA	100	0.040	0.090	0.040	0.030	0.23
LMS Fate and Transport Model										
1992	LMS	0-1	8	0.05	88	0.17	0.17	0.037	ND	0.37
MCP Supplemental Phase II/RFI										
1997-98	BBL	0-1	17	0.13-0.21	12	0.080	0.11	0.021	ND	0.40
		1-6	18	0.13-0.18	11	0.075	0.089	0.011	ND	0.22
1998-02	USEPA	0-6	3	0.02	0	NA	ND	NA	NA	NA
		24-30	1	0.02	0	NA	ND	NA	NA	NA

Notes:
(1) Non-detect data set to 1/2 method detection limit.
(2) S.E.M. = Standard Error of the Mean.
(3) ND = Non detect.
(4) NA = Not Available.
(5) Duplicate samples were included.
(6) High resolution core data were not included.

Table 2-2e.
Summary of sediment total PCB data from Reach 13 of the Housatonic River.

Year	Sampler	Depth Interval (inch)	Number of Samples	Detection Limit (mg/kg)	Frequency of Detection (%)	Median (mg/kg)	Arithmetic Mean (mg/kg)	S.E.M. (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
LMS Fate and Transport Model										
1992	LMS	0-1	1	0.05	100	0.070	0.070	NA	0.070	0.070
		1-2	1	0.05	100	0.060	0.060	NA	0.060	0.060
		2-3	1	0.05	100	0.090	0.090	NA	0.090	0.090
		0-3	4	0.05	75	0.075	0.069	0.017	ND	0.1
MCP Supplemental Phase II/RFI										
1998-02	USEPA	0-3	2	0.02	0	NA	ND	NA	NA	NA
		0-6	5	0.02	0	NA	ND	NA	NA	NA
		6-9	1	0.02	0	NA	ND	NA	NA	NA
		12-18	2	0.02	0	NA	ND	NA	NA	NA

Notes:
(1) Non-detect data set to 1/2 method detection limit.
(2) S.E.M. = Standard Error of the Mean.
(3) ND = Non detect.
(4) NA = Not Available.
(5) Duplicate samples were included.
(6) High resolution core data were not included.

Table 2-2f.
Summary of sediment total PCB data from Reach 14 of the Housatonic River.

Year	Sampler	Depth Interval (inch)	Number of Samples	Detection Limit (mg/kg)	Frequency of Detection (%)	Median (mg/kg)	Arithmetic Mean (mg/kg)	S.E.M. (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
CAES, CDEP, and USGS -- Cooperative PCB Investigation										
1979-82	CAES/CDEP/USGS	0-6	59	NA	97	0.63	0.87	0.097	ND	3.2
		6-12	14	NA	86	0.48	0.61	0.19	ND	2.7
		12-18	11	NA	73	0.40	0.53	0.14	ND	1.3
		18-24	7	NA	86	0.16	0.33	0.18	ND	1.4
LMS Fate and Transport Model										
1992	LMS	0-3	6	0.05	67	0.080	0.085	0.024	ND	0.18
MCP Supplemental Phase II/RFI										
1998-02	USEPA	0-6	1	0.02	100	0.47	0.47	NA	0.47	0.47
		6-12	1	0.02	100	1.2	1.2	NA	1.2	1.2

Notes:
(1) Non-detect data set to 1/2 method detection limit.
(2) S.E.M. = Standard Error of the Mean.
(3) ND = Non detect.
(4) NA = Not Available.
(5) Duplicate samples were included.
(6) High resolution core data were not included.

Table 2-2g.
Summary of sediment total PCB data from Reach 15 of the Housatonic River.

Year	Sampler	Depth Interval (inch)	Number of Samples	Detection Limit (mg/kg)	Frequency of Detection (%)	Median (mg/kg)	Arithmetic Mean (mg/kg)	S.E.M. (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
CAES, CDEP, and USGS -- Cooperative PCB Investigation										
1979-82	CAES/CDEP/USGS	0-6	33	NA	100	0.69	0.70	0.09	0.01	2.2
		6-12	10	NA	100	0.73	0.91	0.29	0.03	2.6
		12-18	10	NA	100	0.60	0.89	0.26	0.03	2.3
		18-24	9	NA	89	0.55	0.87	0.28	ND	2.2
		24-30	1	NA	100	1.0	1.0	NA	1.0	1.0
LMS Fate and Transport Model										
1992	LMS	0-1	1	0.05	100	0.060	0.060	NA	0.060	0.060
		1-2	1	0.05	100	0.14	0.14	NA	0.14	0.14
		2-3	1	0.05	100	0.18	0.18	NA	0.18	0.18
		0-3	5	0.05	80	0.060	0.061	0.011	ND	0.09
MCP Supplemental Phase II/RFI										
1998-02	USEPA	0-6	1	0.02	100	0.038	0.038	NA	0.038	0.038
		6-10	1	0.02	100	0.042	0.042	NA	0.042	0.042

Notes:

(1) Non-detect data set to 1/2 method detection limit.

(2) S.E.M. = Standard Error of the Mean.

(3) ND = Non detect.

(4) NA = Not Available.

(5) Duplicate samples were included.

(6) High resolution core data were not included.

Table 2-2h.
Summary of sediment total PCB data from Reach 16 of the Housatonic River.

Year	Sampler	Depth Interval (inch)	Number of Samples	Detection Limit (mg/kg)	Frequency of Detection (%)	Median (mg/kg)	Arithmetic Mean (mg/kg)	S.E.M. (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
MCP Supplemental Phase II/RFI										
1998-02	USEPA	0-6	6	0.02	0	NA	ND	NA	NA	NA
		6-9	1	0.02	0	NA	ND	NA	NA	NA
		6-12	3	0.02-0.03	0	NA	ND	NA	NA	NA
		30-36	1	0.02	0	NA	ND	NA	NA	NA

Notes:

(1) Non-detect data set to 1/2 method detection limit.

(2) S.E.M. = Standard Error of the Mean.

(3) ND = Non detect.

(4) NA = Not Available.

(5) Duplicate samples were included.

(6) High resolution core data were not included.

Table 2-2i.
Summary of sediment total PCB data from high resolution cores collected from Reaches 9-16 of the Housatonic River.

Year	Sampler	Detection Limit (mg/kg)	Depth Interval (in)	Sediment PCB Concentrations (mg/kg)					
				Falls Village Impoundment	Bulls Bridge Impoundment	Lake Lillinonah		Lake Zoar	
				Reach 10	Reach 12	Reach 14		Reach 15	
				RM 77.7	RM 48.95 (LMS) or 53.2 (BBL)	RM 34.2	RM 29.8	RM 26.8	RM 19.7
1986	LMS	0.1	00-01	0.29	0.19	1.5	1.2	ND	1.9
			01-02	0.32	0.33	1.2	1.0	ND	2.2
			02-03	0.30	0.19	1.3	1.1	ND	2.1
			03-04	0.19	ND	1.9	1.2	ND	2.0
			04-05	0.22	ND	1.1	1.2	ND	0.12
			05-06	0.16	ND	1.0	1.5	ND	1.1
			06-07	0.19	ND	1.3	2.1	ND	1.7
			07-08	---	ND	1.1	4.3	---	1.8
			08-09	---	ND	1.3	3.0	---	1.5
			09-10	---	ND	1.8	3.5	---	0.95
			10-11	---	ND	1.8	4.3	---	2.3
			11-12	---	0.52	2.3	2.9	---	2.6
			12-13	---	1.1	2.7	4.2	---	0.52
			13-14	---	1.3	3.5	1.7	---	2.2
			14-15	---	---	4.3	5.4	---	3.4
			15-16	---	---	4.8	8.2	---	2.9
			16-17	---	---	4.8	6.0	---	3.7
			17-18	---	---	3.0	5.4	---	2.4
			18-19	---	---	0.96	2.4	---	2.0
			19-20	---	---	---	1.3	---	3.1
			20-21	---	---	---	0.63	---	1.6
			21-22	---	---	---	---	---	0.85
			22-23	---	---	---	---	---	1.5
			23-24	---	---	---	---	---	1.1
			24-25	---	---	---	---	---	5.9
			25-26	---	---	---	---	---	4.1
			26-27	---	---	---	---	---	3.0
			27-28	---	---	---	---	---	0.23
			28-29	---	---	---	---	---	ND
			29-30	---	---	---	---	---	ND
			30-31	---	---	---	---	---	ND

Table 2-2i.
Summary of sediment total PCB data from high resolution cores collected from Reaches 9-16 of the Housatonic River.

Year	Sampler	Detection Limit (mg/kg)	Depth Interval (in)	Sediment PCB Concentrations (mg/kg)					
				Falls Village Impoundment	Bulls Bridge Impoundment	Lake Lillinonah		Lake Zoar	
				Reach 10	Reach 12	Reach 14		Reach 15	
				RM 77.7	RM 48.95 (LMS) or 53.2 (BBL)	RM 34.2	RM 29.8	RM 26.8	RM 19.7
1992	LMS	0.05	00-01	ND	0.31	0.22	0.70	ND	0.30
			01-02	ND	0.19	0.25	0.78	ND	0.37
			02-03	0.060	0.090	0.47	0.31	ND	0.10
			03-04	---	---	---	---	---	0.19
			04-05	ND	0.10	0.36	0.24	ND	0.61
			05-06	---	---	0.77	---	---	0.080
			06-07	---	---	0.41	0.65	ND	0.14
			07-08	ND	0.11	---	---	ND	0.56
			08-09	ND	---	0.36	1.7	ND	0.08
			09-10	ND	0.10	---	---	ND	---
			10-11	ND	---	0.28	1.6	ND	0.16
			11-12	ND	0.060	---	---	ND	---
			12-13	ND	0.060	0.45	1.5	ND	1.9
			13-14	ND	0.060	0.49	0.10	ND	1.2
			14-15	ND	0.24	0.36	0.12	---	0.21
			15-16	ND	0.55	0.20	0.41	---	0.55
			16-17	---	0.32	0.30	0.23	---	1.2
			17-18	ND	0.50	0.43	ND	---	1.1
			18-19	---	0.25	0.52	0.070	---	0.96
			19-20	ND	0.17	0.67	ND	---	ND
			20-21	---	0.16	0.55	ND	---	ND
			21-22	ND	---	---	---	---	0.060
			22-23	---	---	0.46	ND	---	ND
			23-24	ND	---	---	---	---	---
			24-25	---	---	0.14	ND	---	---
			25-26	ND	---	---	---	---	---
			26-27	---	---	---	ND	---	---

Table 2-2i.
Summary of sediment total PCB data from high resolution cores collected from Reaches 9-16 of the Housatonic River.

Year	Sampler	Detection Limit (mg/kg)	Depth Interval (in)	Sediment PCB Concentrations (mg/kg)					
				Falls Village Impoundment	Bulls Bridge Impoundment	Lake Lillinonah		Lake Zoar	
				Reach 10	Reach 12	Reach 14		Reach 15	
				RM 77.7	RM 48.95 (LMS) or 53.2 (BBL)	RM 34.2	RM 29.8	RM 26.8	RM 19.7
1997-98	BBL	0.15	0.0-0.4	---	0.35	---	---	---	---
			0.4-0.8	---	0.31	---	---	---	---
			0.8-1.2	---	0.35	---	---	---	---
			1.2-1.6	---	0.34	---	---	---	---
			1.6-2.0	---	0.34	---	---	---	---
			3.5-4.3	---	NA	---	---	---	---
			5.9-6.7	---	0.38	---	---	---	---
			8.3-9.1	---	1.9	---	---	---	---
			10.6-11.4	---	1.9	---	---	---	---
			13.0-13.8	---	1.5	---	---	---	---
			15.4-16.1	---	1.3	---	---	---	---
			17.7-18.5	---	2.3	---	---	---	---
			22.4-23.2	---	0.67	---	---	---	---
			26.4-27.2	---	ND	---	---	---	---
			30.3-31.1	---	1.8	---	---	---	---
			34.3-35.0	---	0.20	---	---	---	---

Notes:
(1) ND = Non detect.
(2) NA = Not available.
(3) Zero PCB concentration within 3.5-4.3" collected by BBL in 1997-98 was replaced with NA in the table.

Table 2-3a.
Summary of fish total PCB data collected in Reach 9 of the Housatonic River.

Sampler	Year	Species	Tissue Type (1)	Age Class (2), (3)	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
Stewart	1980	bass	fillet	adult	1	0.63	3.9	3.9	---	3.9	3.9
		sunfish	fillet	adult	1	1.7	2.7	2.7	---	2.7	2.7
		yellow perch	fillet	adult	1	0.46	3.0	3.0	---	3.0	3.0
	1982	brown trout	fillet	adult	1	7.6	3.3	3.3	---	3.3	3.3
		largemouth bass	fillet	adult	1	0.75	6.9	6.9	---	6.9	6.9
BBL	1994	bluegill	whole body	yoy	7	4.2	3.5	3.5	0.20	2.8	4.2
		largemouth bass	whole body	yoy	7	3.2	4.3	4.3	0.20	3.3	4.8
		yellow perch	whole body	yoy	7	2.8	4.6	4.5	0.063	4.2	4.6
	1996	bluegill	whole body	yoy	7	3.7	1.3	1.5	0.21	0.90	2.6
		largemouth bass	whole body	yoy	7	3.6	3.6	3.4	0.11	3.0	3.7
		yellow perch	whole body	yoy	7	2.6	3.3	3.3	0.086	3.0	3.7
	1998	brown bullhead	fillet	adult	2	1.1	1.7	1.7	0.40	1.3	2.1
		bluegill	whole body	yoy	5	3.8	2.3	2.1	0.30	1.0	2.7
		bluntnose minnow	whole body	adult	5	4.5	5.0	4.9	0.23	4.0	5.4
		largemouth bass	fillet	adult	2	1.8	4.9	4.9	2.3	2.7	7.2
		largemouth bass	whole body	yoy	7	3.0	2.4	2.5	0.17	2.1	3.4
		largemouth bass	whole body	adult	3	1.6	0.20	0.40	0.27	0.059	0.94
		pumpkinseed	whole body	adult	5	3.6	1.3	1.2	0.42	0.27	2.5
		yellow perch	fillet	adult	20	1.4	3.9	4.4	0.59	0.92	9.6
		yellow perch	whole body	yoy	7	2.5	3.1	3.2	0.28	2.5	4.5
Arcadis	1999	largemouth bass	whole body	adult	5	5.0	18	26	7.1	17	54
BBL	2000	bluegill	whole body	yoy	5	3.9	3.6	3.7	0.28	3.1	4.5
		largemouth bass	whole body	yoy	7	3.2	3.4	3.4	0.22	2.3	4.0
		pumpkinseed	whole body	yoy	3	3.3	4.0	4.1	0.35	3.5	4.7
		yellow perch	whole body	yoy	7	2.6	4.2	4.1	0.23	2.8	4.6
	2002	bluegill	whole body	yoy	5	3.2	2.0	1.9	0.13	1.6	2.4
		largemouth bass	whole body	yoy	7	2.9	1.9	1.9	0.040	1.8	2.1
		pumpkinseed	whole body	yoy	2	2.5	1.8	1.8	0.10	1.7	1.9
		yellow perch	whole body	yoy	4	2.4	2.5	2.5	0.094	2.3	2.7
	2004	bluegill	whole body	yoy	3	3.6	3.3	2.9	0.85	1.3	4.2
		largemouth bass	whole body	yoy	7	3.1	2.3	2.6	0.32	1.3	3.7
		pumpkinseed	whole body	yoy	4	3.8	2.8	2.9	0.085	2.7	3.1
		yellow perch	whole body	yoy	7	2.5	4.7	4.4	0.26	3.1	5.0
	2006	bluegill	whole body	yoy	7	3.4	2.8	3.0	0.24	2.5	4.3
		largemouth bass	whole body	yoy	7	3.2	3.2	2.8	0.44	0.33	3.6
		yellow perch	whole body	yoy	7	2.7	3.3	3.1	0.51	0.36	4.7

Notes:
(1) Samples with unknown tissue type not included
(2) yoy = young-of-year
(3) yoy = age less than 1 year; adults = age greater than or equal to 1 year.

Table 2-3b.
Summary of fish total PCB data collected in Falls Village (Reaches 10) of the Housatonic River.

Sampler	Year	Species	Tissue Type (1)	Age Class (2), (3)	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
CDEP	1977	brook trout	fillet	adult	1	---	0.30	0.30	---	0.30	0.30
		yellow perch	fillet	adult	1	---	4.7	4.7	---	4.7	4.7
ANSP	2000	brown bullhead	fillet	adult	1	1.7	1.0	1.0	---	1.0	1.0
		bluegill	fillet	adult	2	1.3	0.68	0.68	0.42	0.26	1.1
		pumpkinseed	fillet	adult	1	1.4	0.20	0.20	---	0.20	0.20
		yellow perch	fillet	adult	3	1.4	0.34	0.33	0.015	0.30	0.35
BBL	2004	brown bullhead	fillet	adult	4	1.6	0.43	0.39	0.078	0.16	0.52
		bluegill	fillet	adult	3	2.0	0.48	0.46	0.041	0.38	0.51
		northern pike	fillet	adult	3	1.0	1.1	16	15	0.85	46
		pumpkinseed	fillet	adult	3	1.2	0.30	0.31	0.033	0.26	0.37
		smallmouth bass	fillet	adult	1	2.0	1.2	1.2	---	1.2	1.2
		yellow perch	fillet	adult	1	1.3	0.56	0.56	---	0.56	0.56

Notes:
(1) Samples with unknown tissue type not included
(2) yoy = young-of-year
(3) yoy = age less than 1 year; adults = age greater than or equal to 1 year.

Table 2-3c.
Summary of fish total PCB data collected in West Cornwall (Reach 11) of the Housatonic River.

