GE
159 Plastics Avenue
Pittsfield, MA 01201
USA

February 7, 2005

Alison Wolfe
Marasco Newton Group
2801 Clarendon Blvd, Suite 100
Arlington, VA 22201

Re: GE-Pittsfield/Housatonic River Site
Rest of River
Comments on US EPA's Model Calibration Report

Dear Ms. Wolfe:

In accordance with Peer Review process for US EPA's Model Calibrati on Report (MCR) for the Housatonic River (dated December 2004), I am enclosing a document entitled *Comments of the General Electric Company on the U.S. Environmental Protection Agency's Model Calibration: Modeling of PCB Contamination in the Housatonic River,* which was prepared on GE's behalf by Quantit ative Environmental Analysis. This document presents GE's comments on the MCR for consideration by the Peer Review Panel. These comments are formatted to address the specific questions in the MCR charge, which the Peer Review Panel will be using to evaluate the MCR.

To assist in the distribution of this document to the Peer Review Panel, the document is being provided to MNG in three different formats: an electronic-PDF file format sent via email to GEPittsfield@sra.com and followed up with paper-bound and paper-unbound formats sent via Federal Express.

Please let me know if you have any questions.

Very truly yours,

Andrew Silfer, P.E.
GE Project Coordinator

Enclosures

Comments of the General Electric Company on the U.S. Environmental Protection Agency's Model Calibration: Modeling of PCB Contamination in the Housatonic River

Prepared for:

General Electric Company

Pittsfield, MA

Prepared by:

Quantitative Environmental Analysis, LLC

Liverpool, NY

February 7, 2005

Comments of the General Electric Company on the U.S. Environmental Protection Agency's Model Calibration: Modeling of PCB Contamination in the Housatonic River

Prepared for:

General Electric Company

Pittsfield, MA

Prepared by:

Quantitative Environmental Analysis, LLC

Liverpool, NY

February 7, 2005

Table of Contents

SECTION 1
INTRODUCTION

1.1 BACKGROUND

On behalf of General Electric Company (GE), Quantitative Environmental Analysis, LLC (QEA) has prepared these comments on the U.S. Environmental Protection Agency's (EPA's) document titled *Model Calibration: Modeling Study of PCB Contamination in the Housatonic River* (Model Calibration Report or MCR; Weston 2004a). That document describes the second in a three-phased modeling effort of the system. This second phase includes the development and calibration of PCB fate, transport, and bioaccumulation model of the Housatonic River between the confluence of the East and West Branches and Woods Pond Dam. The first phase included the development of a Model Framework Design (MFD; Weston 2000a) and Quality Assurance Project Plan (QAPP; Weston 2000b), which described the modeling plans for the system. These plans were subject to peer review in April 2001 and subsequently reissued by the EPA in April 2004 (Weston 2004b). The third phase, model validation, will be conducted and be subject to peer review following the MCR review. Upon completion of the model validation peer review, EPA will provide the model to GE for use in evaluating remedial alternatives as part of the Corrective Measures Study (CMS) for the Rest of River portion of the GE-Pittsfield/Housatonic River Site.

This document presents GE's comments on the MCR for consideration by the Peer Review Panel.

1.2 OVERVIEW OF CHANGES IN EPA'S MODEL SINCE THE MFD PEER REVIEW

Since the April 2001 MFD peer review, GE developed, and EPA approved, the Housatonic River RCRA Facility Investigation Report (RFI Report; BBL and QEA 2003), which contains a comprehensive examination of the entire data set for the system. In addition, a number of modeling-related activities have been conducted by EPA. These have included several data collection programs to support the modeling effort:

- GE and EPA co-sponsored water column and sediment pore water partitioning studies, which are documented in the RFI Report (BBL and QEA 2003) as well as the Revised MFD (Weston 2004b);
- additional flow and stage height monitoring has been conducted by EPA at several locations within the system, including upstream on the West Branch;
- EPA conducted bed load sampling during three high flow events on the system; and
- to help quantify bank erosion, EPA installed and monitored toe pins in a short stretch of the river, conducted detailed surveys of select river bends, and mapped areas of active bank erosion and accretion.

The revised MFD issued in April 2004 included analyses of these and other data sets, as well as the presentation of EPA's conceptual model (Weston 2004b). Additionally, based on inputs from the MFD peer review, the new data collections, engagement of new modeling team members, and interactions with GE and QEA, EPA has made several substantive changes to the framework relative to that presented at the MFD peer review. These changes are listed by sub-model in the following sections.

1.2.1 Hydrodynamic Model

Significant changes made to EPA's hydrodynamic model framework include:

- The attempt to use a curvilinear grid for the channel nested within a larger scale grid in the floodplain, which would not have conserved momentum of overbank flows, was abandoned for a single grid that provides a more consistent representation of the system's geometry.
- The original framework specified the use of HSPF outputs to specify input flow rates at the East and West Branch boundaries of the hydrodynamic model. As documented in the

MCR, a series of data-based relationships was developed to specify inflows at the model boundaries for the calibration period.

1.2.2 Sediment Transport Model

Significant changes made to EPA's sediment transport model framework include:

- Similar to the hydrodynamic model, a series of data-based relationships was developed to specify solids load at the model boundaries for the calibration period.
- Sediment bed load has been added to the model framework and the governing equations are detailed in the revised MFD (Weston 2004b).
- EPA developed boundary models spanning short stretches of the East and West Branches to estimate bed load and the grain size composition of solids entering the model as suspended load.

