Wilbert Lick Questions

This first set of questions is about the sediment-water flux of PCB. The questions are more-or-less related. I have only read through section 4 so that some of the questions may be answered later in the report.

1. Table 4.1-2. Mixing rates are in units of 10^{-9} m/s. Is this a mass transfer coefficient (m/s) or should the units be 10^{-9} m^2/s (a particle mixing or diffusion coefficient)? On p. 4-14, line 12, reference is made to a mixing coefficient of 10^{-9} m^2/s.

<u>EPA Response</u>: The reference to 10^{-9} m^2 s^{-1} on line 12 of page 4-14 is described correctly in the text as the value used for the mixing coefficient in the Phase 1 Calibration modeling (with units of length squared per time [L^2 T^{-1}] applied to the initial layer thicknesses of 7 and 8.24 cm). However, as indicated in the Phase 1 Calibration Report, it was recognized that the sediment mixing process would need to be further evaluated for the longer-term modeling.

More detailed analyses (described on pages 4-14 through 4-16) were conducted as part of the Phase 2 Calibration efforts, and a different approach was adopted to better use the site-specific taxonomic data. The subduction velocities (summarized in Table 4.1-2 of the Validation Report, in units of length per time (L T^{-1}), were calculated using the equation presented on page 4-15, lines 3 and 4 of the report (Gschwend, 1987). These values were derived using site-specific benthic taxonomic data and taxonomic group-specific reworking rates (in units of grams of sediment per individual per day) obtained from the literature.

2. p. 4-14, line 16. "Evaluation of mixing rates (subduction velocities)…." Is it mixing rates or subduction velocities? They're not the same by the usual definitions.

<u>EPA Response</u>: The term mixing rate was used in a generic context in the report (as the reviewer notes in the above quote and as was indicated parenthetically on page 4-15, line 19). In the Phase 2 Calibration and Validation modeling, PCB transport by sediment mixing was described using the subduction velocities calculated from site-specific benthic biomass and taxonomic-based reworking rates. In Phase 1 Calibration, the process was described using a mixing coefficient (as discussed above).

3. If it's a particle mixing coefficient or whatever, what is it used for? The assumption in the analysis is that the mixed layer is "thoroughly mixed", which I assume means completely and instantaneously mixed (an infinite diffusion coefficient).

<u>EPA Response</u>: The Reviewer is correct that each sediment layer in a grid cell is a completely mixed volume. The subduction velocity was applied to the interface between sediment layers.

4. p 4-14, line 23. "Based on abundances and biomass density, the …." Where is the data for this statement and all statements about this subject? Not the raw data, but at least some summary.