Sampler	Year	Species	Tissue Type (1)	Age Class (2), (3)	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
CDEP	1977	brown trout	fillet	adult	10	---	17	21	3.7	9.6	43
		rainbow trout	fillet	adult	6	---	12	13	3.0	4.6	26
		smallmouth bass	fillet	adult	1	---	4.0	4.0	---	4.0	4.0
	1979	brown trout	fillet	adult	38	---	10	11	1.3	0.91	37
		rainbow trout	fillet	adult	40	---	9	11	1.3	1.4	38
	1982	brown trout	fillet	adult	3	3.4	5.8	5.1	1.1	2.9	6.5
		smallmouth bass	fillet	adult	1	0.44	1.1	1.1	---	1.1	1.1
	1984	brown trout	fillet	adult	6	---	0.23	0.27	0.10	0.056	0.71
ANSP	1984	brown trout	fillet	adult	36	2.9	2.1	3.4	0.55	0.35	15
		smallmouth bass	fillet	adult	16	0.64	2.2	2.4	0.36	0.61	6.3
	1986	brown trout	fillet	adult	24	3.8	5.3	6.8	1.0	1.9	24
		smallmouth bass	fillet	adult	13	1.0	2.9	3.2	0.52	0.62	6.0
	1988	brown trout	fillet	adult	36	2.9	4.8	5.7	0.51	2.6	17
		rainbow trout	fillet	adult	9	0.95	3.0	3.2	0.23	2.3	4.3
		smallmouth bass	fillet	adult	13	1.6	2.8	4.8	1.0	1.6	14
	1990	brown trout	fillet	adult	36	1.3	5.4	5.6	0.30	2.9	9.3
		smallmouth bass	fillet	adult	12	0.57	3.1	3.5	0.47	1.2	6.5
	1992	brown trout	fillet	adult	44	4.0	8.4	9.3	0.78	2.5	29
		smallmouth bass	fillet	adult	14	1.3	3.8	3.7	0.43	1.1	6.6
	1994	brown trout	fillet	adult	36	2.5	1.2	1.5	0.26	0.42	9.4
		smallmouth bass	fillet	adult	13	2.3	1.6	1.6	0.19	0.67	2.6
	1996	brown trout	fillet	adult	20	1.6	1.8	2.7	0.59	0.094	9.7
		smallmouth bass	fillet	adult	5	0.68	1.2	1.1	0.18	0.68	1.5
	1998	brown trout	fillet	adult	30	2.5	1.6	2.3	0.36	1.0	11
		smallmouth bass	fillet	adult	10	0.76	0.82	0.97	0.17	0.35	1.9
	2000	brown trout	fillet	adult	36	3.6	1.4	1.5	0.10	0.71	3.3
		smallmouth bass	fillet	adult	10	1.4 (4)	0.96	0.99	0.15	0.27	1.6
	2002	brown trout	fillet	adult	30	4.5	1.4	1.7	0.16	0.67	4.8
		smallmouth bass	fillet	adult	10	1.8	1.0	1.1	0.11	0.45	1.6
	2004	brown trout	fillet	adult	30	4.4	1.9	1.9	0.11	1.1	4.2
		smallmouth bass	fillet	adult	10	1.8	0.97	1.1	0.16	0.43	2.2

Notes:
(1) Samples with unknown tissue type not included
(2) yoy = young-of-year
(3) yoy = age less than 1 year; adults = age greater than or equal to 1 year.
(4) Sample size for lipid analysis = 9

Table 2-3d.
Summary of fish total PCB data collected in Bulls Bridge (Reach 12) of the Housatonic River.

Sampler	Year	Species	Tissue Type (1)	Age Class (2), (3)	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
CDEP	1979	brown bullhead	fillet	adult	10	---	2.2	2.5	0.48	1.3	6.5
		black crappie	fillet	adult	3	---	2.0	2.1	0.11	2.0	2.3
		carp	fillet	adult	7	---	4.1	4.8	1.6	0.81	14
		chain pickerel	fillet	adult	10	---	1.5	2.2	0.50	0.60	4.5
		largemouth bass	fillet	adult	10	---	1.9	2.3	0.35	1.3	4.5
		smallmouth bass	fillet	adult	22	---	9.0	10	1.5	1.7	30
		sunfish	fillet	adult	10	---	0.73	0.75	0.08	0.37	1.3
		white sucker	fillet	adult	9	---	4.6	8.2	3.0	0.87	28
		yellow perch	fillet	adult	10	---	1.2	1.3	0.15	0.68	2.0
ANSP	1984	brown bullhead	fillet	adult	12	0.66	0.82	0.80	0.09	0.38	1.4
		bluegill	fillet	adult	2	1.4	0.88	0.88	0.28	0.60	1.2
		carp	fillet	adult	1	1.5	1.1	1.1	---	1.1	1.1
		largemouth bass	fillet	adult	24	0.80	1.0	1.4	0.17	0.34	2.8
		redbreasted sunfish	fillet	adult	2	0.73	1.5	1.5	0.07	1.5	1.6
		smallmouth bass	fillet	adult	12	0.92	1.9	1.9	0.18	0.89	2.9
		yellow perch	fillet	adult	23	0.83	1.0	1.3	0.28	0.46	6.3
	1986	brown bullhead	fillet	adult	6	1.1	1.6	1.8	0.40	0.84	3.1
		smallmouth bass	fillet	adult	12	1.3	1.3	1.6	0.22	0.73	2.8
		yellow perch	fillet	adult	25	1.0	0.62	0.82	0.10	0.20	2.1
	1988	brown bullhead	fillet	adult	14	1.0	1.5	2.0	0.43	0.39	6.4
		bluegill	fillet	adult	3	2.2	1.2	2.2	1.1	1.1	4.4
		carp	fillet	adult	3	10	7.7	6.7	2.2	2.4	9.9
		largemouth bass	fillet	adult	11	1.4	1.9	2.6	0.71	0.52	8.8
		pumpkinseed	fillet	adult	2	0.79	0.29	0.29	0.26	0.030	0.55
		redbreasted sunfish	fillet	adult	2	1.2	2.0	2.0	0.60	1.4	2.6
		smallmouth bass	fillet	adult	14	1.5	2.6	2.8	0.32	1.0	5.7
		yellow perch	fillet	adult	23	0.81	0.79	0.99	0.10	0.40	1.9
	1990	smallmouth bass	fillet	adult	6	0.74	2.6	2.5	0.40	0.87	3.8
		yellow perch	fillet	adult	18	0.66	0.75	0.95	0.12	0.16	1.9
	1992	smallmouth bass	fillet	adult	8	1.2	1.8	1.8	0.21	1.03	2.7
		yellow perch	fillet	adult	12	1.2	0.62	0.69	0.08	0.39	1.3
	1994	smallmouth bass	fillet	adult	8	2.2	1.4	1.4	0.13	0.77	1.8
	1996	smallmouth bass	fillet	adult	8	0.83	1.2	1.2	0.051	0.95	1.3
	1998	redbreasted sunfish	whole body	adult	2	1.7	0.46	0.46	0.04	0.42	0.50
		smallmouth bass	fillet	adult	10	1.5	0.99	0.94	0.11	0.36	1.4
		yellow perch	whole body	adult	2	0.62	0.51	0.51	0.045	0.46	0.55
	2000	brown bullhead	fillet	adult	1	1.0	0.38	0.38	---	0.38	0.38
		bluegill	fillet	adult	2	1.4	0.47	0.47	0.36	0.11	0.82
		pumpkinseed	fillet	adult	1	1.5	0.65	0.65	---	0.65	0.65
		smallmouth bass	fillet	adult	10	1.9	0.81	0.97	0.14	0.59	2.0
		yellow perch	fillet	adult	3	0.99	0.27	0.25	0.038	0.18	0.31
	2002	smallmouth bass	fillet	adult	10	1.6	0.70	0.77	0.11	0.33	1.5

Table 2-3d.
Summary of fish total PCB data collected in Bulls Bridge (Reach 12) of the Housatonic River.

Sampler	Year	Species	Tissue Type (1)	Age Class (2), (3)	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
ANSP	2004	brown bullhead	fillet	adult	2	1.4	0.46	0.46	0.069	0.40	0.53
		bluegill	fillet	adult	3	1.2	0.33	0.31	0.038	0.24	0.37
		largemouth bass	fillet	adult	1	1.5	0.65	0.65	---	0.65	0.65
		northern pike	fillet	adult	3	0.57	0.62	0.51	0.16	0.19	0.72
		pumpkinseed	fillet	adult	3	0.89	0.27	0.27	0.024	0.22	0.31
		smallmouth bass	fillet	adult	10	1.2	1.1	1.2	0.13	0.74	1.9
		yellow bullhead	fillet	adult	1	1.1	0.42	0.42	---	0.42	0.42
		yellow perch	fillet	adult	3	1.2	0.38	0.40	0.046	0.34	0.49

Notes:
(1) Samples with unknown tissue type not included
(2) yoy = young-of-year
(3) yoy = age less than 1 year; adults = age greater than or equal to 1 year.

Table 2-3e.
Summary of fish total PCB data collected in Lake Lillinonah (Reach 14) of the Housatonic River.

Sampler	Year	Species	Tissue Type [(1)]	Age Class [(2), (3)]	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
CDEP	1976	common sucker	whole body	adult	2	---	22	22	16	5.6	38
	1977	largemouth bass	fillet	adult	2	---	5.0	5.0	0.25	4.7	5.2
		smallmouth bass	fillet	adult	5	---	4.1	5.1	1.3	2.7	9.8
		white catfish	fillet	adult	4	---	8.3	8.0	1.4	4.3	11
		white perch	fillet	adult	3	---	6.2	6.6	1.8	3.7	10
	1979	brown bullhead	fillet	adult	10	---	4.8	5.4	1.2	1.0	12
		black crappie	fillet	adult	10	---	0.55	0.50	0.052	0.25	0.69
		carp	fillet	adult	10	---	3.3	5.8	2.6	0.47	28
		largemouth bass	fillet	adult	10	---	0.89	1.2	0.33	0.43	3.8
		smallmouth bass	fillet	adult	10	---	3.0	3.3	0.45	1.3	5.3
		sunfish	fillet	adult	10	---	1.1	1.2	0.24	0.28	2.2
		white catfish	fillet	adult	10	---	13	12.8	1.2	8.0	21
		white perch	fillet	adult	10	---	4.7	5.8	1.1	2.2	13
		white sucker	fillet	adult	10	---	0.84	0.94	0.22	0.22	2.7
		yellow perch	fillet	adult	10	---	0.87	1.0	0.24	0.33	2.5
ANSP	1984	brown bullhead	fillet	adult	3	1.5	2.3	2.4	0.11	2.2	2.6
		bluegill	fillet	adult	2	1.1	0.53	0.53	0.0050	0.52	0.53
		carp	fillet	adult	1	11	2.2	2.2	---	2.2	2.2
		largemouth bass	fillet	adult	6	0.93	1.1	1.3	0.28	0.84	2.7
		redbreasted sunfish	fillet	adult	2	0.56	1.5	1.5	0.40	1.1	1.9
		smallmouth bass	fillet	adult	25	1.2	1.1	1.2	0.11	0.44	2.8
		white catfish	fillet	adult	12	3.2	1.5	6.5	4.4	0.80	55
		white perch	fillet	adult	24	3.3	2.0	2.3	0.23	0.86	5.3
		yellow perch	fillet	adult	3	0.69	0.44	0.64	0.26	0.33	1.2
	1986	smallmouth bass	fillet	adult	26	0.86	0.85	1.6	0.33	0.36	7.3
		white catfish	fillet	adult	15	3.0	2.9	8.4	2.7	1.1	36
		white perch	fillet	adult	15	5.2	1.9	2.2	0.33	0.86	5.2
	1988	brown bullhead	fillet	adult	5	0.50	0.81	1.7	0.69	0.55	4.1
		bluegill	fillet	adult	3	1.1	0.33	0.52	0.19	0.32	0.90
		carp	fillet	adult	3	3.4	4.2	7.4	5.0	0.77	17
		largemouth bass	fillet	adult	7	0.75	0.97	1.4	0.62	0.030	4.8
		pumpkinseed	fillet	adult	1	0.94	0.030	0.030	---	0.030	0.030
		pumpkinseed	fillet	adult	1	0.80	0.28	0.28	---	0.28	0.28
		redbreasted sunfish	fillet	adult	1	1.0	0.030	0.030	---	0.030	0.030
		smallmouth bass	fillet	adult	25	0.79	1.1	1.4	0.18	0.46	3.7
		white catfish	fillet	adult	16	2.2	2.5	5.6	1.8	1.0	25
		white perch	fillet	adult	11	5.2	2.0	1.8	0.21	0.79	2.8
		yellow perch	fillet	adult	6	0.88	0.14	0.23	0.10	0.030	0.62
	1990	bluegill	fillet	adult	6	0.87	0.43	0.51	0.11	0.25	1.0
		pumpkinseed	fillet	adult	6	0.44	0.19	0.21	0.045	0.11	0.37
		redbreasted sunfish	fillet	adult	6	0.57	0.41	0.40	0.088	0.11	0.64
		smallmouth bass	fillet	adult	6	0.91	0.96	1.1	0.17	0.69	1.7
		yellow perch	fillet	adult	18	0.51	0.39	0.38	0.042	0.15	0.76

Table 2-3e.
Summary of fish total PCB data collected in Lake Lillinonah (Reach 14) of the Housatonic River.

Sampler	Year	Species	Tissue Type (1)	Age Class (2), (3)	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
ANSP	1992	bluegill	fillet	adult	4	0.83	0.30	0.62	0.39	0.11	1.8
		pumpkinseed	fillet	adult	2	0.93	0.20	0.20	0.10	0.10	0.30
		redbreasted sunfish	fillet	adult	3	0.95	0.68	0.61	0.095	0.43	0.73
		smallmouth bass	fillet	adult	8	0.97	1.1	1.9	0.60	0.73	5.9
		yellow perch	fillet	adult	8	0.86	0.42	0.41	0.055	0.12	0.62
	1994	smallmouth bass	fillet	adult	9	1.0	0.39	0.56	0.15	0.16	1.6
	1996	smallmouth bass	fillet	adult	5	0.53	0.28	0.33	0.059	0.23	0.56
	1998	redbreasted sunfish	whole body	adult	2	0.49	0.12	0.12	0.0050	0.11	0.12
		smallmouth bass	fillet	adult	10	1.2	0.86	0.80	0.086	0.24	1.3
		yellow perch	whole body	adult	1	0.60	0.083	0.083	---	0.083	0.083
	2000	smallmouth bass	fillet	adult	10	1.7	0.39	0.47	0.084	0.23	1.1
	2002	smallmouth bass	fillet	adult	10	1.7	0.28	0.36	0.071	0.12	0.87
	2004	brown bullhead	fillet	adult	2	2.0	0.38	0.38	0.18	0.21	0.56
		bluegill	fillet	adult	3	0.97	0.15	0.19	0.052	0.13	0.30
		northern pike	fillet	adult	3	2.0	1.1	1.2	0.27	0.86	1.8
		pumpkinseed	fillet	adult	1	1.6	0.049	0.049	---	0.049	0.05
		redbreasted sunfish	fillet	adult	2	1.3	0.15	0.15	0.010	0.14	0.16
		smallmouth bass	fillet	adult	10	1.2	0.54	0.62	0.14	0.24	1.7
		white catfish	fillet	adult	1	1.6	1.5	1.5	---	1.5	1.5
		yellow bullhead	fillet	adult	5	1.1	0.24	0.22	0.048	0.092	0.34
		yellow perch	fillet	adult	3	1.1	0.17	0.17	0.013	0.14	0.18

Notes:
(1) Samples with unknown tissue type not included
(2) yoy = young-of-year
(3) yoy = age less than 1 year; adults = age greater than or equal to 1 year.

Table 2-3f.
Summary of fish total PCB data collected in Lake Zoar (Reach 15) of the Housatonic River.

Sampler	Year	Species	Tissue Type $^{(1)}$	Age Class $^{(2), (3)}$	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
CDEP	1977	black crappie	fillet	adult	1	---	0.66	0.66	---	0.66	0.66
		carp	fillet	adult	1	---	10	10	---	10	10
		largemouth bass	fillet	adult	5	---	2.4	2.3	0.36	1.2	3.3
		smallmouth bass	fillet	adult	2	---	2.0	2.0	0.70	1.3	2.7
		white catfish	fillet	adult	5	---	4.7	9.0	4.3	4.4	26
		white perch	fillet	adult	5	---	6.4	5.9	0.85	3.6	8.2
		yellow perch	fillet	adult	3	---	0.90	1.3	0.67	0.40	2.6
	1978	black crappie	fillet	adult	1	---	0.20	0.20	---	0.20	0.20
		carp	fillet	adult	2	---	4.0	4.0	3.0	1.0	7.0
		smallmouth bass	fillet	adult	1	---	1.2	1.2	---	1.2	1.2
	1979	brown bullhead	fillet	adult	10	---	1.9	2.4	0.50	0.65	6.4
		black crappie	fillet	adult	10	---	0.74	1.0	0.33	0.33	3.9
		carp	fillet	adult	10	---	1.0	2.5	1.1	0.24	10
		American eel	fillet	adult	3	---	7.4	8.8	2.9	4.6	14
		largemouth bass	fillet	adult	10	---	0.70	0.78	0.13	0.32	1.8
		smallmouth bass	fillet	adult	10	---	2.4	2.5	0.37	0.93	4.6
		sunfish	fillet	adult	10	---	0.45	0.49	0.092	0.14	0.90
		white catfish	fillet	adult	10	---	8.0	8.8	0.75	5.1	12
		white perch	fillet	adult	10	---	3.3	4.1	0.57	2.4	7.6
		white sucker	fillet	adult	10	---	0.83	0.86	0.21	0.020	1.9
		yellow perch	fillet	adult	10	---	0.97	1.5	0.49	0.28	5.5
ANSP	1984	brown bullhead	fillet	adult	2	0.72	0.41	0.41	0.11	0.30	0.52
		bluegill	fillet	adult	2	0.90	1.0	1.0	0.24	0.78	1.3
		carp	fillet	adult	1	6.8	4.9	4.9	---	4.9	4.9
		largemouth bass	fillet	adult	2	0.67	0.42	0.42	0.0050	0.42	0.43
		redbreasted sunfish	fillet	adult	2	0.62	0.090	0.090	0.020	0.070	0.11
		smallmouth bass	fillet	adult	24	0.86	0.45	0.50	0.056	0.010	1.1
		white catfish	fillet	adult	12	2.3	2.4	2.7	0.60	0.97	8.6
		white perch	fillet	adult	24	3.4	0.89	0.95	0.076	0.55	2.0
		yellow perch	fillet	adult	2	0.46	0.07	0.065	0.005	0.060	0.070
	1986	white catfish	fillet	adult	16	3.0	2.6	3.1	0.59	0.79	9.2
	1988	brown bullhead	fillet	adult	6	1.1	0.65	0.68	0.082	0.37	0.94
		bluegill	fillet	adult	2	0.58	0.20	0.20	0.17	0.030	0.38
		carp	fillet	adult	3	7.2	21	17	6.9	2.9	26
		American eel	fillet	adult	3	24	1.6	1.2	0.48	0.25	1.8
		largemouth bass	fillet	adult	7	1.4	0.90	1.4	0.55	0.24	4.4
		pumpkinseed	fillet	adult	2	0.85	0.11	0.11	0.080	0.030	0.19
		redbreasted sunfish	fillet	adult	2	1.2	0.15	0.15	0.12	0.030	0.27
		smallmouth bass	fillet	adult	16	1.3	0.69	0.97	0.17	0.14	2.1
		white catfish	fillet	adult	21	2.0	3.3	4.3	0.80	0.86	18
		white perch	fillet	adult	12	4.0	1.2	1.5	0.37	0.030	3.9
		yellow perch	fillet	adult	7	0.72	0.28	0.22	0.057	0.030	0.37

Table 2-3f.
Summary of fish total PCB data collected in Lake Zoar (Reach 15) of the Housatonic River.