1.2.3 PCB Fate Model

Significant changes made to EPA's PCB fate model framework include:

- The original MFD had significant discussion about representing an oil phase of PCBs in its partitioning formulations. Based on the site-specific data collected in 2001-2002, EPA has abandoned any efforts to simulate oil-phase PCBs, and has adopted more conventional partitioning formulations.
- EPA is no longer using two models to simulate biotic and abiotic PCB fate processes separately. The proposed biotic PCB fate and transport model (AQUATOX) has been abandoned and EPA is using a single model code (EFCD) to simulate PCB fate and transport.

1.2.4 Bioaccumulation Model

Significant changes made to EPA's bioaccumulation model framework include:

- The EPA has abandoned the effort to model ecosystem dynamics using AQUATOX and has adopted a more conventional approach to modeling PCB bioaccumulation using the QEAFDCHN model framework (Weston 2004a).

1.3 THE PEER REVIEW CHARGE FOR MODEL CALIBRATION

The charge for the modeling peer review includes a number of specific questions relating to the model calibration. A summary of GE's major comments, as they pertain to these charge questions, is provided below and a detailed discussion is provided in Section 2 of this document.

1. *Are the comparisons of the model predictions with empirical data sufficient to evaluate the capability of the model on the relevant spatial and temporal scales?*

    - Due to lack of water-column and biota PCB data in Reach 5D (backwaters), as well as the exclusion of volatilization as a sink, the Food Chain Model (FCM) cannot be calibrated in Reach 5D. It is thus recommended that Reach 5D be dropped from the calibration report (details in Section 2.2.1).
    - It should be recognized that the congener-specific applications of the FCM are highly uncertain (due to limited congener-specific data on water and sediments) and are inconsequential for application of the linked EFDC-FCM model in the CMS, which will necessarily be based on total PCBs. Therefore, the peer reviewers should focus on the calibration of the linked EDFC-FCM model based on total PCBs, not congeners (details in Section 2.2.2).
    - The 14-month calibration period is an insufficient time scale on which to judge the performance of the model. A longer (e.g., 20-year) calibration period is needed to evaluate whether the model has accurately represented PCB fate, transport, and bioaccumulation processes (details in Section 2.3.1).

2. *Is there evidence of bias in the model, as indicated by the distribution of residuals as a function of the independent variables?*

3. *Does the model, as calibrated, based upon your technical judgment, adequately account for the relevant processes affecting PCB fate, transport, and bioaccumulation in the Housatonic River?*

   - The use of the Lick equation in the sediment transport model to predict resuspension of cohesive sediment from a non-cohesive bed is questionable. The uncertainty associated with this approach should be tested by simulating sediment transport with an alternative approach (details in Section 2.1.2).
   - Bank erosion is an important process that impacts sediment transport and PCB fate and transport in the river reach between the East/West Branch confluence and Woods Pond. Sediment and PCB loads due to bank erosion need to be included in the model framework (details in Section 2.1.3).
   - The use of a 6-inch active surface sediment layer in the FCM does not allow that model to realistically simulate biota's responses to changes in PCB concentrations in surface sediments. This will attenuate the model's temporal response to remedial alternatives. Therefore, the active surface sediment layer in the FCM (and EFDC as necessary) should be reduced to 3-4 inches (details in Section 2.1.4).
   - Because the calibration period is only 14 months, the model calibration is not tested against longer-term data sets, limiting the robustness of the model. One example of this is the model's inability to reproduce the observed decrease in PCB concentrations across Woods Pond at low flows (details in Section 2.3.2).

4. *Based upon your technical judgment, have the adequate methodologies been employed to evaluate the sensitivity of the model to descriptions of the relevant processes, and to evaluate the uncertainties of model predictions?*

- The sensitivity of the sediment transport model should be evaluated over the full calibration period, and its sensitivity to the composition of incoming sediment loads from the East and West Branches needs to be evaluated (details in Section 2.5.1).
- The uncertainties of each of the linked models should be presented and discussed relative to one another; this should include an assessment of how uncertainties in HSPF and the EFDC sub-models translate into uncertainty in FCM-predicted fish tissue concentrations (details in Section 2.5.2).
- The Monte Carlo uncertainty analysis for the FCM needs to be interpreted with caution because the distributions assigned to input parameters are semi-quantitative and comparisons made between output distributions and the data are inappropriate (details in Section 2.5.3).

5. *Is the uncertainty indicated by model-data differences sufficiently inconsequential to permit use of the model to predict differences among remedial options?*

   - Because the model will be used to evaluate remedial options, the MCR should include analysis and discussion of the spatial scale at which the model can be used to accurately resolve the major sediment transport and PCB fate processes (details in Section 2.4.2).

6. *Are the processes in the model calibrated to the extent necessary for predicting future conditions including future concentrations of PCBs in the environment under natural processes and under potential remedial options for sediments and floodplains soils in the Housatonic River in the reach below the confluence? If not, what additional work needs to be done to calibrate the model?*

   - Full linkage between the watershed model and the hydrodynamic and sediment transport models has not been tested (details in Section 2.1.1).
   - The model domain needs to be extended downstream to allow an evaluation of the impact of remediation alternatives on river reaches downstream of Woods Pond Dam (details in Section 2.1.5).

- The model's simulation time is unacceptably long. Evaluating remedial alternatives through long-term projections with the model cannot be completed in an efficient manner (details in Section 2.4.1).