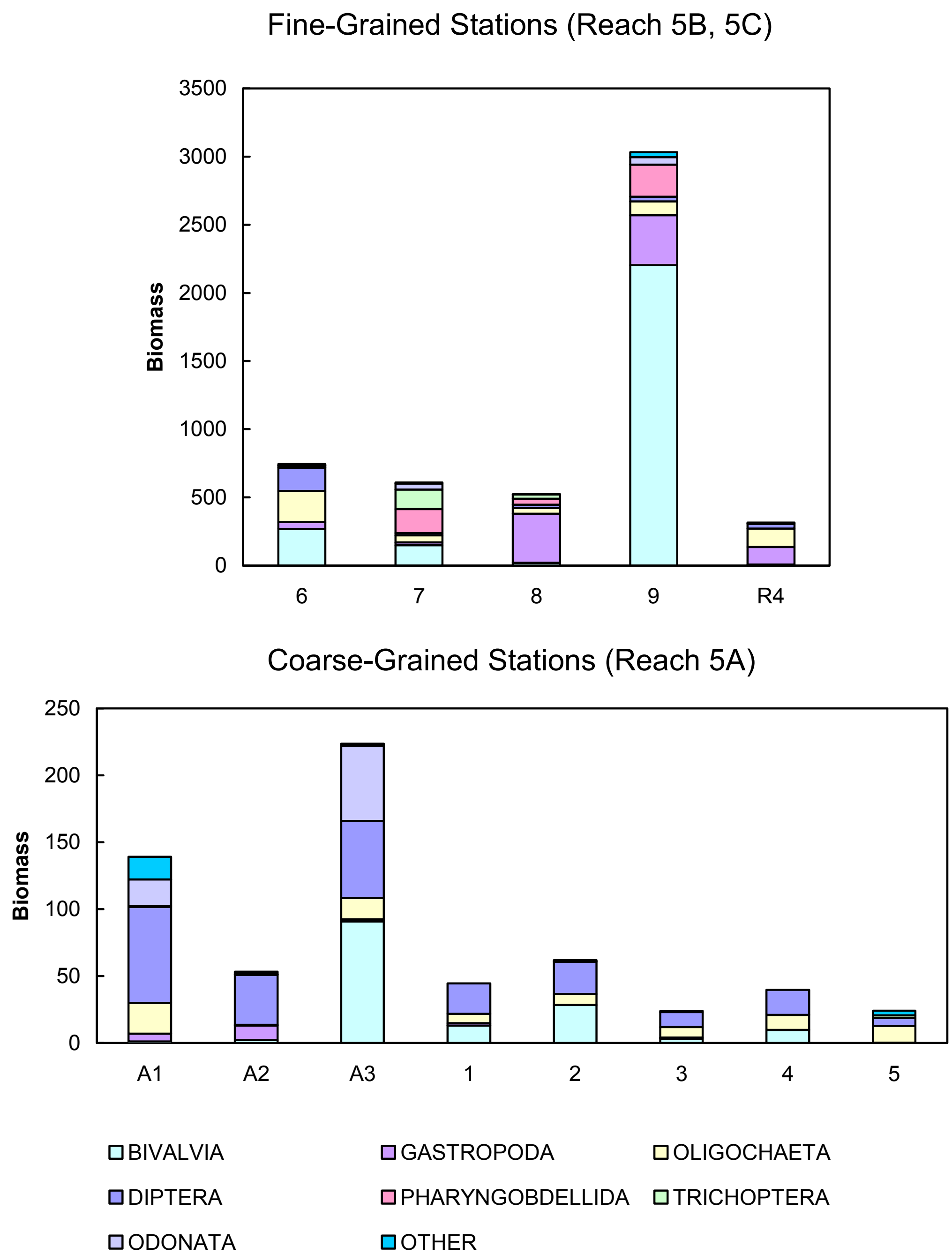
EPA Response: Data on invertebrate biomass and abundance in the Housatonic River PSA are discussed in detail in the following documents:

- Model Calibration Report – Appendix C (Bioaccumulation Model Calibration); Attachment C.11 (Invertebrate Feeding Preferences)
- Model Calibration Report Peer Review Responsiveness Summary – Attachment 1 (Freshwater Bioturbation Depth); Section 3.2 (Site-Specific Biological Communities)
- Ecological Risk Assessment - Appendix D (Benthic Invertebrates); Section D.2.2.2 and Section D.3.7

The first two documents were provided previously to the Peer Review Panel, and all are available at http://www.epa.gov/Region1/ge/thesite/restofriver-reports.html. In summary, the site-specific invertebrate data were obtained from two principal sources:

- EPA macroinvertebrate community sampling conducted in 1999 (WESTON, 2004) – At each of 13 locations (12 in the Housatonic River and 1 in Threemile Pond), EPA collected 12 replicate benthic community samples using a Petite Ponar sampler. Five of these locations were in Reach 5A, in the relatively coarse-grained substrate upstream of the Pittsfield wastewater treatment plant (WWTP). Four were located in the finer (silty) substrate between the WWTP and Woods Pond (i.e., Reaches 5B and 5C), and the remaining four stations were reference locations outside the PSA. The sediment samples were representative of the general substrate types found throughout the PSA.
- Chadwick and Associates' assessment of Housatonic River aquatic ecology conducted in 1993 – Chadwick (1994) sampled 10 stations in the Housatonic River, three of which were located in the PSA. Station HR1 was located at a "shallow water" site in the northern half of the PSA, near the confluence with Sykes Brook. Stations HR2 and WP1 were located in the southern (low gradient, depositional) portion of the PSA at "deep water" locations.