Sampler	Year	Species	Tissue Type (1)	Age Class (2), (3)	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
ANSP	1990	bluegill	fillet	adult	6	0.57	0.15	0.13	0.031	0.028	0.22
		American eel	fillet	adult	18	9.4	1.9	2.9	0.55	0.34	9.0
		pumpkinseed	fillet	adult	6	0.40	0.16	0.17	0.031	0.074	0.29
		redbreasted sunfish	fillet	adult	6	0.46	0.19	0.21	0.054	0.078	0.43
		smallmouth bass	fillet	adult	6	0.41	0.65	0.65	0.12	0.27	1.0
		white perch	fillet	adult	18	2.0	0.82	1.0	0.19	0.18	3.6
		yellow perch	fillet	adult	18	0.39	0.22	0.25	0.033	0.10	0.65
	1992	bluegill	fillet	adult	3	0.68	0.40	0.32	0.14	0.052	0.50
		American eel	fillet	adult	5	19	3.9	8.8	5.0	1.7	28
		pumpkinseed	fillet	adult	3	0.63	0.32	0.29	0.14	0.047	0.51
		redbreasted sunfish	fillet	adult	3	0.70	0.23	0.31	0.16	0.082	0.61
		smallmouth bass	fillet	adult	7	1.5	0.90	1.4	0.44	0.65	3.3
		white perch	fillet	adult	14	1.2	0.70	1.3	0.48	0.14	7.1
		yellow perch	fillet	adult	8	0.80	0.24	0.35	0.10	0.12	0.99
	1994	largemouth bass	fillet	adult	1	0.97	0.26	0.26	---	0.26	0.26
		smallmouth bass	fillet	adult	10	1.3	0.43	0.45	0.094	0.10	1.0
	1996	smallmouth bass	fillet	adult	5	0.61	0.45	0.51	0.077	0.37	0.81
	1998	smallmouth bass	fillet	adult	10	1.2	0.66	0.88	0.24	0.28	2.9
		yellow perch	whole body	adult	1	0.48	0.73	0.73	---	0.73	0.73
	2000	smallmouth bass	fillet	adult	10	1.2	0.22	0.31	0.061	0.11	0.74
	2002	smallmouth bass	fillet	adult	10	1.4	0.35	0.35	0.068	0.13	0.89
	2004	bluegill	fillet	adult	3	1.3	0.14	0.17	0.056	0.092	0.28
		pumpkinseed	fillet	adult	2	1.1	0.086	0.086	0.000	0.086	0.087
		smallmouth bass	fillet	adult	10	1.1	0.28	0.33	0.057	0.15	0.73
		white catfish	fillet	adult	2	3.6	0.70	0.70	0.23	0.47	0.92
		white perch	fillet	adult	1	2.4	0.56	0.56	---	0.56	0.56
		yellow bullhead	fillet	adult	1	0.98	0.062	0.062	---	0.062	0.062
		yellow perch	fillet	adult	3	1.0	0.21	0.19	0.029	0.14	0.24

Notes:
(1) Samples with unknown tissue type not included
(2) yoy = young-of-year
(3) yoy = age less than 1 year; adults = age greater than or equal to 1 year.

Table 2-3g.
Summary of fish total PCB data collected in Lake Housatonic (Reach 16) of the Housatonic River.

Sampler	Year	Species	Tissue Type (1)	Age Class (2), (3)	Number of Samples	Average Lipid (%)	Median PCB (mg/kg wet)	Arithmetic Mean PCB (mg/kg wet)	Standard Error (mg/kg wet)	Minimum (mg/kg wet)	Maximum (mg/kg wet)
CDEP	1979	brown bullhead	fillet	adult	10	---	0.87	0.97	0.074	0.78	1.5
		black crappie	fillet	adult	10	---	0.63	0.71	0.15	0.24	1.7
		carp	fillet	adult	10	---	3.4	5.1	1.6	0.61	18
		American eel	fillet	adult	10	---	12	13	2.4	2.3	29
		largemouth bass	fillet	adult	10	---	0.60	0.61	0.076	0.36	1.2
		smallmouth bass	fillet	adult	4	---	2.2	3.5	2.0	0.33	9.3
		sunfish	fillet	adult	10	---	0.65	0.61	0.10	0.19	1.2
		white catfish	fillet	adult	10	---	4.3	3.7	0.64	0.89	6.8
		white perch	fillet	adult	10	---	3.2	3.3	0.35	1.4	5.1
		white sucker	fillet	adult	10	---	1.1	1.3	0.22	0.31	2.2
		yellow perch	fillet	adult	10	---	0.54	0.79	0.17	0.24	1.8

Notes:
(1) Samples with unknown tissue type not included
(2) yoy = young-of-year
(3) yoy = age less than 1 year; adults = age greater than or equal to 1 year.

Table 2-4.
Summary of benthic invertebrates PCB data from West Cornwall.

Year	Sampler	Species	Number of Samples	Median (ppm)	Arithmetic Mean (mg/kg)	Standard Errors (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)
MCP Interim Phase II								
1978-1990	CDEP	Caddisfly larvae	11	5.60	6.22	1.53	0.50	18.90
		Hellgrammite larvae & stonefly nymphs	11	4.60	5.47	1.82	0.80	22.90
ANSP Samples								
1992-2005	ANSP	Caddisfly larvae	14	1.24	1.90	0.54	0.48	8.17
		Hellgrammite larvae	12	2.02	2.48	0.58	0.31	7.45
		Stonefly nymphs	9	0.55	1.51	0.47	0.46	4.07

Notes:

(1) Total PCB concentrations for benthic invertebrate samples represent Aroclor total PCB.

(2) Samples are composites.

Table 5-1.
Description of Variables in Equation that Predicts Target Soil Concentrations Protective of Mink[1]

Variable	Description	Value	Basis
C_p	Target concentration of PCBs in prey	0.98-2.4 mg/kg	IMPG Proposal
P_a	Proportion of diet comprised of amphibians and reptiles	0.15	ERA
P_f	Proportion of diet comprised of fish	0.23	ERA
P_i	Proportion of diet comprised of aquatic invertebrates	0.36	ERA
P_{tb}	Proportion of diet comprised of terrestrial birds	0.03	Table I.1-2, ERA
P_{ab}	Proportion of diet comprised of aquatic birds	0.08	Table I.1-2, ERA
P_{aba}	Proportion of diet comprised of aquatic birds eating aquatic prey	0.74	ERA
P_{abt}	Proportion of diet comprised of aquatic birds eating terrestrial prey	0.26	ERA
P_{am}	Proportion of diet comprised of aquatic mammals	0.07	Table I.2-2, ERA
P_{tm}	Proportion of diet comprised of terrestrial mammals	0.08	Table I.2-2, ERA
C_{sed}	Target concentrations of PCBs in sediment	1,3,5,10 mg/kg	Range assumed
$BSAF_a$	Biota sediment accumulation factor for amphibians and reptiles	0.727	Table 5-2
$BSAF_f$	Biota sediment accumulation factor for fish	1.21	Table 5-3
$BSAF_i$	Biota sediment accumulation factor for aquatic invertebrates	0.727	Table 5-4
$BSAF_{ab}$	Biota sediment accumulation factor for aquatic birds feeding on aquatic prey	0.56	Table 5-5
$BSAF_{am}$	Biota sediment accumulation factor for aquatic mammals	0.140	Table 5-6
BAF_{tb}	Bioaccumulation factor for terrestrial birds	1.331	Table 5-7
BAF_{ab}	Bioaccumulation factor from soils for aquatic birds feeding on terrestrial prey	0.36	Table 5-5
BAF_{tm}	Bioaccumulation factor from soils for terrestrial mammals	0.435	Table 5-8
$LIPID_a$	Proportion in lipids of amphibians and reptiles	0.015	Table 5-2
$LIPID_i$	Proportion in lipids of invertebrates	0.010	Table 5-4
$LIPID_{ab}$	Proportion in lipids of aquatic birds	0.044	Table 5-5
$LIPID_{am}$	Proportion in lipids of aquatic mammals	0.024	Table 5-6
FOC_{sed}	Fraction of organic carbon in sediment	0.069	CMS Proposal, Appendix B, Table B-4
FOC_{soil}	Fraction of organic carbon in floodplain soil	0.067	Spatially-weighted map of soils

Note:

[1] *Values are unitless unless specified.*

Table 5-2.
Data Used to Calculate Median BSAF and Average Lipid Content of Whole-Body Amphibians[1]

Pond	Tissue PCB (mg/kg)[2]	Lipid Fraction	Sediment PCB (mg/kg)	Sediment FOC	$BSAF_a$
Leopard Frog					
W-1	0.03	0.007	0.4	0.263	2.35
W-9A	3.12	0.030	7.5	0.017	0.23
W-6	1.64	0.028	21.0	0.050	0.14
E-5	1.31	0.006	19.6	0.049	0.55
W-1	0.15	0.004	0.4	0.263	25.38
W-4	0.34	0.010	0.4	0.067	5.75
E-1	3.09	0.013	26.6	0.111	0.99
W-9A	3.59	0.016	7.5	0.017	0.51
W-6	1.76	0.013	21.0	0.050	0.32
W-7A	2.11	0.019	27.6	0.049	0.20
W-8	5.39	0.016	43.5	0.094	0.73
W-1	5.15	0.022	0.4	0.263	156.13
W-9A	0.06	0.008	7.5	0.017	0.02
W-7A	1.30	0.018	27.6	0.049	0.13
W-7A	5.28	0.015	27.6	0.049	0.61
Wood Frog					
18-VP-2	2.92	0.039	4.9	0.048	0.73
23B-VP-1	0.30	0.018	0.21	0.076	6.14
23B-VP-2	1.22	0.020	0.3	0.089	17.98
38-VP-1	0.11	0.008	28.54	0.002	0.001
38-VP-2	5.35	0.011	32.31	0.092	1.38
46-VP-1	0.13	0.015	0.76	0.120	1.38
46-VP-5	0.41	0.010	1.36	0.030	0.92
Bullfrog					
Woods Pond	4.25	0.011	26	0.046	0.72
Woods Pond	7.25	0.009	3.1	0.094	24.60
Woods Pond	6.13	0.011	16.4	0.103	3.64
Woods Pond	3.48	0.011	2.87	0.071	7.86
Woods Pond	0.03	0.017	79.2	0.127	0.003
Woods Pond	7.73	0.023	NA	NA	NA

Notes:

[1] *Sediment data are spatially weighted for all but Woods Pond. Data are from EPA database used for ERA.*

[2] *Mean concentration of PCBs in frogs was 2.81 mg/kg.*

Table 5-3.
Data Used to Calculate Fish Tissue PCB Concentration Using Predicted BSAF Output from Food Chain Model (FCM) for Fish 7 to 20 cm

Target sediment PCB concentrations (mg/kg)	$BSAF_f$	OC-normalized sediment PCB (mg/kg)	Tissue PCB (mg/kg)
1	1.21	14.49	0.61
3	1.21	43.48	1.83
5	1.21	72.46	3.04
10	1.21	144.93	6.09

Notes:

[1] *Data for Reaches 5 and 6 were combined using an average weighted by river length. Input data are described in text. OC = organic carbon.*

[2] *Lipid fraction in 7 to 20 cm fish used in the FCM averaged 0.035.*

Table 5-4.
Data Used to Calculate Median BSAF and Average Lipid Content of Aquatic Invertebrates (Crayfish)[1]

ID	River Mile	Tissue PCB (mg/kg)[2]	Lipid Fraction	OC-normalized sediment PCB (mg PCB/kg OC)	BSAF
H3-TD12OVWB-M018	125.07	5.455	0.005	602	1.81
H3-TD12OVWB-M017	125.07	5.653	0.005	602	1.88
H3-TD12OVWB-M015	125.07	5.975	0.008	602	1.24
H3-TD12OVWB-M014	125.07	3.954	0.004	602	1.64
H3-TD12OVWB-M013	125.07	8.509	0.007	602	2.02
H3-TD12OVWB-M011	125.07	6.632	0.008	602	1.38
H3-TD12OVWB-M010	125.07	4.591	0.003	602	2.54
H3-TD12OVWB-F009	125.07	15.841	0.02	602	1.32
H3-TD12OVWB-F007	125.07	6.742	0.009	602	1.25
H3-TD12OVWB-F006	125.07	4.639	0.007	602	1.10
H3-TD11OVWB-F004	126.07	7.219	0.014	1127	0.46
H3-TD11OVWB-F013	126.07	7.509	0.015	1127	0.44
H3-TD11OVWB-F023	126.07	8.084	0.012	1127	0.60
H3-TD11OVWB-F026	126.07	12.677	0.013	1127	0.87
H3-TD11OVWB-F027	126.07	14.728	0.018	1127	0.73
H3-TD11OVWB-M001	126.07	8.643	0.003	1127	2.56
H3-TD11OVWB-M003	126.07	6.826	0.006	1127	1.01
H3-TD11OVWB-M005	126.07	8.213	0.006	1127	1.21
H3-TD11OVWB-M014	126.07	2.59	0.004	1127	0.57
H3-TD11OVWB-M024	126.07	5.745	0.007	1127	0.73
H3-TD07OVWB-F002	130.07	31.587	0.02	1708	0.92
H3-TD07OVWB-M001	130.07	6.634	0.007	1708	0.55
H3-TD07OVWB-M003	130.07	4.348	0.002	1708	1.27
H3-TD07OVWB-M004	130.07	9.671	0.014	1708	0.40
H3-TD07OVWB-M006	130.07	14.839	0.012	1708	0.72
H3-TD07OVWB-M007	130.07	20.401	0.012	1708	1.00
H3-TD07OVWB-M008	130.07	7.396	0.014	1708	0.31
H3-TD07OVWB-M011	130.07	13.672	0.008	1708	1.00
H3-TD07OVWB-M014	130.07	6.814	0.008	1708	0.50
H3-TD07OVWB-M021	130.07	7.469	0.008	1708	0.55
H3-TD05OVWB-F002	132.07	40.354	0.019	3567	0.60
H3-TD05OVWB-M023	132.07	9.938	0.004	3567	0.70
H3-TD05OVWB-M022	132.07	52.141	0.011	3567	1.33
H3-TD05OVWB-M021	132.07	9.421	0.009	3567	0.29
H3-TD05OVWB-M020	132.07	8.075	0.008	3567	0.28
H3-TD05OVWB-M014	132.07	15.93	0.01	3567	0.45
H3-TD05OVWB-M008	132.07	13.121	0.008	3567	0.46
H3-TD05OVWB-M007	132.07	21.849	0.014	3567	0.44
H3-TD05OVWB-M001	132.07	20.089	0.011	3567	0.51
H3-TD05OVWB-F005	132.07	25.785	0.028	3567	0.26

Notes:

[1] *Data are from database used for RFI.*

[2] *Mean concentration of PCBs in crayfish was 12.24 mg/kg.*

Table 5-5.
Data Used to Calculate Median BSAF and Average Lipid Content of Aquatic Birds (Wood Duck) [1]

ID	Tissue PCB (mg/kg)	Lipid Fraction[2]	Sediment Spatially-Weighted PCB (mg/kg)	Sediment Spatially-Weighted FOC	Soil Spatially-Weighted PCB (mg/kg)	Soil Spatially-Weighted FOC
TS002	5.12	0.014	17.1	0.066	16.7	.068
TS004	7.16	0.010	17.1	0.066	16.7	.068
TS005	6.81	0.008	17.1	0.066	16.7	.068
TS007	6.87	0.007	17.1	0.066	16.7	.068
TS008	11.16	0.024	17.1	0.066	16.7	.068
TS003	4.79	0.024	17.1	0.066	16.7	.068
TS001	12.26	0.024	17.1	0.066	16.7	.068
TS006	4.87	0.025	17.1	0.066	16.7	.068
TS044	1.04	0.023	28.4	0.085	10.7	.051
TS039	3.18	0.092	28.4	0.085	10.7	.051
TS037	6.09	0.053	28.4	0.085	10.7	.051
TS038	17.51	0.073	28.4	0.085	10.7	.051
TS041	10.38	0.071	28.4	0.085	10.7	.051
TS042	8.70	0.089	28.4	0.085	10.7	.051
TS040	5.81	0.131	28.4	0.085	10.7	.051
TS010	5.28	0.003	28.4	0.085	10.7	.051
TS009	3.89	0.003	28.4	0.085	10.7	.051
TS036	3.05	0.044	28.4	0.085	10.7	.051
TS043	3.62	0.161	28.4	0.085	10.7	.051
TS011	7.75	0.003	28.4	0.085	10.7	.051
Average PCB concentration in tissue (mg/kg)						6.77
$BSAF_{ab}$						1.006
BAF_{ab}						0.36

Notes:

[1] *Whole body estimates of lipid content and PCBs are from Appendix L in ERA. Used spatially-weighted sediment data for entire reach, assuming wood duck can forage across such a large range over the year (up to 10 km, Parr et al. 1979). Data are from EPA database for ERA.*

[2] *Lipids obtained using gas chromatograph.*

Table 5-6.
Kalamazoo River Data (Trowbridge Area) Used to Calculate Median BSAF and Average Lipid Content of Aquatic Mammals (Muskrat) [1]

ID	Tissue PCB (mg/kg)	Lipid Fraction	Sediment Average PCB (mg/kg)	Sediment Average FOC	$BSAF_{am}$
OZ21	0.082	0.020	2.177	0.055	0.10
OZ23	0.036	0.007	2.502	0.069	0.14
OZ24	0.059	0.026	0.011	0.057	11.48
OZ27	0.076	0.019	2.177	0.055	0.10
OZ29	0.014	0.013	2.502	0.069	0.03
OZ30	0.112	0.044	0.017	0.057	8.62
OZ31	0.079	0.043	0.017	0.039	4.24

Note:

[1] *Data from Michigan State University, 2004.*

Table 5-7.
Data Used to Calculate Median BSAF and Average Lipid Content of Terrestrial Birds [1]

Location	Egg Tissue PCB (mg/kg)	Estimated Adult Tissue PCB (mg/kg) [2]	Egg Lipid Fraction	Soil Spatially-Weighted Average PCB (mg/kg)	BAF$_{tb}$
House Wren					
Canoe Meadows	57.57	29.36	0.048	24.2	1.21
Canoe Meadows	149.49	76.21	0.192	24.2	3.15
Canoe Meadows	45.94	23.43	0.048	24.2	0.97
Canoe Meadows	63.16	32.21	0.049	24.2	1.33
Canoe Meadows	43.30	22.08	0.054	24.2	0.91
Black-Capped Chickadee					
Canoe Meadows	17.58	8.97	0.029	24.2	0.37
New Lennox Road	18.18	9.27	0.153	13.8	0.67
Roaring Brook Road	24.98	12.74	0.032	27.6	0.46
American Robin					
South of New Lenox	5.04	2.57	0.030	9.25	0.28
South of New Lenox	6.7	3.42	0.047	54.47	0.06
South of New Lenox	18.4	9.38	0.047	5.73	1.64
Reach 5	7.38	3.76	0.059	12.3	0.31
South of New Lenox	150	76.50	0.049	5.61	13.64
South of New Lenox	162	82.62	0.051	6.55	12.61
South of New Lenox	51.4	26.21	0.048	1.58	16.59
Reach 5	37.5	19.13	0.042	4.15	4.61
South of New Lenox	86.3	44.01	0.051	4.15	10.61
South of New Lenox	103	52.53	0.020	5.20	10.10
South of New Lenox	170	86.70	0.039	4.982	17.40

Notes:

[1] *Wren and chickadee data from EPA database for ERA. Robin data from GE database for robin productivity study (ARCADIS G&M, Inc. 2002).*

[2] *Mean concentration of PCBs estimated for adult tissue was 32.69 mg/kg (assuming adult concentrations are 0.51 of egg concentrations, Neigh et al., 2006). Adult lipid fractions are estimated to be 0.54 of egg lipid fractions (Neigh et al., 2006).*

Table 5-8.
Data Used to Calculate Median BSAF and Average Lipid Content of Terrestrial Mammals [1]