SECTION 2
MAJOR COMMENTS

2.1 EPA'S MODEL FRAMEWORK

GE has several concerns with the EPA's model framework, as presented in the MCR, with respect the processes represented (Charge Question 3) and the impacts on the calibration (Charge Question 6). First, the framework has not been fully tested because the simulations using watershed model predictions for the East and West Branch boundaries have not been completed. Second, the approach for modeling cohesive sediment erosion from a predominantly non-cohesive bed is questionable. Third, the framework does not represent a potentially important fate process: bank erosion. Finally, the framework is incomplete because the domain does not address reaches downstream of Woods Pond Dam. These issues are discussed in the following sections.

2.1.1 Linkage to the Watershed Model

MCR Charge Reference:

- ***Question 6 (model's ability to be used to predict future conditions)***

The EPA modeling framework includes a watershed model that predicts flow rates and sediment loadings from the East and West Branches, tributaries and direct drainage. The primary objective of the watershed model is to provide boundary condition inputs for the hydrodynamic and sediment transport models. However, the 14-month calibration simulation did not use watershed model results to specify boundary conditions for these models. Rather, boundary conditions for these models were developed using a series of relationships developed from site-specific data collected during the calibration period. In addition, upstream models of the East and West Branches were developed to estimate the composition of sediment loads from those two sources.

It does not appear that EPA has completed the linkage between the watershed model and the hydrodynamic and sediment transport models. While this linkage is relatively simple, at least conceptually, unforeseen complications can arise during implementation and a demonstration that the linkage is working correctly should have been included.

Beyond demonstrating that the mechanics of model linkage are functioning properly, an evaluation of the potential impacts of driving the hydrodynamic and sediment transport models with boundary conditions derived from watershed model predictions needs to be conducted. Repeating the 14-month calibration simulation with incoming flow and sediment load boundary conditions determined from the watershed model results would be a worthwhile exercise. The results of this simulation could be compared to the results of the data-based 14-month simulation to determine if there are significant differences between the two methods for specifying boundary conditions. This approach may provide insights about potential problems with the long-term validation simulation prior to initiating the development and execution of that simulation.

Another potential complication with the watershed model linkage is the upstream model for the East and West Branches that was developed to estimate the composition of sediment loads from those tributaries. No explanation was provided concerning the interaction between the upstream and watershed models. How will those two models be used to specify boundary condition information for inputs from the East and West Branches?

Full linkage between the watershed model and the hydrodynamic and sediment transport models has not been tested.

2.1.2 Cohesive Sediment Transport Algorithm

MCR Charge Reference:

- ***Question 3 (model's ability to capture relevant PCB fate, transport, and bioaccumulation processes)***

The Lick equation (i.e., MCR, Equation B.3-25) was used to predict erosion of cohesive sediment. Site-specific parameters in the Lick equation (i.e., M, n and τ_{ce}) were determined from Particle Entrainment Simulator (PES) and Sedflume data collected within the Primary Study Area. This approach is consistent with the conventional method for applying the Lick equation to a cohesive sediment bed, which is a muddy bed with a significant fraction of clay and silt, but which can also contain sand.

However, the EPA approach for using the Lick equation to predict the resuspension of cohesive sediment (i.e., clay and silt) from a non-cohesive bed is problematic. A non-cohesive bed is primarily composed of sand and gravel, with a small fraction of clay and silt. Conceptually, the EPA approach of applying different resuspension formulations to representative sediment size classes in the bed may be appropriate. The difficulty arises when the Lick equation is applied to the cohesive fraction of a bed that is non-cohesive. Site-specific parameters in the Lick equation (M and n) are determined from PES tests on cohesive sediment cores collected within the study area. The PES device cannot be used to test the resuspension properties of non-cohesive sediment cores, or those of cohesive sediment within a non-cohesive bed. Thus, the applicability of the Lick equation to the cohesive fraction of a non-cohesive bed is questionable. The impact of this inconsistent application of the Lick equation on sediment transport model results is unclear.

The sensitivity of the sediment transport model to the assumption that the Lick equation is applicable to the cohesive fraction of a non-cohesive bed should be evaluated. This sensitivity analysis could be conducted as follows: Delineate the bed into cohesive and non-cohesive areas using conventional definitions of these sediment types. In non-cohesive bed areas, apply the non-cohesive erosion algorithm to the cohesive fraction of the bed, and apply the Lick equation to the sediments in the cohesive bed. Repeat the 14-month calibration simulation using this modified approach and compare the results to original simulation.

The use of the Lick equation in the sediment transport model to predict resuspension of cohesive sediment from a non-cohesive bed is questionable. The uncertainty associated with this approach should be tested by simulating sediment transport with an alternative approach, as described above.

2.1.3 Bank Erosion

MCR Charge Reference:

- ***Question 3 (model's ability to capture relevant PCB fate, transport, and bioaccumulation processes)***

Sediment and PCB loads associated with bank erosion processes were neglected in the EPA's 14-month calibration. The following reasons were provided to justify the exclusion of bank erosion sources: 1) slumping is the dominant mode of bank erosion; 2) spikes in TSS or PCB water-column concentrations are not evident during high-flow events; and 3) the additional complexity is not warranted for the short time scale of the simulation. The report indicates that bank erosion will be incorporated into the long-term validation simulation.