The EPA sampling program measured both abundance and biomass of invertebrates. Attachment C.11 of the Model Calibration Report details the feeding strategies of invertebrates observed in both sampling programs. This biological information was used in the development of biological mixing depths and velocities for each reach of the PSA. The following figure summarizes the invertebrate biomass in each of the coarse-grained (i.e., Reach 5A) and fine-grained (i.e., Reaches 5B and 5C) habitats found within the PSA.



Biomass (g) of Benthic Invertebrates Measured in Grab Samples, with Subdivision into Major Taxonomic Groups, for Fine- and Coarse-Grained Sediment

5. p. 4-15, line 24. "Mixing rates applied across the interface between sediment layers are summarized in Table 4.1-2." Mixing rates in Table 4.1-2 are listed for each layer. How does this apply to mixing rates between layers?

EPA Response: The vertical profiles of subduction velocities at the interface between bed layers relative to the sediment-water interface were maintained temporally constant. However, simulated erosion and deposition result in changes in the depth of the interface between sediment layers from the bed surface. As the simulation progresses, the subduction velocity at the interface between two sediment layers is assigned based on the depth (at that time step) of the interface summarized in Table 4.1-2 as the maximum depth for that subduction velocity. For example in Reach 5A, if Layer 1 completely erodes and Layer 2 (which then becomes Layer 1) is 3-cm thick, the subduction velocity assigned for the interface between Layer 1 and 2 is the value assigned to the 0-4 cm interval, since the Layer 1-Layer 2 interface is in the 0-4 cm depth interval .

6. What is the value of the mass transfer coefficient for the flux of PCB between the sediment and overlying water? Previously you had given a value of 1.5 cm/day. Is this still the value used? Does it (or should it) vary over the length of the river? Should it depend on the numbers and types of organisms? How is this number related to the mixing rate (subduction velocity)?

EPA Response: The value of the sediment-water mass transfer coefficient used in the Phase 2 Calibration and Validation modeling was not changed from the value of 1.5 cm/d used in the Phase 1 Calibration. The value was not varied spatially or temporally. As described in the Calibration Report, the mass transfer coefficient, K_f, is used as a lumped parameter that accounts for several processes, including the effect of bio-irrigation, bioturbation, advection, and diffusion. The site specific data did not indicate a spatial vaiation of in K_f. As part of the Phase 1 Calibration, an analysis was performed (see pages B.4-32 to B.4-35 and Figure B.4-30 of the Calibration Report) to determine if temporal variations in K_f that could potentially be related to temperature or biota activity were observed in the site-specific data. The assessment did not indicate seasonal variations, which suggests that temperature-influenced biota activity is not the dominant factor contributing to the water-sediment flux, and therefore the value of K_f was not varied as a function of the numbers or types of organisms.

Note also that the mass transfer coefficient, K_f, is used to calculate transport of dissolved PCBs between sediment and water, while the sediment subduction velocities summarized in Table 4.1-2 affect transport of sorbed PCBs between sediment layers.

Doug Endicott Questions

Example Model Simulations: Can more simulation results be provided? For example, EFDC predictions of TSS, and water column and sediment PCB concentrations as functions of time and river location. Same request regarding food chain model predictions?

EPA Response: Additional discussion will be provided at the Document Overview Meeting.