ID	Tissue PCB (mg/kg)	Soil Spatially-Weighted Average PCB (mg/kg)	BAF_{tb}
Short-Tailed Shrew			
H3-TM15SS15-0-M002	10.68	0.71	15.13
H3-TM15SS15-0-M001	5.46	1.12	4.88
H3-TM15SS15-0-F001	7.45	1.25	5.94
H3-TM15SS15-0-F002	4.45	1.27	3.52
H3-TM05SS13-0-M001	127.60	23.56	5.42
H3-TM05SS13-0-M002	91.93	23.56	3.90
H3-TM05SS13-0-F004	93.37	24.60	3.80
H3-TM05SS13-0-M006	130.78	24.98	5.24
H3-TM05SS13-0-F001	135.77	26.07	5.21
H3-TM07SS14-0-M004	14.81	27.98	0.53
H3-TM05SS13-0-M003	139.27	28.32	4.92
H3-TM05SS13-0-F002	102.25	28.78	3.55
H3-TM05SS13-0-M005	131.95	29.23	4.51
H3-TM07SS14-0-F005	49.47	31.36	1.58
H3-TM05SS13-0-M004	117.67	32.59	3.61
H3-TM07SS14-0-F009	80.46	33.05	2.43
H3-TM07SS14-0-F004	80.15	33.92	2.36
H3-TM07SS14-0-M005	99.47	34.33	2.90
H3-TM07SS14-0-M001	147.93	35.24	4.20
H3-TM07SS14-0-M006	85.54	35.47	2.41
H3-TM07SS14-0-F001	19.82	36.58	0.54
H3-TM07SS14-0-F002	87.13	37.38	2.33
H3-TM07SS14-0-M003	54.40	37.38	1.46
H3-TM05SS13-0-F003	59.41	37.65	1.58
White-Footed Mouse			
H3-TM15WO15-0-F003	1.01	0.66	1.53
H3-TM15WO15-0-M003	0.44	0.66	0.67
H3-TM15WO15-0-F001	0.35	0.69	0.51
H3-TM15WO15-0-M002	0.61	0.71	0.86
H3-TM15WO15-0-M006	0.38	0.71	0.54
H3-TM15WO15-0-F002	0.45	1.18	0.38
H3-TM15WO15-0-M001	1.81	1.25	1.44
H3-TM15WO15-0-M004	0.21	1.29	0.16
H3-TM15WO15-0-F006	0.40	1.33	0.30
H3-TM15WO15-0-M005	1.61	1.73	0.93
H3-TM15WO15-0-F004	0.54	1.96	0.27
H3-TM15WO15-0-F005	0.19	1.97	0.10
H3-TM07WO14-0-F005	3.94	20.83	0.19
H3-TM07WO14-0-M018	4.02	22.16	0.18
H3-TM05WO13-0-F004	27.39	23.14	1.18
H3-TM05WO13-0-M007	4.50	23.14	0.19

ID	Tissue PCB (mg/kg)	Soil Spatially-Weighted Average PCB (mg/kg)	BAF$_{tb}$
Table 5-8 continued.			
H3-TM05WO13-0-M001	6.02	23.37	0.26
H3-TM05WO13-0-F005	12.43	24.56	0.51
H3-TM05WO13-0-M002	6.76	25.14	0.27
H3-TM05WO13-0-M005	15.98	25.14	0.64
H3-TM05WO13-0-M009	7.94	25.14	0.32
H3-TM05WO13-0-F007	1.92	25.92	0.07
H3-TM05WO13-0-M008	2.42	26.07	0.09
H3-TM05WO13-0-M004	2.38	26.50	0.09
H3-TM05WO13-0-M012	16.72	27.35	0.61
H3-TM05WO13-0-F008	2.10	27.86	0.08
H3-TM07WO14-0-F003	3.72	27.98	0.13
H3-TM05WO13-0-F001	19.98	28.43	0.70
H3-TM07WO14-0-M010	1.62	31.09	0.05
H3-TM07WO14-0-M003	0.15	31.38	0.00
H3-TM07WO14-0-M005	2.17	31.38	0.07
H3-TM05WO13-0-F009	2.15	31.60	0.07
H3-TM05WO13-0-M003	15.38	31.60	0.49
H3-TM07WO14-0-F011	1.13	32.72	0.03
H3-TM07WO14-0-M007	8.78	33.27	0.26
H3-TM07WO14-0-F002	5.56	33.48	0.17
H3-TM07WO14-0-M004	5.60	34.62	0.16
H3-TM07WO14-0-F004	34.98	35.13	1.00
H3-TM07WO14-0-M006	1.72	35.47	0.05
H3-TM07WO14-0-F007	4.64	35.50	0.13
H3-TM07WO14-0-F013	1.03	35.50	0.03
H3-TM07WO14-0-F010	2.49	35.54	0.07
H3-TM05WO13-0-F003	10.10	35.62	0.28
H3-TM07WO14-0-F014	1.07	36.58	0.03
H3-TM07WO14-0-M009	2.36	38.73	0.06
H3-TM05WO13-0-M011	3.61	39.48	0.09
H3-TM07WO14-0-M017	1.51	40.28	0.04
H3-TM05WO13-0-F006	1.63	42.92	0.04
H3-TM05WO13-0-F002	2.44	45.27	0.05
H3-TM05WO13-0-F010	2.00	47.47	0.04
H3-TM07WO14-0-F018	5.33	50.35	0.11
H3-TM07WO14-0-M011	3.19	52.80	0.06

Note:

[1] *Mean concentration of PCBs in small mammals was 28.21 mg/kg. Data from EPA database for ERA.*

Table 8-2.
Dredging Production Rates for Environmental Dredging Projects[1]

Project (Contaminant)	Volume Removed (CY) (Duration)	Operating Schedule (hours/days per week)	Number of Dredges Simultaneously	Production Rates: Average CY/Day per Dredge [1]	Production Rates: Projected: CY Annual Basis per Dredge [2]	Reference
Hydraulic Dredge						
Cumberland Bay, NY (PCBs)	146,000 (year 1)	24/5.5	Two	210	41,600	MCSS Database
Fox River 56/57, WI (PCBs)	50,300 (year 2 – 69 days)	24/7	One	240	47,500	MCSS Database
Gruber’s Grove Bay, WI (mercury)	88,300 (7 months)	10/5.5	One	480	95,000	MCSS Database
Cherry Farm, NY (Niagara River, PAHs)	42,400 (6 months)	12/6	One	230	45,500	MCSS Database
Manistique River/ Harbor, MI (PCBs)	66,000 (‘98 and ’99)	12/7	One	175	34,600	MCSS Database
New Bedford Harbor Hot Spot, MA (PCBs)	14,000 (16.5 months)	4-6 (assume 5/5)	One	65	12,900	See Note 3 below
Menominee River – 8th Street Slip, WI (arsenic)	12,400 (3 months)	Assume 8/5	Assume One	190	37,600	MCSS Database
Bucket Dredge						
Saginaw River, MI (PCBs)	342,300 (1 year)	24/6	One	375	74,200	MCSS Database
Reynolds Metals, NY (PCBs)	85,600 (4 months)	20/6	Three (1st shift), One (2nd shift)	175	9,900	MCSS Database
United Heckathorn, CA (Pesticides)	108,000 (7 months)	24/6	One	190	37,600	See Note 3 below
Bayou Bonfouca, LA (Creosote)	169,000 (15 months)	9/5	One	455	90,100	See Note 3 below
Black River, OH (Metals, PAHs)	60,000 (5.5 months)	Assume 8/5	One	500	99,000	See Note 3 below

Table 8-2.
Dredging Production Rates for Environmental Dredging Projects[1]

				Production Rates		
Project (Contaminant)	**Volume Removed (CY) (Duration)**	**Operating Schedule (hours/days per week)**	**Number of Dredges Simultaneously**	**Average CY/Day per Dredge [1]**	**Projected: CY Annual Basis per Dredge [2]**	**Reference**
Ford Outfall, MI (River Raisin, PCBs)	28,500 (3 months)	8/5	One	430	85,100	MCSS Database
Ketchican Pulp – Ward Cove, AK	20,500 (2 months)	10/6	One	300	59,400	MCSS Database
New Bedford Harbor MA (PCBs)	880,000 (underway)	12/5	One	430	85,140	Capitol Press, LLC. "PCB Cleanup: Dredging to Begin Again at New Bedford Harbor Site." *Hazardous Waste/Superfund Alert*. May 30, 2006.
Lower Fox River OU-1, WI (PCBs)	88,243 (5 months)	24/5 24/7 (Nov. '07)	2 3 (Nov 07)	135	26,700	See Note 4 below
Dry Excavation						
Housatonic River, MA (PCBs) – Bldg 68	7,000 (8.5 months)	8/5	One	40	7,300	GE project
Ottawa River, Ohio (PCBs)	9,700 (5 months)	Assume 8/5	One	90	17,400	See Note 3 below
Housatonic River, MA (PCBs) – ½ Mile	12,000 (18 months – est.)	8/5	One	30	6,000	GE project
Housatonic River, MA (PCBs) – 1.5 Mile	91,700 (43 months)	10/5.5	One	60	11,900	GE/EPA project
Messer Street MGP – Phase I, NH (PAHs)	2,200	Assume 8/6	One	Max. 300 cy/day	66,000	Maxymillian. *Fact Sheet*. Date Unknown (www.maxymillian.com/messer2.html)

Table 8-2.
Dredging Production Rates for Environmental Dredging Projects[1]

Project (Contaminant)	**Volume Removed (CY) (Duration)**	**Operating Schedule (hours/days per week)**	**Number of Dredges Simultaneously**	**Production Rates**		**Reference**
				Average CY/Day per Dredge [1]	**Projected: CY Annual Basis per Dredge [2]**	
Messer Street MGP – Phase II, NH (PAHs)	17,000	10/6	Two	140 - 240 cy/day	2,770 - 47,500	Maxymillian. *Fact Sheet*. Date Unknown (www.maxymillian.com/messer2.html) EPRI. *Innovative Sediment Remediation Using a Risk-based Mixed Remedy at the Laconia Manufactured Gas Plant Site: Data and Lessons*. November 2001.

Notes:

1. *Adjusted to 8 hours per day.*
2. *Projected based on 22 days per month and 9 months per year of operation.*
3. *YEC, Inc. and TAMS Consultants, Inc. Review of Remedial Projects with Significant Contaminated Sediment Removal Components. November 2000. Appendix A.4 of the Hudson River PCBs Reassessment Feasibility Study (http://www.epa.gov/hudson/fs000026.pdf).*
4. *Fort James Corporation, et al. Final Report 2000 Sediment Management Unit 56/57 Project Lower Fox River, Green Bay, Wisconsin. January 2001 (http://dnr.wi.gov/org/water/wm/foxriver/documents/finalreport/final_report.pdf).*

   Montgomery Watson. Draft Summary Report Sediment Removal Demonstration Project Sediment Management Unit 56/57, Fox River, Green Bay, Wisconsin. April 2000.

Table 8-3.
Capping Production Rates for Environmental Capping Projects

Project	**Material Placed**	**Volume Placed**	**Placement Method**	**Timeframe**	**Average Daily Rate (CY/day)[1]**	**Reference**
Anacostia River Pilot Study - Sand Cap, DC	Sand	313.5 cy	2-cy clamshell bucket	3 days	100	Horne Engineering Services. *Revised Draft Cap Completion Report For Comparative Validation of Innovative "Active Capping" Technologies Anacostia River, Washington DC.* 2004 (http://www.hsrc-ssw.org/pdf/cap-completion-rpt.pdf)
Anacostia River Pilot Study - AquaBlok™ Cap, DC	AquaBlok™	124 cy	2-cy clamshell bucket	3 days	40	
	Sand	174 cy	2-cy clamshell bucket	2 days	90	
Anacostia River Pilot Study - Coke Breeze Cap, DC	Sand	241.5 cy	2-cy clamshell bucket	2 days	120	
Anacostia River Pilot Study - Apatite Cap, DC	Apatite	168 cy	2-cy clamshell bucket	3 days	50	
	Sand	250.5 cy	2-cy clamshell bucket	2 days	190	
Duwamish/Diagonal CSO/SD, WA	Sand, rip rap, quarry spalls, sandy gravel	75,232 cy	2-cy clamshell bucket	28.5 days	1,300	Anchor Environmental. *Duwamish/Diagonal CSO/SD, Sediment Remediation Project Closure Report*. July 2005 (http://dnr.metrokc.gov/WTD/duwamish/diagonal/Report-0507/Duwamish_Diagonal_Closure_Report-0507.pdf)
Ketchikan Pulp Company Superfund Site - Ward Cove, AK	Sand	23,307 cy	Derrick barge with modified Cable Arm re-handling bucket	27 days	875	Foster Wheeler. *Final Construction Report*. July 2001
Koppers (Charleston Plant) Superfund Site, SC	Sand	12,225 cy	Tubular mixing device and amphibious excavator	5 months (Assumes 22 days per month)	110	USEPA Region 4. *Preliminary Closeout Report*. September 2003

Table 8-3.
Capping Production Rates for Environmental Capping Projects

Project	**Material Placed**	**Volume Placed**	**Placement Method**	**Timeframe**	**Average Daily Rate (CY/day)**[1]	**Reference**
McCormick & Baxter, OR	Sand, gravel, 6" minus rock, rip rap	7,695 cy	"Skip box" and clamshell bucket	50 days	155	Ecology and Environment. *Remedial Action Construction Summary Report, Summary Cap Completion Report*. May 2006
Portland General Electric (PGE) Station L, OR	Sand, gravel, rip rap	1,500 tons of sand, 4,000 tons of gravel, 2,000 tons of rip rap	"Skip box" and 4-cy clamshell bucket	10 days	500	CH2M Hill. *Final Report Phase II Station L PCB Contaminated River Sediment Remediation Portland G&E*. January 1991

Note:

[1] *Based on an 8-hour day*

Figures

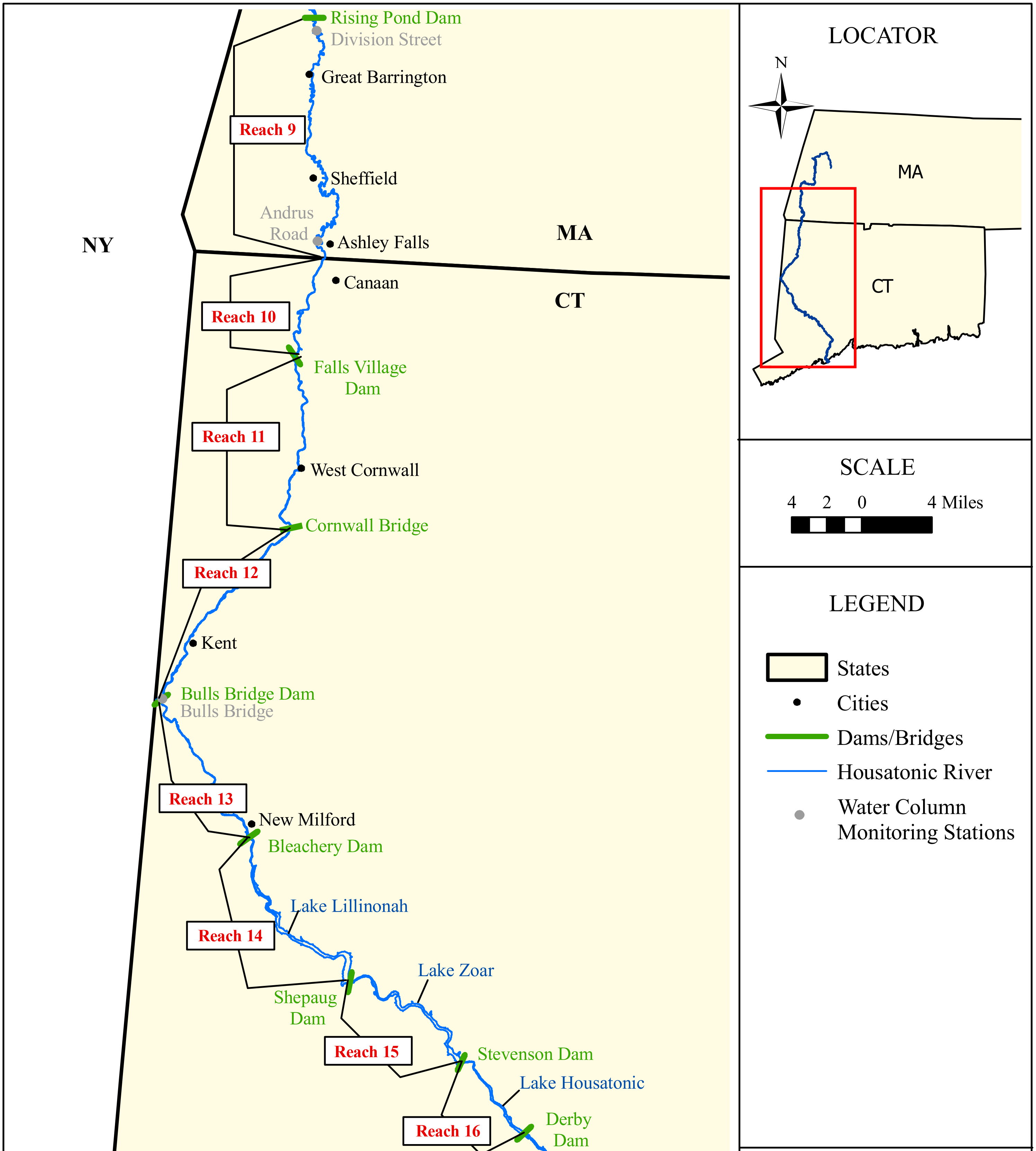


Figure 2-1.
Map of Housatonic River Reaches 9 to 16.