The conceptual model for bank erosion described in the MCR is limited to only one mechanism: slumping after a storm due to hydrostatic pressure differences in the bank. Another possible mechanism, however, is erosion of the toe of the bank, followed by undercutting and finally slumping of solids into the river. Erosion of the toe would result in a continual release of solids during time of high shear stress, which would coincide with the period of elevated flows. To the extent that these solids are transported to downstream sampling locations, this mechanism would be reflected in the storm sampling data to which the model was calibrated.

Two field studies were conducted by EPA to collect bank erosion data. Toe pins were installed along a 2000-foot section of the riverbank near RM 130 from October 2000 to June 2002. In addition, bank location data (i.e., top- and bottom-of-bank) were obtained along 15 riverbank stretches in Reaches 5A and 5B between November 2001 and June 2002. Analyses of these data indicate that sediment loads due to bank erosion within Reach 5 range between 1,400 and 3,200 MT/yr, which correspond to about 22% to 86% of the estimated sediment load at the confluence of the East and West Branches (RFI Report, Section 8.8.1.9). EPA has developed similar calculations, which suggest that the solids load due to bank erosion is on the order of 1,000 to 1,500 MT/yr, which corresponds to approximately 20% of the annual load at the confluence (MCR, Appendix B, Table B.4-1). Given the magnitude of these estimates, bank erosion should have been incorporated into the calibration simulation. This process represents a significant source of solids and PCBs that needs to be included in the EPA model. Impacts of bank erosion loads on model predictions would have been evident during the 14-month simulation, which represents a time scale that cannot be considered "short" with respect to bank erosion.

Bank erosion is a complex process that is difficult to quantify and simulate. Since data-based analyses indicate that bank erosion represents a significant sediment source, the goal of modeling this process should be annual estimates that have an order-of-magnitude accuracy. While model complexity will be increased with inclusion of a bank erosion sub-model, a relatively simple approach can be developed using the linear Ikeda-Parker model (Ikeda et al. 1981). This approach does not require acquisition of additional geotechnical data from the study area; it can be developed, calibrated and applied using available data.

Bank erosion is an important process that impacts sediment transport and PCB fate and transport in the river reach between the East/West Branch confluence and Woods Pond. Sediment and PCB loads due to bank erosion need to be included in the model framework.

2.1.4 Bioavailable Depth for Food Chain Exposure

MCR Charge Reference:

- ***Question 3 (model's ability to capture relevant PCB fate, transport, and bioaccumulation processes)***

The Food Chain Model (FCM) is applied with a 15-cm (six-inch) thick surficial sediment layer as its bioavailable layer, or active feeding zone. A layer of this thickness will overestimate the zone within which feeding and exposure are most likely to occur. This will result in an attenuated model response to the deposition of cleaner sediments following remediation.

Thibodeaux and Bierman (2003), as cited in the FCM calibration report, give a nominal bioavailable layer depth of 10 cm (4 inches). Other literature suggests that freshwater benthic macroinvertebrates are found as deep as 10 cm, but are concentrated within the top 4 cm (1.5 inches) of sediments (Krezoski et al. 1978; Millbrink 1973; Ford 1962). To our knowledge, there is no site-specific information regarding benthic infaunal abundances with depth to define the depth of active feeding in the modeled reaches of the Housatonic River.

Attachment C.19 of MCR Appendix C states that "*the model framework only requires that the average PCB exposures measured within the surface 6-inch horizon are unbiased estimates of the actual exposure concentrations encountered by the benthic community*" (p. 1). The concern expressed here is not with the estimates of surficial sediment PCB concentration, but with the model's temporal response to a variety of proposed remedial strategies. Additional justification needs to be provided to show that the specification of a deep bioavailable layer will not bias FCM projection results.

This is an issue that needs to be addressed in the fate and transport model, as the bioavailable layer can be no thinner than the thickness of the topmost layer of the fate model.

The use of a 6-inch active surface sediment layer in the FCM does not allow that model to realistically simulate biota's response to changes in PCB concentrations in surface sediments. This will attenuate the model's temporal response to remedial alternatives. Therefore, the active surface sediment layer in the FCM (and EFDC as necessary) should be reduced to 3-4 inches.

2.1.5 Extent of Model Domain

MCR Charge Reference:

- ***Question 6 (model's ability to be used to predict future conditions)***

The model developed and calibrated by the EPA and documented in the MCR represents the reach of the Housatonic River between the East/West Branch confluence and Woods Pond Dam. Models describing PCB fate, transport, and bioaccumulation were developed and calibrated for this reach of the river. This domain is too limited for the intended application of these models because it does not include reaches of the river downstream of Woods Pond Dam, specifically Reaches 7 and 8, which contain a number of impoundments, most notable Rising Pond (Reach 8). Consequently, the model will be unable to predict the impact of natural attenuation and potential sediment remediation activities on PCB levels within these impoundments. It is important for the model to include at least a portion of the river between Woods Pond Dam and the Massachusetts/Connecticut border. By extending the model domain further downstream, the impact of potential sediment remediation in the reach between the confluence and Woods Pond Dam on downstream sediment, water column, and biota PCB levels, and consequently human health and ecological risk, can be directly and objectively assessed. Without such an extension, extrapolation of downstream impacts of remedial action scenarios will be unconstrained and subject to considerable uncertainty.

The model domain needs to be extended downstream to allow an evaluation of the impact of remediation alternatives on river reaches downstream of Woods Pond Dam.