Revised Upstream Boundary PCB Loading/rating Curve: Are the discontinuities in the log-log relationships between boundary PCBs and flow simply empirical fits of the data, or is there some rationale (i.e. conceptual model) to support this treatment? Why do you believe that particulate PCB concentrations did not exceed 25 ppm? There seem to be higher concentrations both within and above the PSA?

EPA Response: The discontinuities in the log-log relationships between East Branch boundary PCB concentrations and river flow are consistent with the Conceptual Model, recognizing that runoff can initially result in a dilution of sorbed PCB concentrations as suspended solids are carried into the river. However, as flow increases and resuspension of contaminated sediment occurs, the additional source of PCBs can more than offset the dilution of solids entering the river with the runoff flow. Although there is considerable variability in the East Branch water column PCB concentrations, the data support this concept.

The constraint on the maximum sorbed PCB concentration at high flow conditions was based on site-specific data collected in February 1998 and June 2000 from Reach 4 riverbanks, terraces and floodplain following high flow events. PCB concentrations in the freshly deposited sediment were approximated by a log-normal distribution (Figure DE-2) with an arithmetic mean of 23.3 mg/kg. This mean was rounded to the value of 25 mg/kg used in the development of the boundary PCB estimates. It is recognized that concentrations during high-flow conditions vary above and below this value, however, the mean values was used rather than attempt to incorporate variability based on the data. Although PCB concentrations have been measured historically in floodplain soil on the residential properties in the lower end of Reach 4, these data discussed above were believed to best represent the concentrations transported at high flow during the Calibration and Validation time periods.

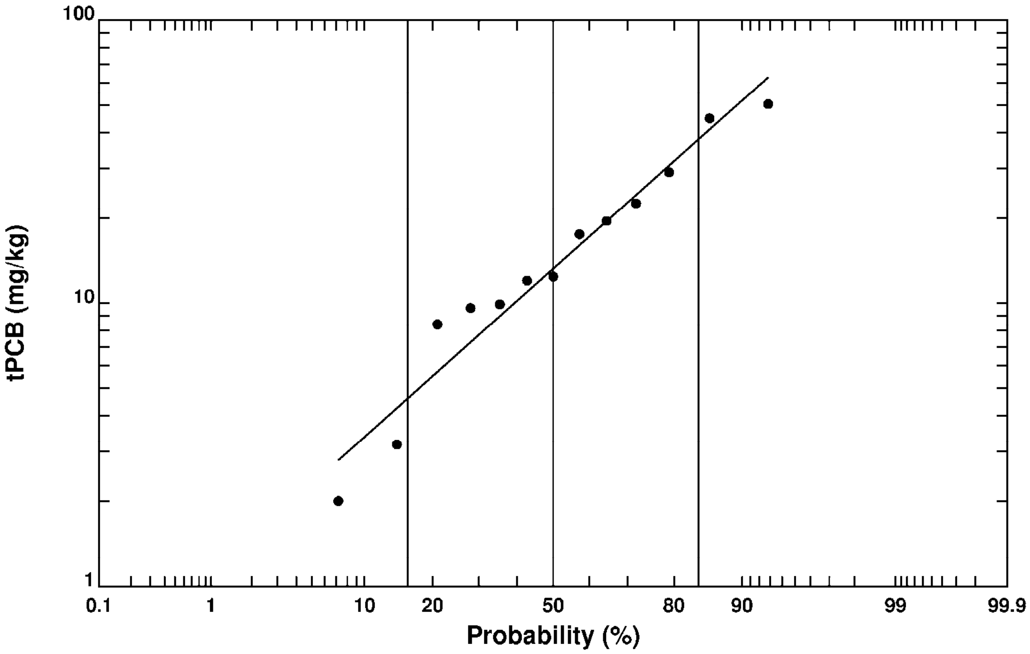


Figure DE-2. Probability Distribution of tPCB Concentrations Measured in Recent Sediment Deposits on Riverbanks, Terraces, and Floodplain in Reach 4

Bank Erosion: Could you provide more information to help us understand how solids and PCB loads from bank erosion vary as a functions of river flow? Maybe this could be done in the same manner that bed load is represented in Figure 4.2-63, Figures 6.2-15 thru –18, and Figure 6.2-39?