QEA
Quantitative Environmental Analysis, LLC

GENcms

May 07

IF - Q:\GENcms\DOCUMENTS\reports\CT_MNR_Evaluation\Figures\src\Map\HousRIver_Reach9_16.mxd

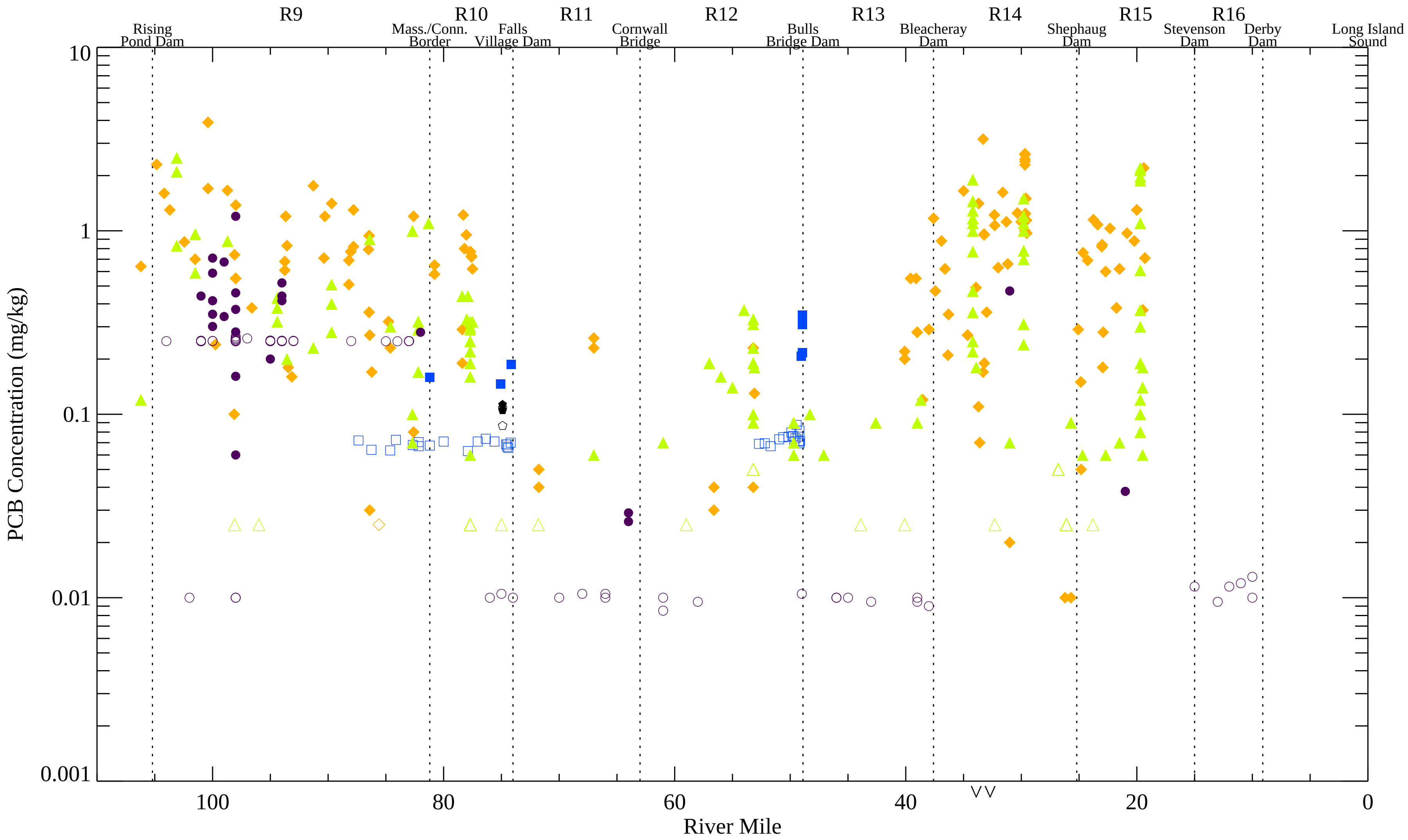


Figure 2-2. Spatial profiles of surface sediment total PCB concentration in Reaches 9-16.

Notes: Data within 0-6" sediment and high resolution data less than or equal to 6" included; Non-detect PCBs plotted as open symbols at 1/2 MDL. HydroTechnologies data excluded due to insufficient depth information.

rrm - Q:\GENcms\DOCUMENTS\reports\Supplement\CT_MNR_Evaluation\Figures\src\Sediment\fig2_surf_sed_spat.pro
Thu May 10 17:04:13 2007

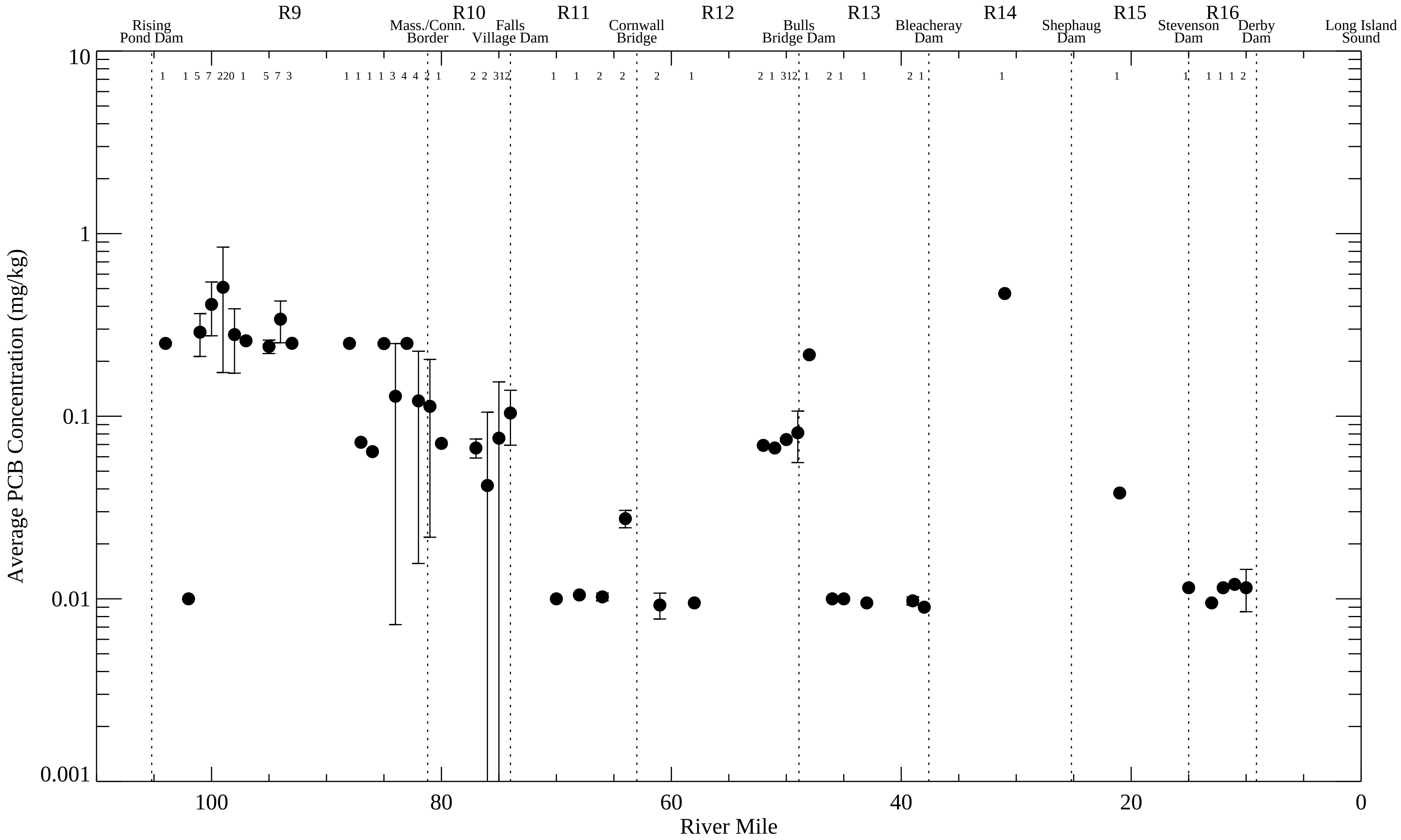


Figure 2-3. Spatial profiles of recent (1998-2002) surface sediment (0-6 inches) total PCB concentration from Reaches 9-16.

Notes: Data averaged by river mile; error bars represent +/- 2 standard errors of the mean; Non-detect PCBs set to 1/2 MDL. Posted numbers represent sample counts.

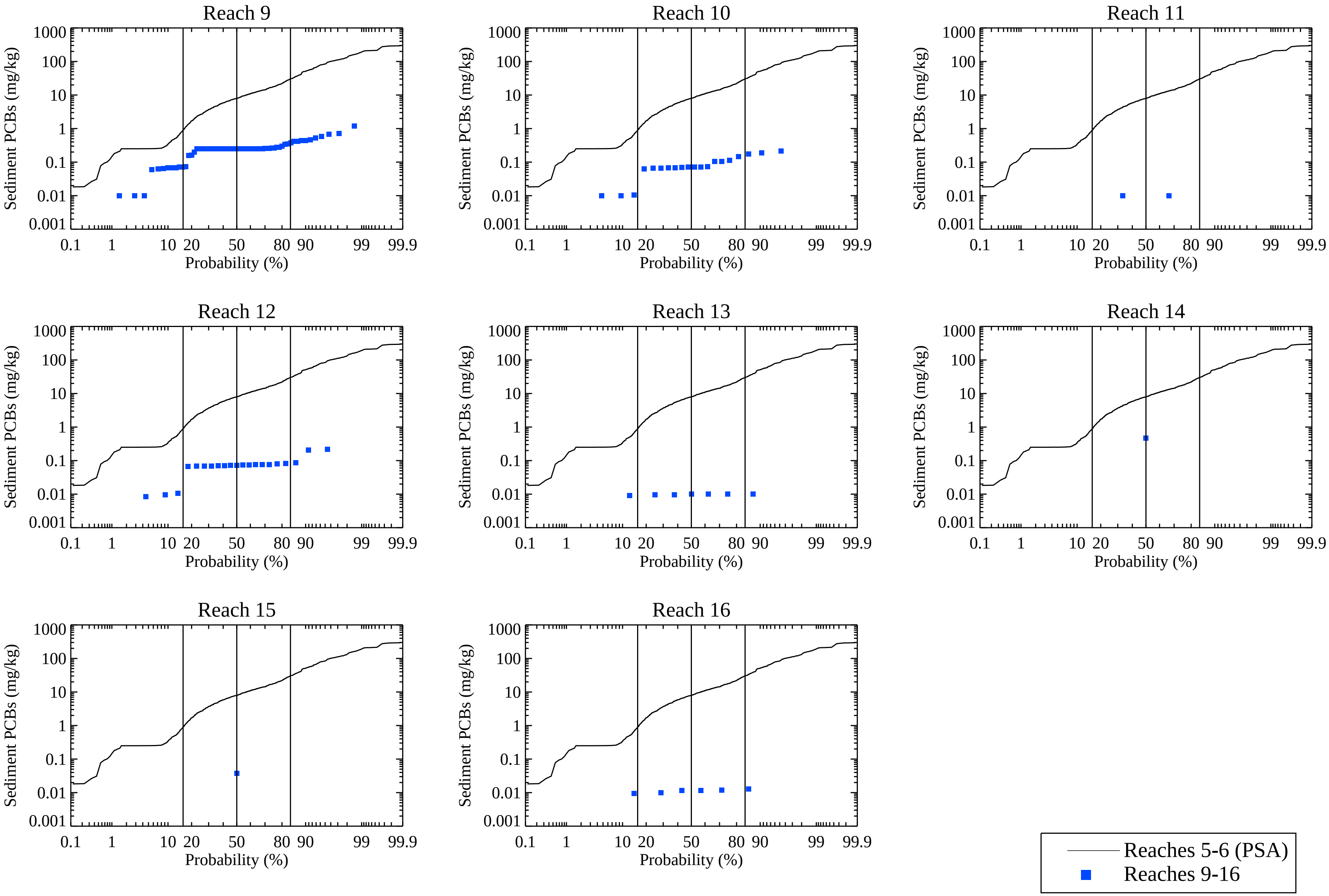


Figure 2-4. Comparison of recent (1998-2002) surface sediment (0-6 inches) total PCB concentrations between Reaches 9-16 and Reaches 5-6 (PSA).

Notes: 0-3" sediment data included; high resolution data (all segments) excluded; Non-detect PCBs set to 1/2 MDL.

rrm - Q:\GENcms\DOCUMENTS\reports\Supplement\CT_MNR_Evaluation\Figures\src\Sediment\fig4_surf_sed_spat_PPs.pro
Thu May 10 17:05:16 2007

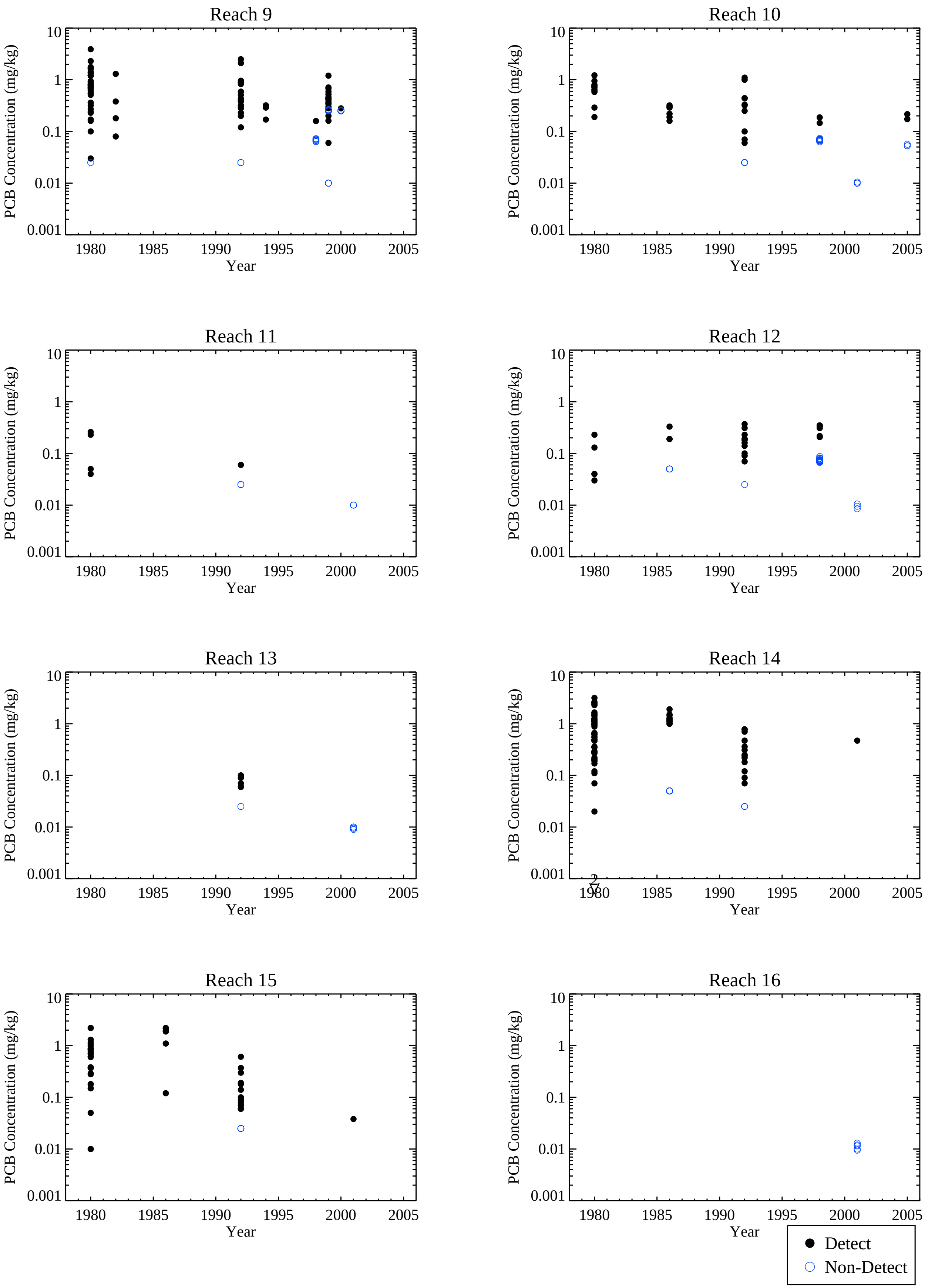


Figure 2-5. Temporal profiles of surface sediment (0-6 inches) total PCB concentrations in Reaches 9-16.

Notes: All data points within top 6" interval included; Non-detect PCBs plotted as open symbols at 1/2 MDL.

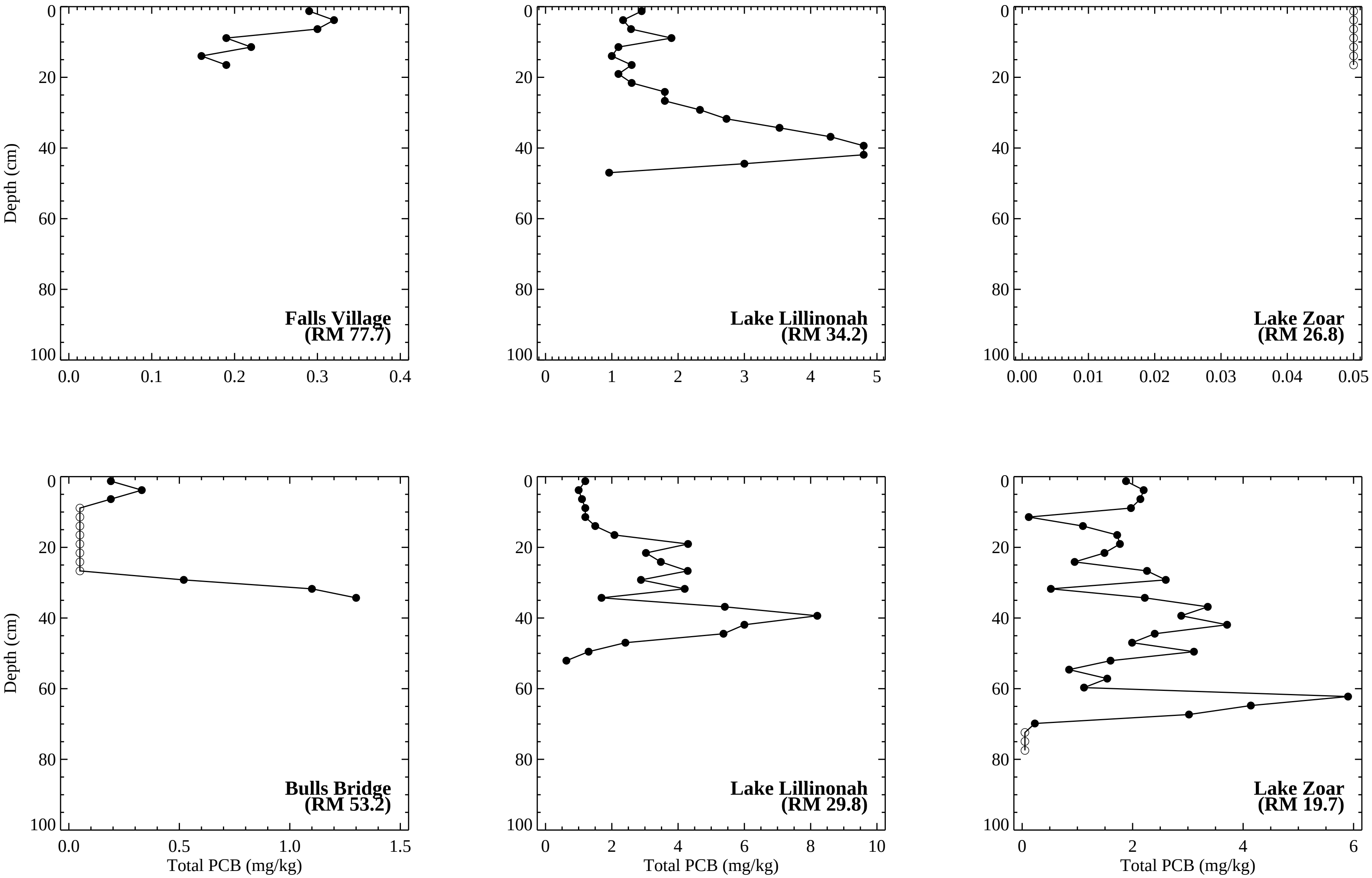


Figure 2-6. Depth profiles of total PCB concentrations from finely segmented sediment cores collected by LMS in 1986.
Note: Non-detect PCBs plotted at 1/2 MDL.