2.2 MODELING OF AREAS AND PROCESSES THAT ARE NOT ADEQUATELY CONSTRAINED BY DATA

GE has concerns with two portions of the modeling that add uncertainty to the framework as presented in the MCR without offering any predictive advantages to the calibrated model.

Modeling of Reach 5D is not adequately constrained by calibration data, and congener-based bioaccumulation modeling contains limited predictive ability.

2.2.1 Backwater (Reach 5D) Modeling

MCR Charge Reference:

- ***Question 1 (sufficiency of model-data comparisons)***

While the MCR includes FCM results for backwater habitats (Reach 5D), there were no measurements of water-column PCBs in backwaters nor were there any fish samples taken from backwaters. Exposure data for backwaters are limited to sediment samples. It is difficult, then, to assess the calibration of the PCB fate model-predicted concentrations or to assess the uncertainty of data-based calculations of exposures for the FCM in Reach 5D. Thus, development of independent FCM predictions for Reach 5D are not supported by the available exposure data.

Furthermore, given the shallow depths and high surface area to volume ratio in these backwaters, the reduced flows and intermittent hydraulic connections with the main channel, and high summertime temperatures in these backwaters, volatilization may be a much more important factor for the fate of PCBs in these habitats as compared to the main channel. The lack of water-column data precludes an assessment of this. However, volatilization has been excluded from the fate model framework, based on calculations performed for the main channel areas of the river (e.g., Woods Pond). Thus, the PCB fate model and FCM predictions of water column (dissolved and particulate), invertebrate tissue, and fish tissue PCB concentrations for Reach 5D cannot be calibrated nor assessed for uncertainty. As such, FCM results for Reach 5D should be considered highly uncertain and are not relevant to the calibration of EPA's model.

Due to lack of water-column and biota PCB data in Reach 5D (backwaters,) as well as the exclusion of volatilization as a sink, the FCM model cannot be calibrated in Reach 5D. It is thus recommended that Reach 5D be dropped from the calibration report.

2.2.2 Congener-Based Bioaccumulation Modeling

MCR Charge References:

- ***Question 1 (sufficiency of model-data comparisons)***
- ***Question 5 (uncertainty in model-data comparisons)***
- ***Question 6 (model's ability to be used to predict future conditions)***

The linked EFDC-FCM simulates processes involving total PCBs. Thus, in the CMS, that linked model can only be used to evaluate remedial alternatives for total PCBs; it cannot be used to simulate processes involving individual PCB congeners.

Nevertheless, the MCR applies the FCM on a congener-specific basis. The role of these congener-specific applications of the FCM is essentially limited to exploring the model's performance over a range of congeners that differ in their partitioning coefficients (K_{ow}) and other properties that may affect their uptake by biota. The congener model's predictive power is limited, however, by uncertainties in exposure concentrations. While there were considerable fish tissue congener data, there were far less congener data for water and sediments. In order to derive congener-based exposures, a variety of regression procedures and adjustments to the data were used. The variability associated with these regressions limits any practical application of these results.

It should be recognized that the congener-specific applications of the FCM are highly uncertain (due to limited congener-specific data on water and sediments) and are inconsequential for model application of the linked EFDC-FCM model in the CMS, which will necessarily be based on total PCBs. Therefore, the peer reviewers should focus on the calibration of the linked FCM-EDFC model based on total PCBs, not congeners.

2.3 MODEL CALIBRATION

The model calibration results presented in the MCR appear to generally match the data within EPA's targets set forth in the QAPP. However, the temporal scale of the model calibration is insufficient because a long-term simulation is needed. It is only through a long-term simulation that an evaluation of whether the model properly captures sediment transport processes occurring over decadal timescales (i.e., deposition and erosion patterns) can be conducted. Additionally, the choice of a short, 14-month, calibration period for the sediment transport and PCB fate models limits the amount of data available for calibration and, therefore, its robustness.

2.3.1 Long-Term Sediment Transport

MCR Charge References:

- ***Question 1 (sufficiency of model-data comparisons)***
- ***Question 3 (model's ability to capture relevant PCB fate, transport, and bioaccumulation processes)***

The model's ability to capture the major sediment transport processes within the system cannot be fully evaluated through the 14-month calibration presented in the MCR. The sediments within the river reflect processes that have occurred over decadal time scales. The predictions of net deposition during the 14-month calibration period presented in the MCR are generally comparable to sedimentation rates estimated from radionuclide-dated cores from

Woods Pond; however, these data represent long-term, decadal-scale averages. The model calibration should have been run over a comparable time scale to make such comparisons more meaningful.

While it appears that the sediment transport model provides an adequate match to the TSS data over the 14-month calibration, there may be processes occurring in the model that will cause problems when it is run over longer time scales that were not evident in the calibration results. For example, it is possible that the model's parameterization may result in deposition and erosion patterns within the system or shifts in grain size distribution that are inconsistent with the conceptual model when a long-term run is completed. Without such an assessment, the sediment transport model calibration is incomplete, because long time scales will be the focus of the model's ultimate use.

Furthermore, without a long-term calibration run, it is not possible to evaluate the effects of specifying sediment loads based on results from the watershed model. This evaluation is important because long-term projection simulations to evaluate remedial alternatives in the CMS will be based on sediment loads from the watershed model.

Finally, calibrating the model over a longer time scale would eliminate the disconnect between model calibration and validation with respect to inclusion of bank erosion. As discussed in Section 2.1.3, data presented in the RFI, revised MFD, and MCR suggest that bank erosion accounts for a significant source of solids and PCBs to the river. While EPA contends that this process is not important over short time scales (and therefore excluded it from the model calibration), EPA has acknowledged that it is important over longer time scales. Calibration over a longer period would therefore need to include bank erosion. Without such a long-term calibration, the model will likely be significantly changed during validation because inclusion of bank erosion will result in the need to alter the parameter specifications for channel erosion and deposition processes simulated by the model in the current 14-month calibration.

The 14-month calibration period is an insufficient time scale on which to judge the performance of the model. A longer (e.g., 20-year) calibration period is needed to evaluate if the model has accurately represented PCB fate, transport, and bioaccumulation process.

2.3.2 Calibration Data Set is Limited

MCR Charge References:

- ***Question 1 (sufficiency of model-data comparisons)***
- ***Question 3 (model's ability to capture relevant PCB fate, transport, and bioaccumulation processes)***

Although a large body of data was collected during the EPA's 14-month calibration period, this relatively short period precludes the use of additional data sets that would improve the robustness of the model calibration. One particular dataset is the routine water column monitoring that has been conducted since 1996. Because of the large amount of storm sampling data collected during the 14-month calibration period, quantitative comparisons of the model to PCB and TSS concentrations focused largely on these sampling data, with a lesser focus on the routine, non-event data (due to the lower number of samples). The low-flow PCB and TSS data from the 14-month calibration period may not adequately characterize the important system features at low flows due to the relatively short timeframe. In particular, EPA's PCB calibration at low flows generally matches the average of the data from select events during 1999-2000 (Appendix B, Figure B.4-37). This spatial profile indicates relatively little change in PCB concentrations between Woods Pond headwaters and Woods Pond Dam, with the model predicting a very slight increase. However, when the longer-term data set containing more low flow samples from these locations is considered, a different spatial pattern is observed. A plot of the spatial profile from low-flow data collected over 1996-2001 developed by EPA (Appendix B, Figure B.4-29) indicates a prominent decrease in PCBs across Woods Pond, with the mean concentration at the downstream end being over 30% lower during this six-year period. Because of the short-term calibration period used by EPA, the PCB fate model does not capture this dynamic.

Because the calibration period is only 14 months, the model calibration is not tested against longer-term data sets, limiting the robustness of the model. One example of this is the model's inability to reproduce the observed decrease in PCB concentrations across Woods Pond at low flows.

2.4 APPLICATION OF THE MODEL FOR EVALUATION OF REMEDIAL ALTERNATIVES

Ultimately, this model will be used by GE to evaluate remedial alternatives for the Rest of River during the Corrective Measures Study. As documented in the MCR, issues with the length of simulation times and the spatial resolution of the model need to be resolved prior to its application in the CMS.

2.4.1 Simulation Time is Intractable for Long-Term Projections

MCR Charge References:

- ***Question 6 (model's ability to be used to predict future conditions)***

Section B.5.2 of the MCR (Appendix B) provides a discussion of the model's computational time. Currently, the 14-month calibration period (which includes the 60-day model spin up) requires 40 hours of computation time to complete (information on the computer speed and platform for which this benchmark was based in not provided in the MCR). Assessment of remedial alternatives in the CMS will be based on long-term simulations with this model that project PCB concentrations several decades into the future. Based on the model simulation time cited in the MCR (i.e., 40 hours for 1.33 years), it appears that it will take 50 to 90 days of computation time to complete a <u>single</u> long-term simulation of PCB fate that projects 40 to70 years into the future. Simulation times of this duration will not be tractable given the

180-day CMS schedule set forth in the Consent Decree (i.e., the time allotted between EPA approval of the CMS Proposal and the required delivery of the CMS Report).

One of the alternatives EPA discusses for improving the computational efficiency of EFDC in the MCR (Appendix B, Section B.5.2) is decreasing the number of simulated layers in the sediment bed. However, because the total bed thickness (24 inches) may not be large enough for the model to properly capture sediment dynamics over long time scales and because the current number of bed layers (5) limits the model's ability to resolve PCB concentrations at the proper vertical resolution (see Section 2.1.4), it is unlikely that this strategy will be feasible without compromising the model's predictive ability. Other options for improving model simulation times are introduced by EPA; however, without documentation of model testing, it is not clear whether these approaches will allow simulation times to be reduced by the substantial amount necessary to improve the model's utility for the CMS.

The model's simulation time is unacceptably long. Evaluating remedial alternatives through long-term projections with the model cannot be completed in an efficient manner.

2.4.2 Scale at Which the Model is Accurate

MCR Charge Reference:

- ***Question 1 (sufficiency of model-data comparisons)***
- ***Question 5 (uncertainty in mode-data comparisons)***

Because the EFDC model will be used to evaluate remedial alternatives in the CMS, it is appropriate for the MCR to provide analyses and a discussion of the scale at which the model can accurately resolve the important sediment transport and PCB fate processes. That is, if the model is to be used to help identify areas for potential remediation, what is the spatial scale of the "remedial unit"? This scale is smaller than the entire PSA and larger than an individual grid cell, and should be defined based on the insights gained by EPA during model development and calibration and careful consideration of factors that control the model's scale of accuracy, such as:

- the spatial resolution of the model inputs (e.g., PCB concentrations and bulk bed properties were averaged over spatial bins – is the model sufficiently accurate at the scale of a single bin?);
- the variability of the data used to define model inputs and calibrate the model (e.g., data presented in MCR Figure B.1-2 indicates substantial small-scale variability in sediment PCB concentrations – over what spatial scale are PCBs sufficiently defined to resolve differences in concentrations?); and
- the scale at which the data themselves can be used to differentiate areas for remediation (e.g., high versus low PCB concentration, high versus low current velocity, high versus low sediment erosion).