● Detect PCB
○ Non-detect PCB

IF - Q:\GENcms\DOCUMENTS\reports\Supplement\CT_MNR_Evaluation\Figures\src\Sediment\Fig_6_LMS_DEPTH_PROFILES.pro
Thu May 10 16:58:25 2007

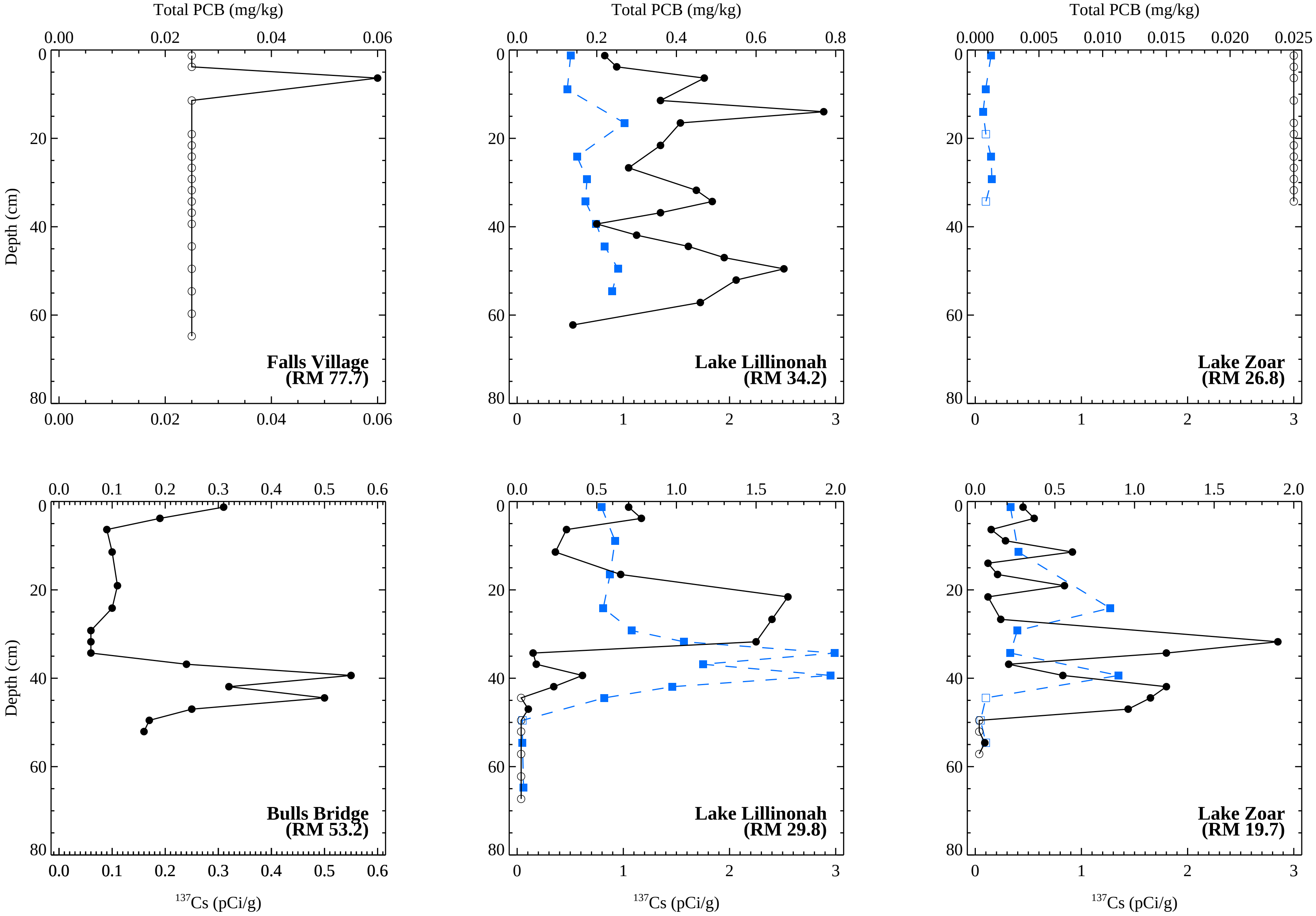


Figure 2-7. Depth profiles of total PCB and ^{137}Cs concentrations from finely segmented cores collected by LMS in 1992.

Note: Non-detect data plotted at 1/2 MDL.

● Detect PCB
○ Non-detect PCB
■ Detect ^{137}Cs
□ Non-detect ^{137}Cs

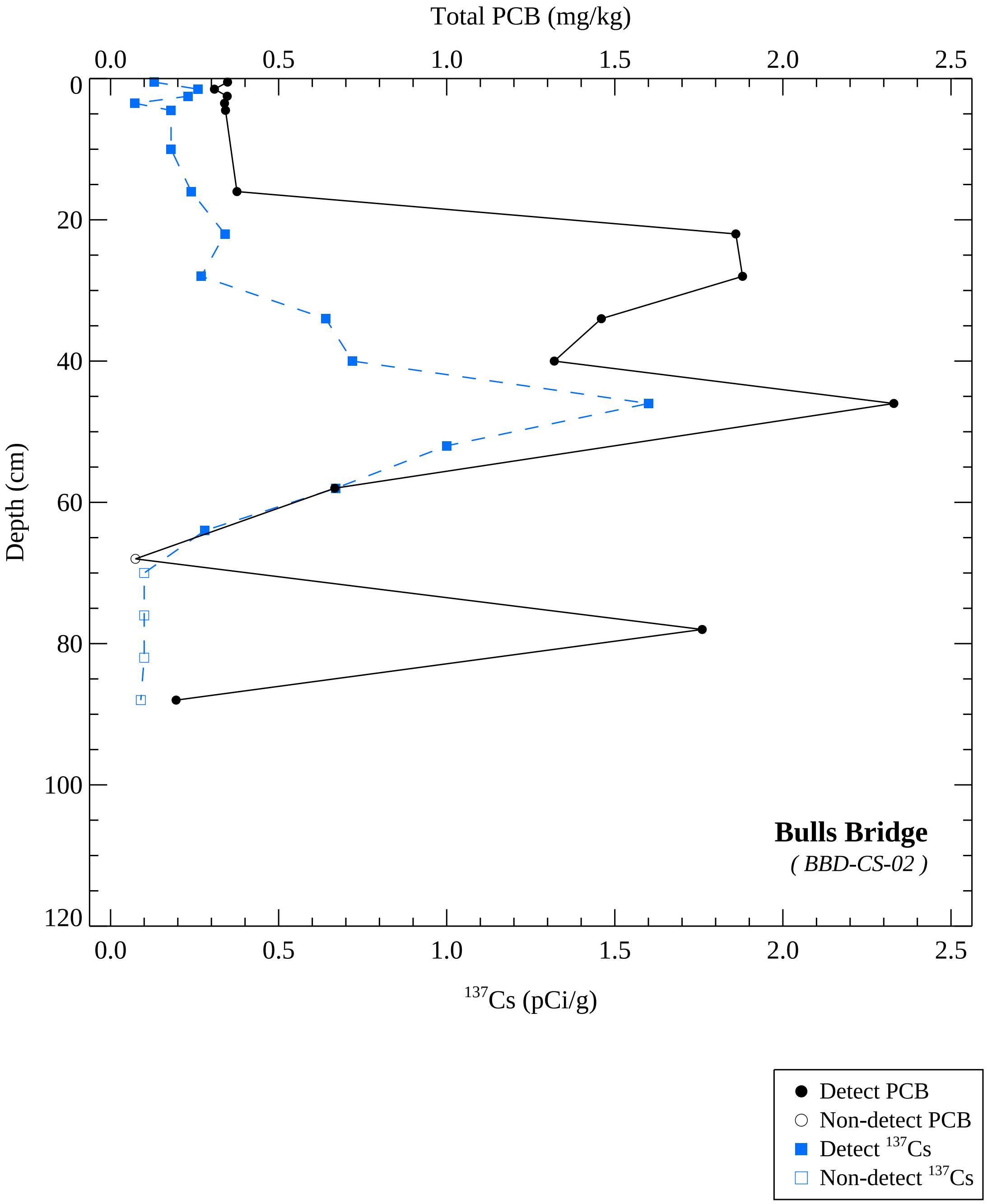


Figure 2-8. Depth profiles of ^{137}Cs and total PCB concentrations from a sediment core collected from Reach 12 in 1998.

Notes: Zero total PCB concentration of sample collected from 9-11 cm depth interval excluded from analysis. Non-detect data plotted at 1/2 MDL.

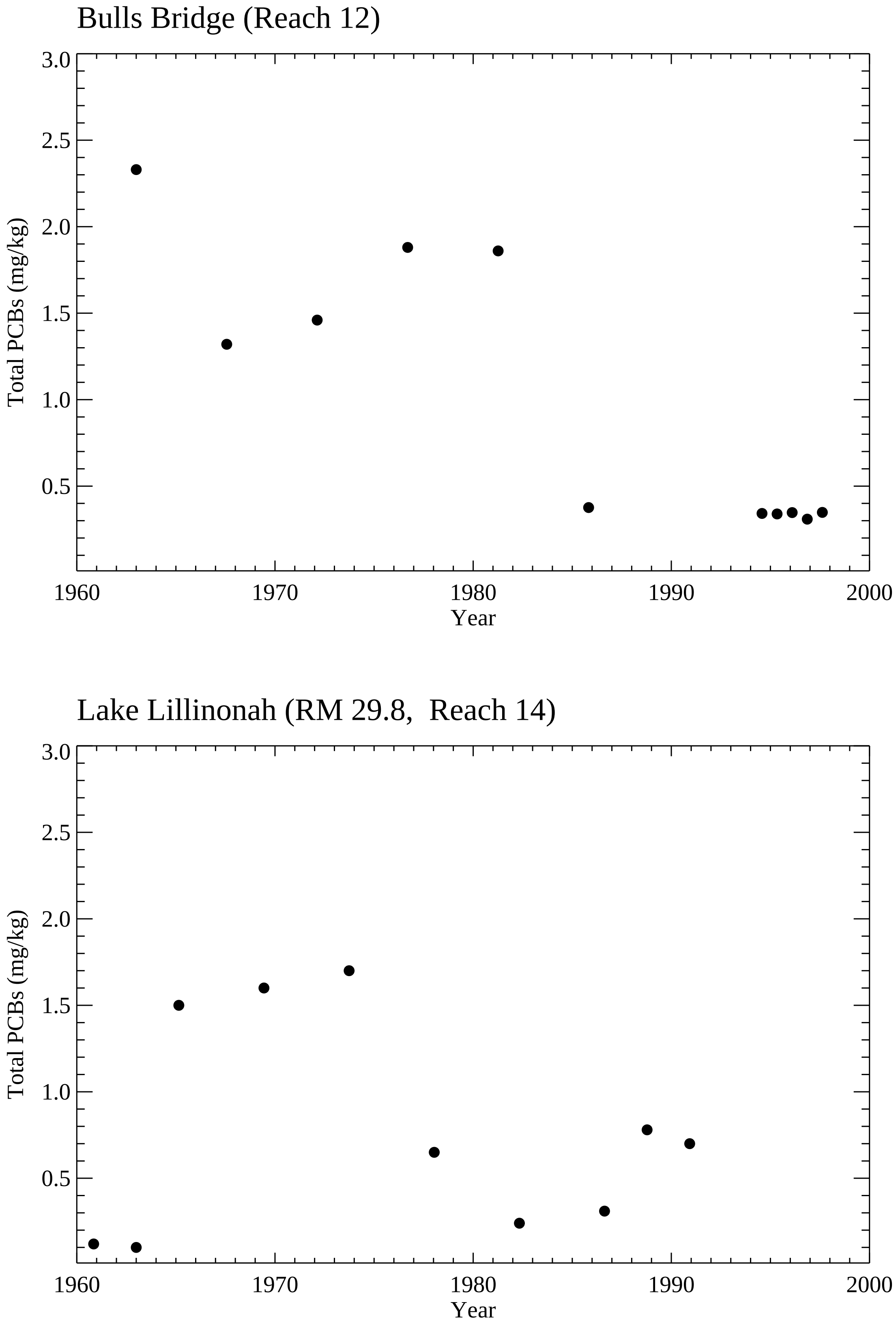


Figure 2-9. Temporal profiles of sediment PCB concentrations estimated from finely segmented sediment cores.

Notes: Bulls Bridge core collected by BBL in 1998. Lake Lillinonah core collected by LMS in 1992.
Dating assumes ^{137}Cs peak in 1963 and constant deposition rate.
Zero total PCB concentration of sample collected at Bulls Bridge from 9-11 cm depth interval excluded from analysis.

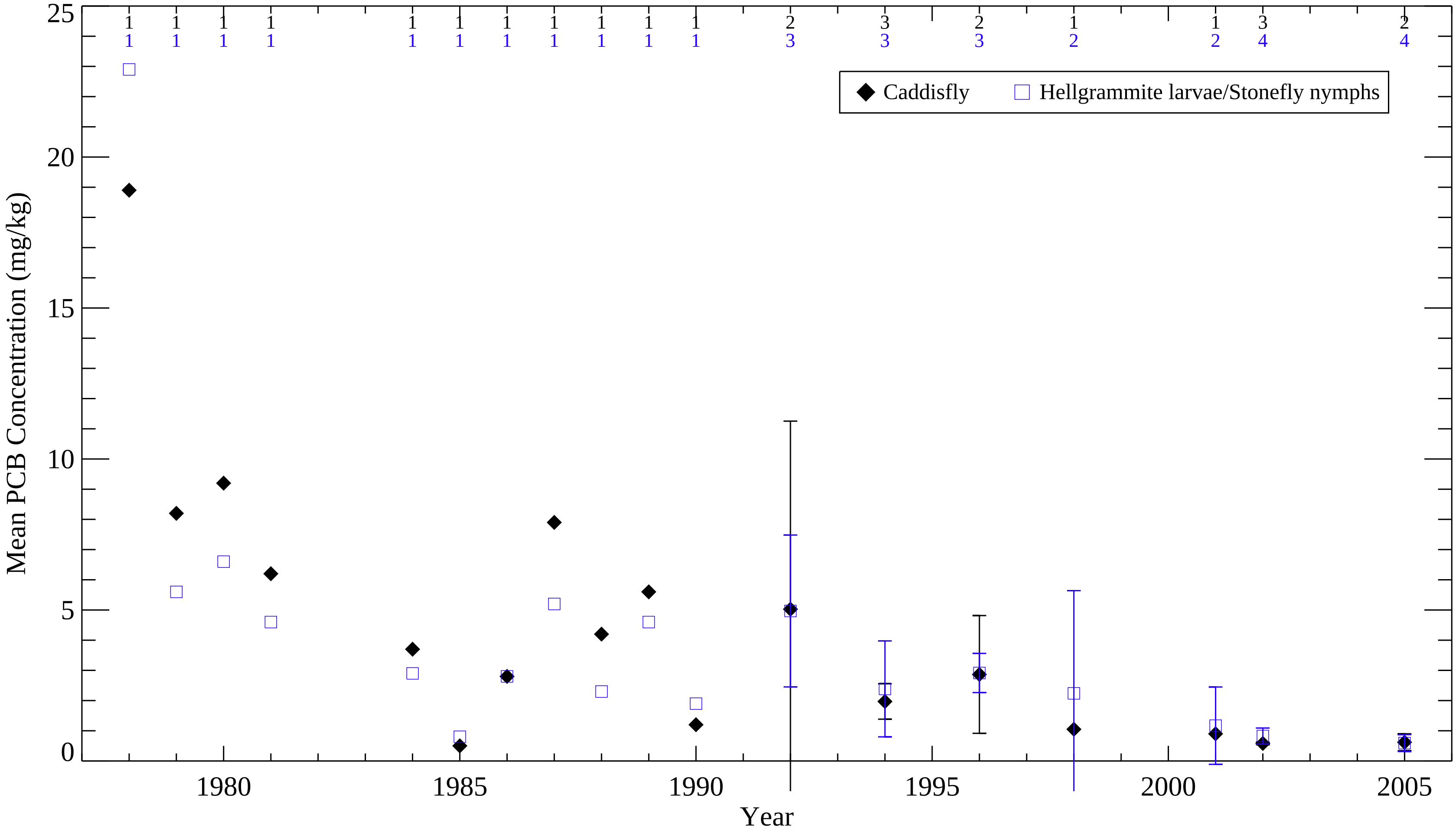


Figure 2-10. Temporal profiles of annual average total PCB (aroclor) concentrations in benthic macroinvertebrates collected from Reach 11 (West Cornwall, CT).

Values shown represent arithmetic means; error bars represent +/- 2 standard errors of the mean; posted numbers represent sample counts.

LD - Q:\GENcms\DOCUMENTS\reports\Supplement\CT_MNR_Evaluation\Figures\src\Fish\temporal_macroinverts_ct.pro
Thu May 10 17:09:41 2007

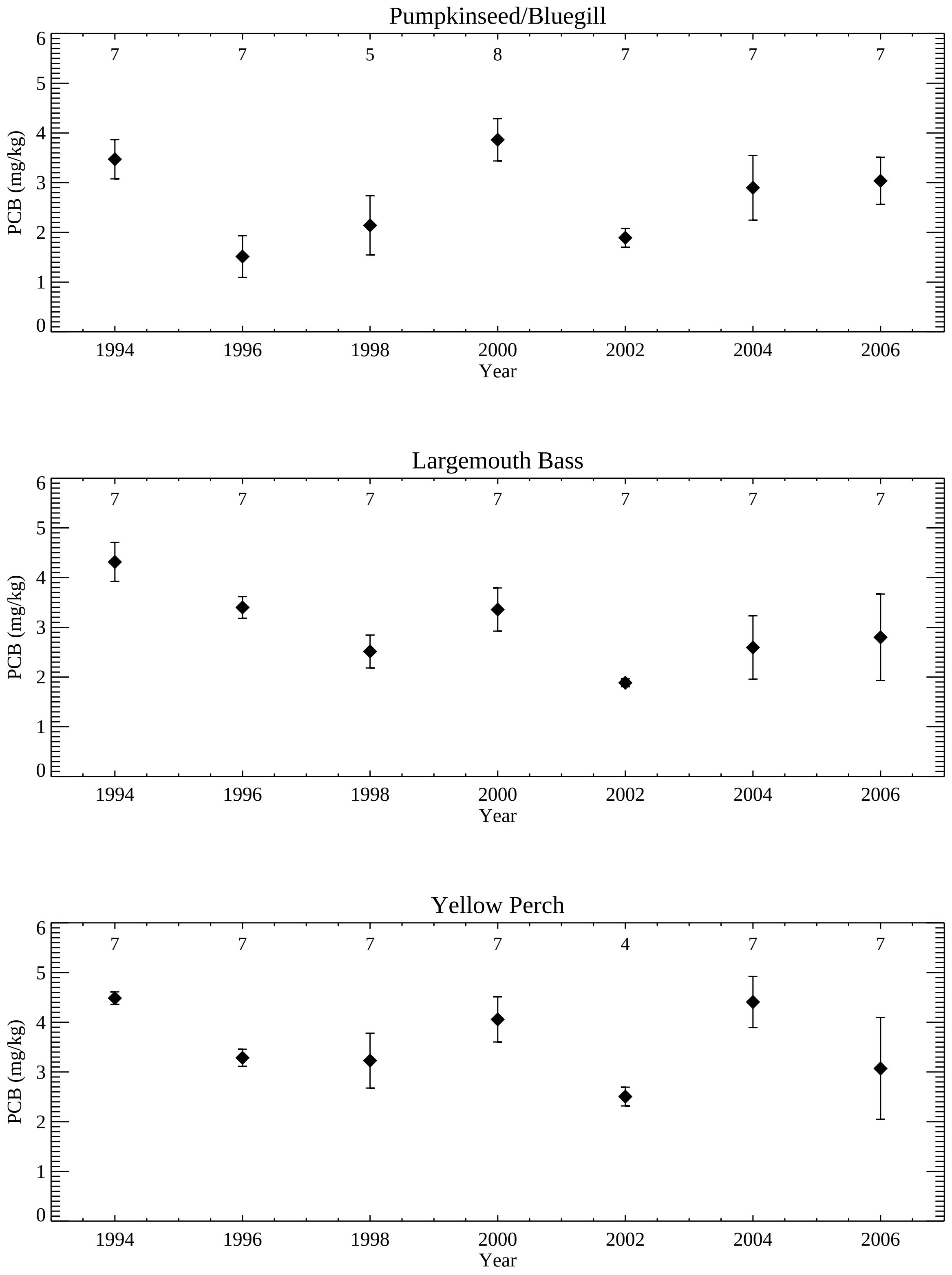


Figure 2-11. Temporal profiles of annual average total PCB concentrations in young-of-year fish collected from Reach 9.

Values shown represent arithmetic means; error bars represent +/- 2 standard errors of the mean; posted numbers represent sample counts.

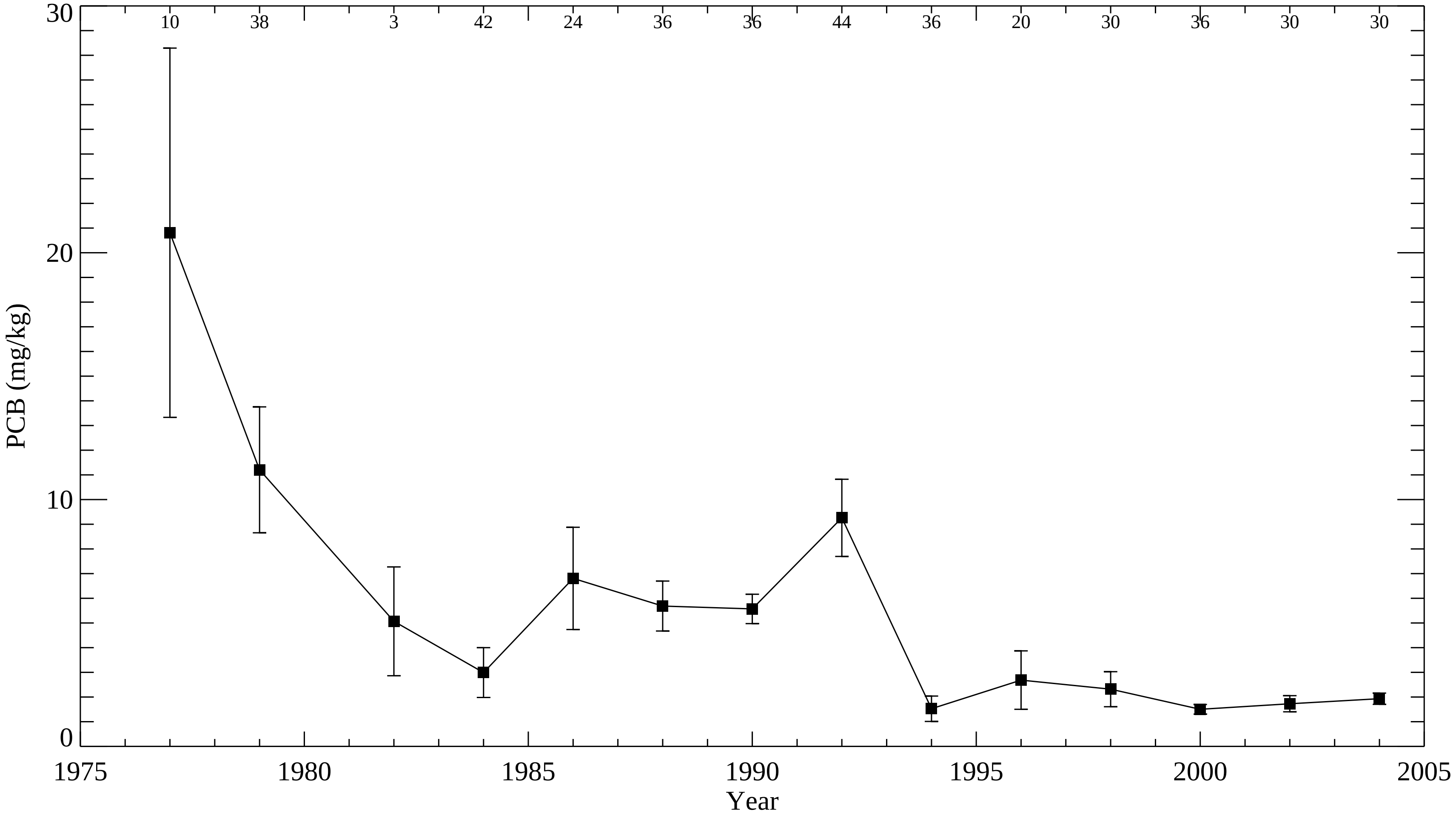


Figure 2-12. Temporal profile of annual average wet weight total PCB concentrations in brown trout fillets collected from Reach 11 (West Cornwall).

Values shown represent arithmetic means; error bars represent +/- 2 standard errors of the mean; posted numbers represent sample counts.
Note: 2 composite samples (1978) were excluded.

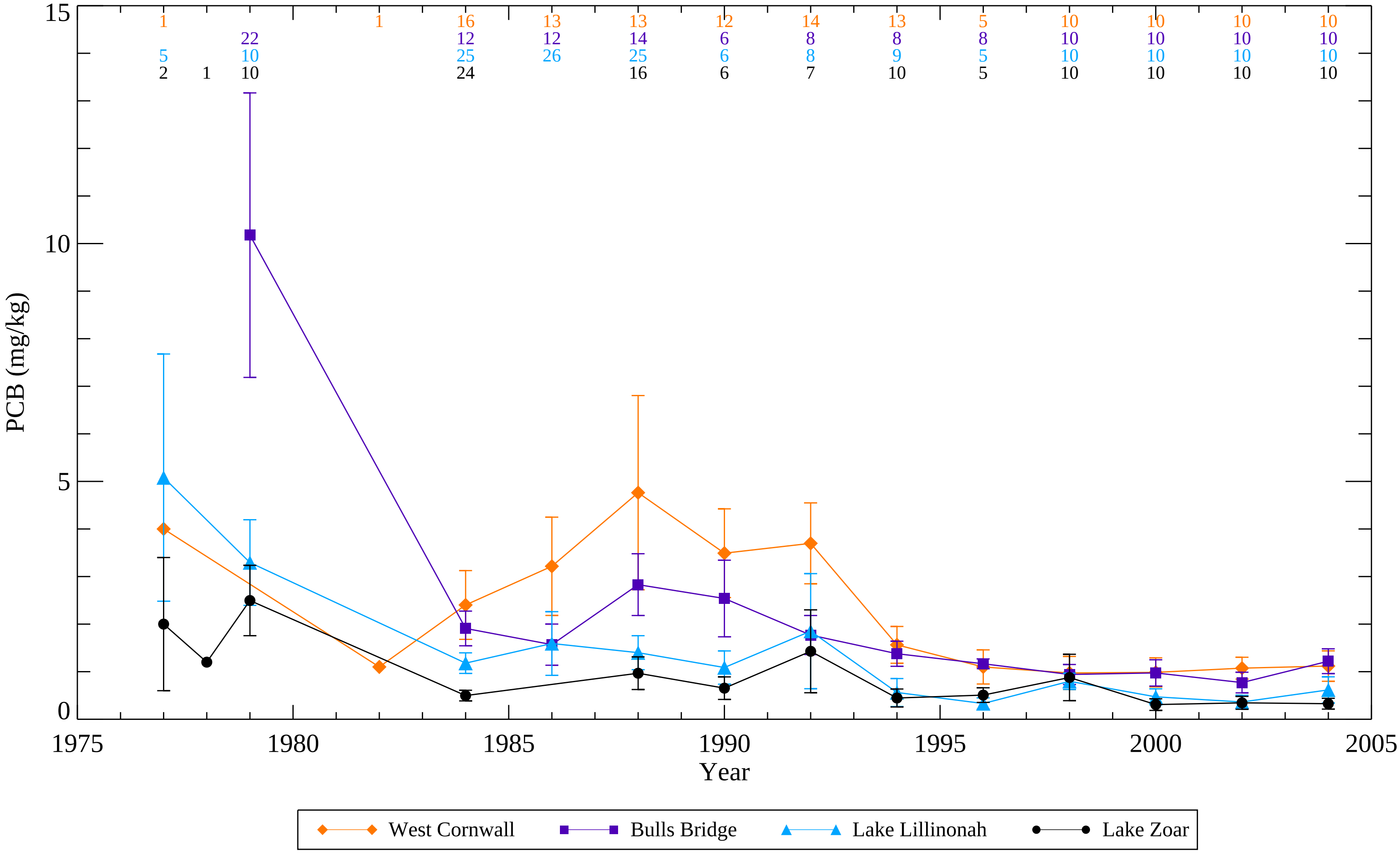


Figure 2-13. Temporal profile of annual average wet weight total PCB concentrations in smallmouth bass fillets collected from Reach 11 (West Cornwall), Reach 12 (Bulls Bridge), Reach 14 (Lake Lillinonah) and Reach 15 (Lake Zoar).

Values shown represent arithmetic means; error bars represent +/- 2 standard errors of the mean; posted numbers represent sample counts.
Notes: West Cornwall - 1 composite sample included (1977); Bulls Bridge - 6 samples (1983-unknown prep) were excluded,
Lake Lillinonah - 2 samples (1983-unknown prep) were excluded.

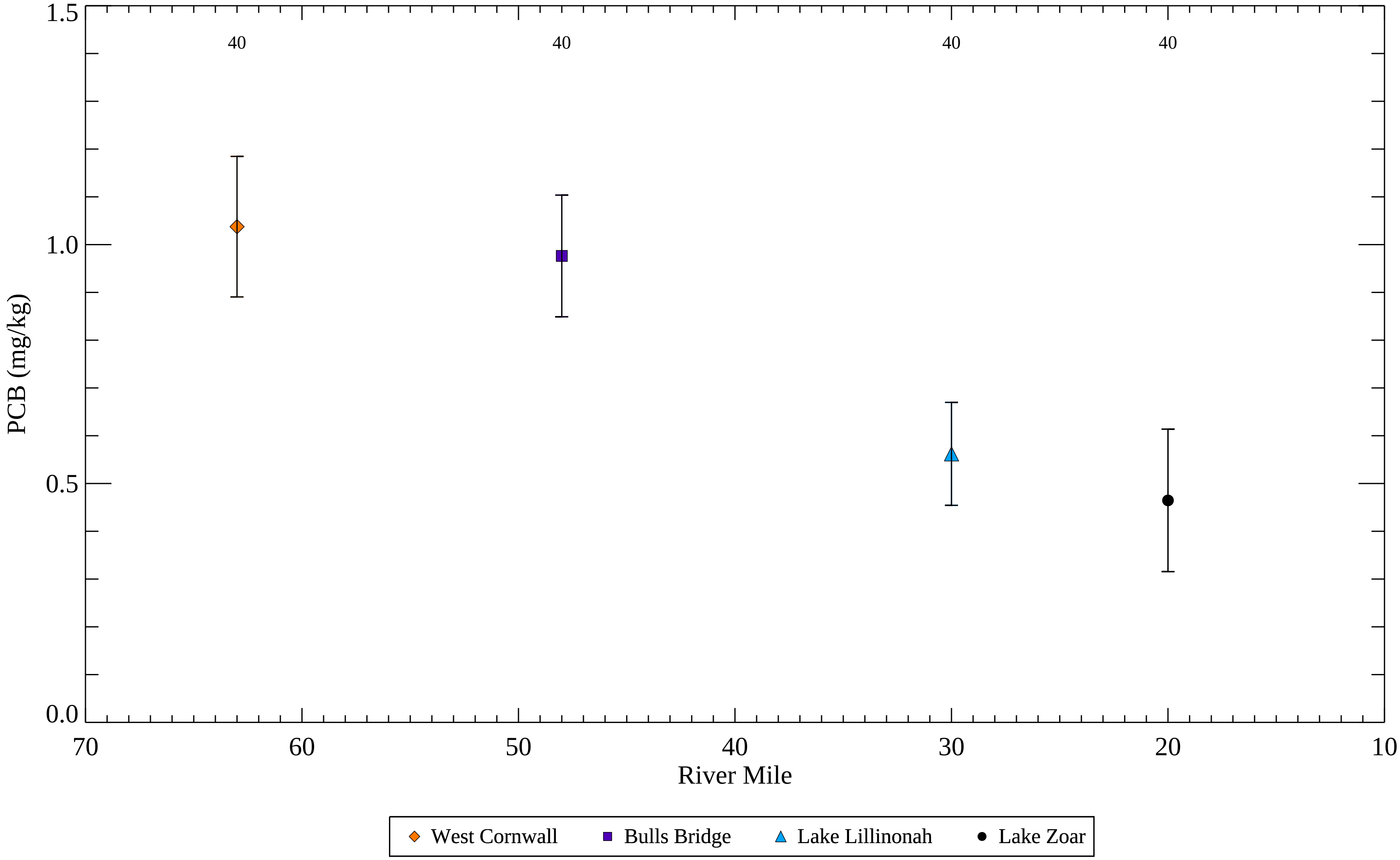


Figure 2-14. Spatial profile of average wet weight total PCB concentrations in smallmouth bass fillets collected from Reach 11 (West Cornwall), Reach 12 (Bulls Bridge), Reach 14 (Lake Lillinonah) and Reach 15 (Lake Zoar) from 1998 to 2004.
Values shown represent arithmetic means; error bars represent +/- 2 standard errors of the mean; posted numbers represent sample counts.

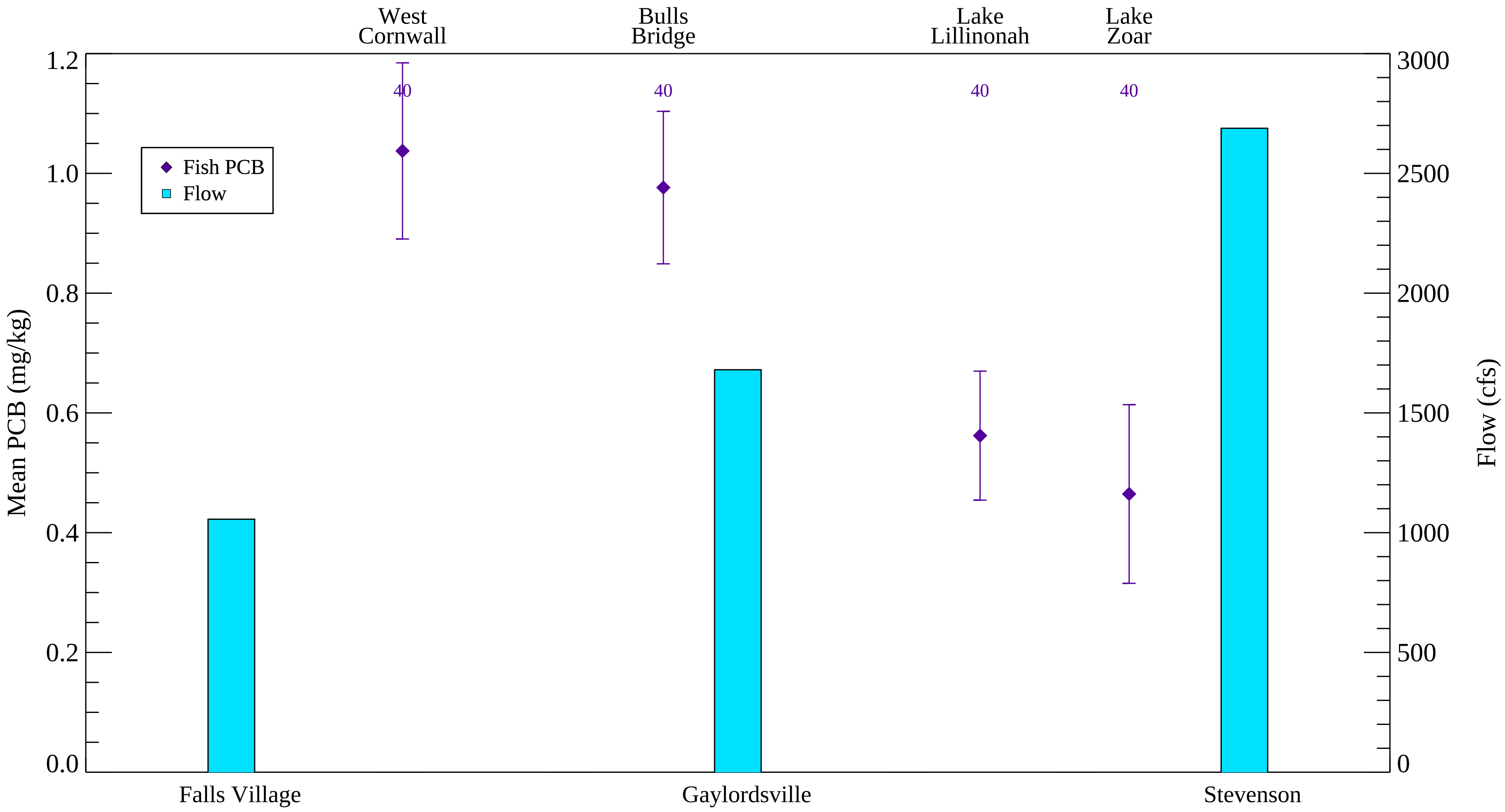


Figure 2-15. Spatial profile of flow at three USGS gauge locations and PCB concentrations in smallmouth bass fillets collected from Reach 11 (West Cornwall), Reach 12 (Bulls Bridge), Reach 14 (Lake Lillinonah) and Reach 15 (Lake Zoar) for 1998 to 2004.

Values shown represent arithmetic means; error bars represent +/- 2 standard errors of the mean; numbers posted represent sample counts.

ARCADIS BBL

Appendix A

Phase I Cultural Resources Assessment Work Plan for the Housatonic River – Rest of River

APPENDIX A:

Phase I Cultural Resources Assessment Work Plan for the Housatonic River - Rest of River

General Electric Company
Pittsfield, Massachusetts

May 2007

URS

WORK PLAN

TABLE OF CONTENTS

WORK PLAN

1. Introduction

URS Corporation (URS) has prepared this Phase I Cultural Resources Assessment (CRA) Work Plan on behalf of General Electric Company (GE). The activities described in the CRA Work Plan will be conducted to assess the potential for cultural, archaeological, and historical resources to exist in portions of the Housatonic River and its floodplain that could be impacted by implementation of corrective measures (remedial actions) selected by the United States Environmental Protection Agency (EPA) to address polychlorinated biphenyls (PCBs) in river sediments and floodplain soils in that area.