Because the model will be used to evaluate remedial options, the MCR should include analysis and discussion of the spatial scale at which the model can be used to accurately resolve the major sediment transport and PCB fate processes.

2.5 MODEL SENSITIVITY AND UNCERTAINTY

Charge Question 4 relates to whether the model's sensitivity and uncertainty have been properly evaluated. Based on GE's review of the MCR, it appears that the sensitivity analysis for the sediment transport model may not have been properly focused. Furthermore, as presented in the MCR, it appears that the uncertainty of the model was not evaluated, with the exception of the bioaccumulation model, for which the Monte Carlo analyses presented were not properly conducted.

2.5.1 Sediment Transport Model Sensitivity

MCR Charge Reference:

- ***Question 4 (adequacy of methodologies to evaluate model sensitivity and uncertainties)***

A sensitivity analysis for the sediment transport model was conducted by varying six model parameters or inputs by ± 50% of the calibration simulation values: four parameters affecting cohesive sediment transport; particle diameters of three non-cohesive sediment classes; and incoming sediment loads. Sensitivity simulations were conducted for two periods: 1) low-flow period, August 3-8, 1999; and 2) high-flow period, June 6-11, 2000. Generally, the model displayed relatively low sensitivity to the cohesive transport parameters and non-cohesive particle diameters. As might be expected, the model was relatively sensitive to variations in sediment loads.

More insights about model sensitivity would have been achieved by increasing the scope of the analysis as follows. First, the simulations should be conducted for the entire 14-month calibration period. This approach would allow for a more thorough evaluation of model response to variations in parameters and inputs. Of particular importance is examining the impacts on: 1) bed elevation change; and 2) sediment mass balances. Second, an analysis should be conducted of the model's sensitivity to the composition of incoming sediment loads from the East and West Branches. The MCR estimates the composition of these incoming loads using the upstream models. This approach introduces uncertainty into the model. Sediment transport modeling experience from other river systems (e.g., QEA 1999) shows that model results are often sensitive to the composition of upstream and tributary sediment loads. Since it is thus highly likely that the sediment transport model is sensitive to the composition of sediment loads from upstream sources, this parameter should be added to the sensitivity analysis.

The sensitivity of the sediment transport model should be evaluated over the full calibration period, and its sensitivity to the composition of incoming sediment loads from the East and West Branches needs to be evaluated.

2.5.2 Inadequate Uncertainty Analyses

MCR Charge Reference:

- ***Question 4 (adequacy of methodologies to evaluate model sensitivity and uncertainties)***

Uncertainty analysis was not conducted during the model calibration phase for either the watershed model (i.e., HSPF) or for the various components of EFDC (i.e., hydrodynamics, sediment transport, chemical fate models). According to the MCR, uncertainty analysis for these models will be performed during validation. However, an extensive Monte Carlo based uncertainly analysis was conducted for the FCM. In addition, FCM predictions based on data-driven and EFDC-Fate predicted exposure concentrations were compared. Because uncertainty in the PCB fate and transport model has not been addressed in the MCR, the uncertainty of the FCM is not fully developed because the uncertainty of EFDC-predicted exposures has not been quantified.

The uncertainties of each of the linked models should be presented and discussed relative to one another; this should include an assessment of how uncertainties in HSPF and the EFDC sub-models translate into uncertainty in FCM-predicted fish tissue concentrations.

2.5.3 Bioaccumulation Model Monte Carlo Analysis

MCR Charge Reference:

- ***Question 4 (adequacy of methodologies to evaluate model sensitivity and uncertainties)***

The Monte Carlo (MC) analysis for the bioaccumulation model as presented in the report must be interpreted with care. Estimation of the parameters' underlying distributions is only semi-quantitative. The distributions assigned to the FCM parameters in the report do not include potential correlations among variables, which can affect the resulting distributions of predicted PCB concentrations in fish. In addition, comparisons of extremes in the MC analysis with extreme values of PCBs in individual organisms are not valid because the extremes of the MC analysis describe uncertainty in the central tendency, while extremes in the data are due largely to variability among individuals. Therefore, the comparison is inappropriate.

The Monte Carlo uncertainty analysis for the FCM needs to be interpreted with caution because the distributions assigned to input parameters are semi-quantitative and comparisons made between output distributions and the data are inappropriate.

SECTION 3
SPECIFIC COMMENTS

In addition to the major comments presented in Section 2, GE would like to offer additional specific comments, which are organized according to the various sub-models within EPA's framework.

3.1 HYDRODYNAMIC MODEL

The following specific comments pertain to the hydrodynamic portion of the model report:

- Sensitivity Analyses: Sensitivity of the hydrodynamic model was investigated for the following parameters and inputs: channel roughness, floodplain vegetation, and boundary flows (upstream, tributary and direct runoff). The values for these parameters were varied by ± 50% from the values used during the calibration simulation. This analysis was conducted for the 14-month simulation period, with comparisons of water depth (stage height) and flow rate at Woods Pond Footbridge and New Lenox Road. The present sensitivity analysis should be expanded to provide more information on the sensitivity of the model. First, current velocity should be added to the variables used to evaluate model response. Second, impacts at a location upstream of New Lenox Road need to be investigated, either at Holmes Road or at the confluence of the East and West Branches.