In February 2007, GE submitted to EPA a Corrective Measures Study (CMS) Proposal (Arcadis BBL & QEA 2007) for the Rest of River portion of the Housatonic River, which begins at the confluence of the East and West Branches of the river (about two miles south of the GE facility in Pittsfield, MA) and flows generally south through western Massachusetts and Connecticut. In April 2007, EPA approved that proposal subject to numerous conditions, and it directed GE to submit a Supplement to provide additional information to address several of those conditions. Condition #3 of EPA's letter directed GE to submit a plan for conducting a Phase I Cultural Resource Evaluation as required for compliance with Section 106 of the National Historic Preservation Act (NHPA). The current document provides that plan.

At this stage of the CMS process, the extent of any remedial activities in the river and floodplain of the Rest of River area is unknown. GE will study and evaluate potential remedial alternatives in the CMS and make a recommendation in the CMS Report, and EPA will subsequently select remedial actions for the Rest of River. Accordingly, the activities described in this Phase I CRA Work Plan will include a general identification of locations within the river and on the adjacent river banks and floodplain that contain or have the potential to contain archaeological or historic resources that could potentially be impacted by implementation of the remedial actions to be selected by EPA for the Rest of River. The primary goals of this study will be to:

- Provide background information on the environmental setting, prehistory, and history of the project area and region;
- Describe previous cultural resource studies (if any) and types of known archaeological and historic resources in the Area of Potential Effects (APE) established for the project;
- Provide a preliminary assessment of the potential of the APE, as well as specific areas within the APE, to contain as-yet-unidentified cultural resources; and
- Outline future steps that may be taken under Section 106 of the NHPA once the scope and extent of remediation for the Rest of River have been determined.

The CRA will be performed in a manner consistent with Section 106 of NHPA and the implementing regulations issued by the Advisory Council on Historic Preservation (ACHP) (36 C.F.R. Part 800). The activities described herein will implemented by professional staff who meet the professional qualifications standards and guidelines for archaeologists and historians established by the Secretary of the Interior (36 C.F.R. Part 61) and who have experience with archaeological and historical research in the region. The archaeologists responsible for the project will be members of the Register of Professional Archaeologists.

1.1 Background

GE's CMS Proposal for the Rest of River describes the proposed study that GE will undertake to evaluate potential corrective measures to address PCBs within the Rest of River portion of the Housatonic River and its floodplain. That Proposal identifies the corrective measures that GE will study, provides a justification for selecting those corrective measures, and presents GE's proposed methodology for evaluating those measures.

The CMS is being conducted pursuant to Special Condition II.E of a permit issued to GE by EPA under the corrective action provisions of the federal Resource Conservation and Recovery Act (RCRA) on July 18, 2000. This permit (which constitutes a reissuance of a RCRA permit previously issued to GE in the early 1990s) was issued as part of a comprehensive settlement embodied in the Consent Decree (CD) for the GE-Pittsfield/Housatonic River Site, which became effective on October 27, 2000. The CD details the terms of an agreement among GE, EPA, the Massachusetts Department of Environmental Protection (MDEP), the Connecticut Department of Environmental Protection (CDEP), and other federal, state, and local governmental entities relating to the cleanup of GE's facility in Pittsfield, Massachusetts, the Housatonic River downstream of GE's facility, and other adjacent and nearby areas.

As described in the CMS Proposal, EPA has divided the Rest of River area into various reaches, designated Reaches 5 through 16 (in downstream order). As further described in that Proposal and in GE's Supplement to that Proposal, all remediation alternatives to be evaluated in the CMS will include monitored natural recovery (MNR) for Reaches 9 through 16. Thus, active remediation will be evaluated for Reaches 5 through 8. Correspondingly, the investigations described in this Work Plan will likewise encompass Reaches 5 through 8, which are shown on Figure 1 and described as follows:

- Reach 5 begins at the confluence of the East and West Branches and extends downstream approximately 10 miles to the head of Woods Pond). This section of the river is bordered by extensive floodplains, and has a meandering pattern with numerous oxbows and backwaters.
- Reach 6 encompasses Woods Pond, a 56-acre impoundment that was formed by the construction of a dam in the late 1800s.

- Reach 7 extends from the Woods Pond Dam downstream approximately 18 miles to the head of Rising Pond. This section contains a number of small dams and does not have as many wide floodplain areas as Reach 5.

- Reach 8 encompasses Rising Pond, which is a long, narrow, in-stream impoundment and the last dammed impoundment in Massachusetts.

As defined in the CD, the Rest of River includes portions of the river's floodplain as well as the river proper. Between the Confluence and Woods Pond Dam, the Rest of River floodplain is defined as the area extending laterally to the 1 milligram per kilogram (mg/kg) PCB isopleth. Downstream of Woods Pond Dam, the Rest of River floodplain is defined as those floodplain areas containing PCBs.

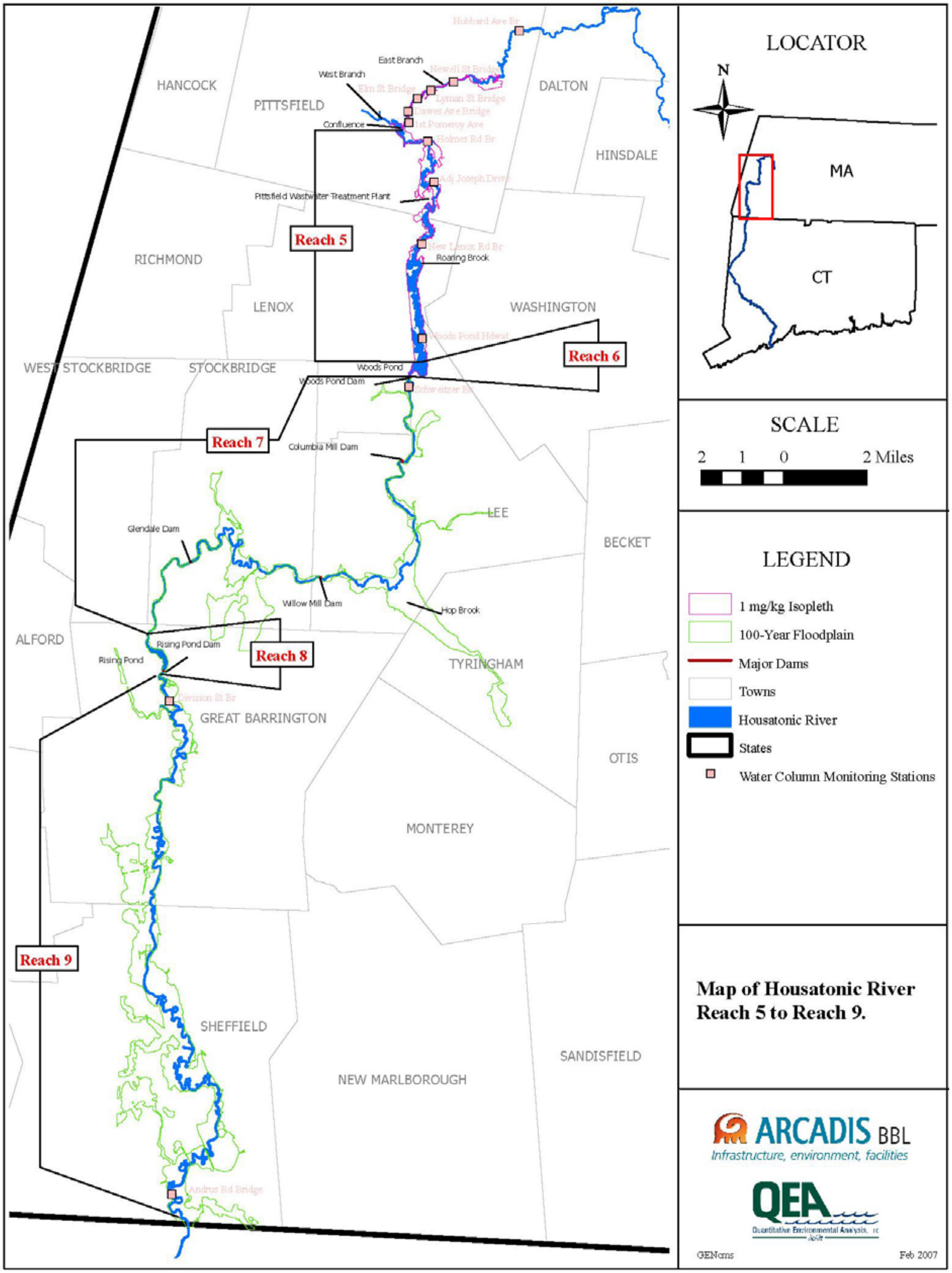


Figure 1. Location of Cultural Resources Study Area for the Housatonic Rest of River Project in Western Massachusetts (River Reaches 5 through 8).

1.2 The Section 106 Regulatory Framework

Section 106 of NHPA of 1966, as amended (16 U.S.C. §§ 470 et seq.), provides that federal agencies must take into account the effects of their actions on any district, site, building, structure, or object listed in, or eligible for inclusion in, the National Register of Historic Places. Implementing regulations for Section 106, promulgated by the ACHP, are contained in 36 C.F.R. Part 800. These regulations set out a process for conducting reviews and provide specific criteria for assessing the effects of federal undertakings on historic properties and identifying adverse effects on historic properties. The general approach is to determine the Area of Potential Effects (APE), identify and collect information about the historic properties within this area and whether they are listed or eligible for the National Register, and then assess the potential for the undertaking to impact these properties (36 C.F.R. § 800.4[a]-[d]). The APE is the area "within which an undertaking may directly or indirectly cause changes in the character or use of the historic properties" (36 C.F.R. § 800.16[d]).

The effects of an undertaking on a cultural resource are predicted by evaluating the significant characteristics of the resource and the design and anticipated consequences of the undertaking. Effects to cultural resources listed in, or eligible for listing in, the National Register are evaluated with regard to the Criteria of Adverse Effect, set forth in 36 C.F.R. § 800.5. Under these regulations, an adverse effect occurs "when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, setting, materials, workmanship, feeling, or association" (36 C.F.R. § 800.5[a][1]).

Cultural resource assessments are often divided into two general phases. Phase I is intended to identify archaeological sites and historic structures that may be affected by the proposed project. It can include both information-gathering, which consists of literature searches and an assessment of the archaeological sensitivity of the project area (sometimes called Phase

IA) and, once the parameters of potential impacts are better defined, field investigations designed to collect additional information about cultural and archaeological resources in the project area (Phase IB). If, following completion of Phase I investigations, it is determined that the project will affect cultural or archaeological resources and that such effects cannot be avoided, a Phase II investigation can be conducted to assess the eligibility of the identified resources for the National Register of Historic Places. Phase II can consist of both additional background research and additional fieldwork.

1.3 Scope of Phase I CRA

In this case, since the remedial actions for the Rest of River are unknown, this CRA Work Plan includes the gathering of information, based on literature searches, contact with knowledgeable individuals, and visual reconnaissance, regarding the presence or potential presence of archaeological sites and historic properties within the areas that could be subject to or affected by active remediation activities, including the river, the adjacent shoreline, and the floodplain. Specifically, for purposes of this Phase I CRA, the Archaeological APE includes the river, shoreline, and floodplain (as defined above) of Reaches 5 through 8. The Historic Architectural APE is defined as those historic properties that may be within the Archaeological APE or visible from areas involved in remediation.

The specific methods to be used for this work are described in Section 2, and scheduling and reporting are discussed in Section 3.

2. Methodology

The methods to be employed for this Phase I CRA will include a literature review and collection of background data on potential archaeological and architectural historic resources, as well as Traditional Cultural Properties, within the identified APE, visual reconnaissance to ground-truth the findings from the research, compilation of the data, and an archaeological sensitivity assessment. These activities are described in the following subsections. As subsequently discussed in Section 3, once the remedial actions for the Rest of River have been selected, additional activities will be conducted as necessary to complete the Section 106 process for this project

2.1 Literature Review and Collection of Background Data

Background literature review will be conducted to: 1) develop historical and archaeological contexts for interpretation and evaluation of any archaeological sites or historic structures determined to be present within the APE; 2) review the results of previous archaeological and historical work within the APE and vicinity; 3) identify the locations of previously recorded cultural resources; and 4) develop a specific strategy for creating an archaeological sensitivity map. To begin, sources such as the following will be reviewed for pertinent additional information relating to the project:

- Massachusetts Archives and Massachusetts Historical Commission, Boston, Massachusetts
- Berkshire County Historical Society, Pittsfield, MA
- The Berkshire Athenaeum – Pittsfield, MA
- Berkshire Museum – Pittsfield, MA

These and other local sources such as libraries and historical societies will be reviewed for information on the area's prehistory and history. Specific sources on the area's prehistory will include reports, articles, papers, reports, and volumes on archaeological investigations within the region, as well as historic maps and atlases that delineate earlier landforms and drainage systems. Data from these sources will be used specifically to evaluate the area's potential to contain prehistoric resources.

To obtain information on the area's history, published works on the history of the area will be examined. Local archaeologists, historians, librarians, and public officials will also be contacted. Other sources to be consulted include unpublished monographs and reports, historical architecture files, documentary photographs, county atlases, and fire insurance maps. The focus of this background historical research will be to reconstruct historic and modern land use within the APE, and identify the locations of previously recorded historic structures and districts.

The following maps will be examined: historic topographic maps, current 7.5' USGS quadrangle maps; and geologic maps. Current and historic aerial photographs will be reviewed to note natural and human-induced changes to river-associated landforms.

Based on the information collected, the archaeologists will develop preliminary GIS-based "sensitivity maps" showing areas of no, low, and high potential to contain archaeological sites. Multiple data categories will be evaluated to help assess the likelihood of archaeological resources being present in an area; these will likely include variables such as proximity to stream confluences, proximity to known archaeological and historic resources, slope, soil characteristics, and historic map data.

In addition, to obtain further information on historic architectural resources in and around the project area, Massachusetts Historical Commission (MHC) files will be examined in an effort to identify such properties that are:

- Listed in, nominated to, or previously determined eligible or ineligible for inclusion in the National or State Registers of Historic Places;
- Included in the Historic American Buildings Survey (HABS), or Historic American Engineering Record (HAER); or
- Included in cultural resource surveys, as well as pertinent local or county inventories of historic/cultural resources.

Section 106 compliance may also require investigation of the potential location of Traditional Cultural Properties (TCPs). The traditional cultural significance of an historic property is derived from the role the property plays in a community's historically rooted beliefs, customs, and practices. Examples of properties possessing such significance include:

- a location associated with the traditional beliefs of a Native American group about its origins, its cultural history, or the nature of the world;
- a rural community whose organization, buildings and structures, or patterns of land use reflect the cultural traditions valued by its long-term residents;
- a location where Native American religious practitioners have historically gone, and are known or thought to go today, to perform ceremonial activities in accordance with traditional cultural rules of practice; and
- a location where a community has traditionally carried out economic, artistic, or other cultural practices important in maintaining its historic identity.

A traditional cultural property, then, can be defined generally as one that is eligible for inclusion in the National Register of Historic Places because of its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community.

As part of the Phase I background research, ethnographic research and local informant interviews will be conducted to identify and evaluate whether the APE possesses National Register-eligible TCPs.

2.2 Visual Reconnaissance

Following the collection of the above-referenced information, the preliminary archaeological sensitivity maps will be ground-truthed. Archaeologists will conduct an initial reconnaissance of the archaeological APE, including pedestrian inspection of the floodplain sections and examination of the river channel and banks from a small boat. The reconnaissance will include all of the APE, not just the areas initially classified as having high archaeological potential. This reconnaissance will be designed to obtain data to update the classification system as needed. On the river, the archaeologists will slowly drift downstream along the river banks (where river conditions allow), visually inspecting conditions and classifying the terrain. At frequent intervals, the team will stop the boat, and get out to conduct a pedestrian reconnaissance to obtain detailed information on the terrain, soils, and vegetation.

In addition, to further assess the potential for historic architectural resources in the APE, an architectural historian will conduct a reconnaissance level (or windshield) survey of the project area to identify all standing resources that appear to be 50 years or older. All resources identified will be recorded, photographed, and mapped. Documentation will include location, brief physical description, including visible alterations, and preliminary assessment of potential eligibility. Duplication of previously conducted, professionally acceptable work identified during background research will be avoided, and state inventory forms will not be filled out at this stage of the project.

2.3 Data Compilation

The information collected in the background research, supplemented by the visual reconnaissance, will be organized in a database of known cultural resources. This database will systematically record information on the age, affiliation, location, and resource type for every cultural resource located in the APE. This database will be linked to a master project GIS to facilitate later comparisons with the locations of remediation activities.

In addition, following completion of the reconnaissance, the GIS-based archaeological sensitivity maps of the project's Archaeological APE will be updated. As noted above, these maps will depict areas of no, low, and high potential to contain archaeological sites. For each category, it is anticipated that multiple data sources will be combined in an analytical matrix to define the archaeological sensitivity of a given area.

3. Schedule and Reporting

The activities described in Section 2 will commence upon EPA approval of this Work Plan and will be completed prior to the completion of the CMS. An initial Phase I Cultural Resources Assessment Report (CRA Report) will be prepared and submitted to EPA as part of the CMS Report.

The initial Phase I CRA Report will present the results of the activities outlined in this Work Plan. It will also identify potential additional data needs, if any, to complete the Phase I cultural resources investigations. Such data needs will likely depend on the scope and locations of the selected remedial actions for the Rest of River, since additional Phase I investigations, particularly field investigations, would be focused on areas that would be subject to or affected by those remedial actions. As such, the report will include a plan for conducting further investigations and evaluations, if necessary, once EPA has selected the remedial actions for the Rest of River. Depending on the extent and locations of those remedial actions, such further investigations and evaluations may be necessary to:

- determine whether archaeological or historic resources are actually present in an area of high sensitivity that is targeted for remediation;
- evaluate whether any archaeological or historic resources present are potentially significant (i.e., eligible for the National Register of Historic Places); and
- determine whether the remediation could have an adverse effect on any such potentially significant resources.

The plan included in the initial Phase I CRA Report for collecting such information will necessarily be general, since the remediation will not yet be selected at that time. Accordingly, it is anticipated that that plan will call for submission of a more detailed supplemental work plan for such additional investigations and evaluations after EPA has selected the remedial actions for the Rest of River. Ultimately, if such additional investigations and evaluations indicate that the remediation program could result in an adverse effect to potentially significant archaeological or historic resources and that such effects cannot be avoided, then a further, Phase II work plan may be necessary in the future to evaluate whether the archaeological or historic resources in question in fact meet the criteria for eligibility for the National Register.

All CRA work plans, reports, and addenda will be submitted to EPA. To ensure compliance with the confidentiality requirements of Section 304 of the National Historic Preservation Act (if applicable), GE will not release information regarding the locations of identified archaeological resources to the public without authorization from EPA.

REFERENCES

Arcadis BBL and QEA

2007 *Housatonic River - Rest of River Corrective Measures Study Proposal.* Prepared for General Electric Company, Pittsfield, Massachusetts, February 2007.