- Model Coupling: In the revised MFD, EPA explained that a desirable characteristic of the hydrodynamic model is its ability to be decoupled from the sediment transport model, because "*this reduces the computational overhead when sediment transport simulations are to be performed for a predetermined hydrodynamic transport field*" (Weston 2004b, Page 5-25). This common modeling practice can effectively improve computational efficiency when bed elevation changes are small relative to the total water depth. EPA's model framework as documented in the MCR does not have this capability, as sediment transport and hydrodynamic model calculations are coupled. EPA should modify the framework to include this feature or, at a minimum, should perform testing to demonstrate that this coupling is necessary.

3.2 SEDIMENT TRANSPORT MODEL

The following specific comments pertain to the sediment transport portion of the model report:

- Composition of Tributary Solids Loads: No discussion is provided regarding the method used to specify the composition of sediment loads from tributaries, other than the East and West Branch. Additional information needs to be provided on the method used to determine tributary load composition.

- Model-Predicted Deposition/Erosion Patterns: Predicted rates of bed elevation change for the 14-month calibration period are presented in Figure 4-29 of the MCR. An examination of this spatial distribution indicates several areas that may be problematic during the long-term validation simulations. Potential problems may exist at locations where relatively large erosion is immediately upstream of relatively large deposition – i.e., where a deep hole is dug and the eroded material creates a hill downstream. For example, this “hole-hill” pattern appears near River Miles 134.1, 133.2, 131.2 and 130.9 (MCR Figure 4-29). An examination of bed properties and the shear-stress regime within these “hole-hill” areas should be conducted to determine if localized adjustments to channel geometry or specification of bed properties are warranted.

3.3 PCB FATE MODEL

The following specific comment pertains to the PCB fate portion of the model report:

- Diffusive Mass Transfer Coefficient: On page 5-33 of the MCR, EPA states that primary calibration parameter for the PCB fate model was the low flow diffusive mass transfer coefficient (K_f). Data analyses indicating the order of magnitude of K_f are presented in Appendix B (MCR Appendix B, Page B.4-35 and Figure B.4-30). However, the value of K_f used in the final calibration is not stated in the MCR, nor is it compared for consistency with K_f values used in models of PCB fate and transport in other river systems.

3.4 BIOACCUMULATION MODEL

The following specific comment pertains to the bioaccumulation portion of the model report:

- Appendix C, Page C.2-30: It appears that EPA modified the FCM code to preclude fish growth during winter months when temperatures fall below 10C. Growth rates are controlled through model inputs, specifically day-weight-lipid inputs (Section E.5 of fdchain.inp, as described in the MFD, Appendix D). To reproduce the observed temperature-dependent wintertime stasis in fish growth, there was no need to modify the FCM code, if indeed this was done, because the model input files can be configured to produce this effect.

SECTION 4
REFERENCES

Blasland, Bouck, and Lee, Inc. and Quantitative Environmental Analysis, LLC, 2003. *Housatonic River, Rest of River, RCRA Facility Investigation*. Prepared on behalf of the General Electric Company, Pittsfield, MA. September 2003.

Ford, J.B., 1962. The vertical distribution of larval chironomidae (dipt.) in the mud of a stream. *Hydrobiologia* 19:262-272.

Ikeda, S., G. Parker and K. Sawai, 1981. Bend theory of river bends, 1: linear development. *J. Fluid Mechanics* 112:363-377.

Krezoski, J.R., S.C. Mozley, and J.A. Robbins, 1978. Influence of benthic macroinvertebrates on mixing of profundal sediments in southeastern Lake Huron. *Limnology and Oceanography* 23:1011-1016.

Millbrink, G., 1973. *On the vertical distribution of oligochaetes in lake sediments*. Inst. of Freshwater Biology, Fishery Board of Sweden, Report No. 53.

Quantitative Environmental Analysis, LLC, 1999. *PCBs in the Upper Hudson River, Volume 2, A Model of PCB Fate, Transport and Bioaccumulation.* Prepared for General Electric Company, May 1999.

Thibodeaux, L.J. and Bierman, V.J., 2003. The bioturbation-driven chemical release process. *Environ. Sci. Technol.* 37(13):252A-258A.

Weston, 2004a. *Model Calibration: Modeling Study of PCB Contamination in the Housatonic River*. Prepared for the U.S. Environmental Protection Agency, Region I, and the U.S. Army Corps of Engineers. December 2004.

Weston, 2004b. *Modeling Framework Design: Modeling Study of PCB Contamination in the Housatonic River*. Prepared for the U.S. Environmental Protection Agency, Region I, and the U.S. Army Corps of Engineers. April 2004.

Weston, 2000a. *Modeling Framework Design, Modeling Study of PCB Contamination in the Housatonic River*. Prepared by R.F. Weston, Inc. and Aqua Terra Consultants for the U.S. Environmental Protection Agency, Region I and U.S. Army Corps of Engineers, New England District. October 2000.

Weston, 2000b. *Quality Assurance Project Plan, Modeling Study of PCB Contamination in the Housatonic River*. Prepared by R.F. Weston, Inc. and Aqua Terra Consultants for the U.S. Environmental Protection Agency, Region I and U.S. Army Corps of Engineers, New England District. October 2000.