<u>EPA Response</u>: Additional information will be provided at the Document Overview Meeting.

Initial PCB Conditions and Rate of Sediment Decline: I think you initialized PCB sediment concentrations by using the model's predicted rate of decline to extrapolate the1999 data backwards in time. Did you check whether the model predicted the <u>same</u> rates of decline, after doing this extrapolating of initial conditions?

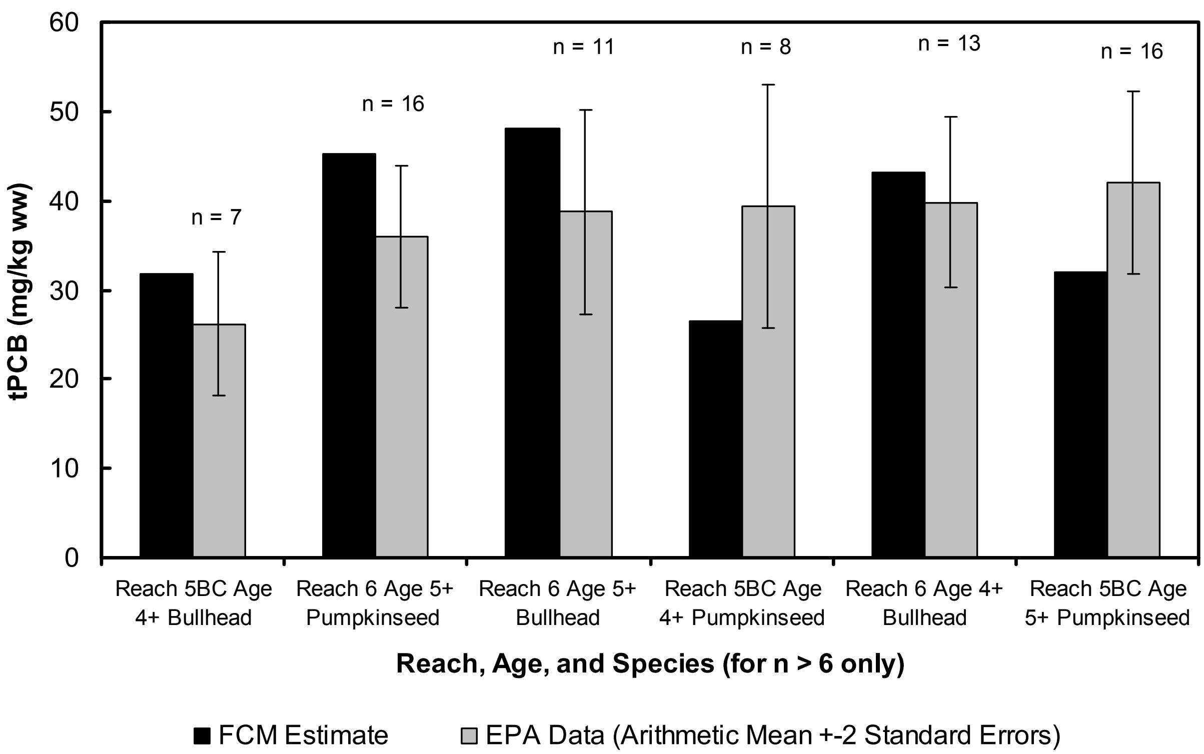
<u>EPA Response</u>: Additional information will be provided at the Document Overview Meeting.

Low-Concentration Bias in TSS and PCBs: Is it safe to ignore or discount the bias in model predictions under low-flow conditions? Is there some way that information could be used to improve the model?

<u>EPA Response</u>: Additional information will be provided at the Document Overview Meeting.

Food Chain Model Calibration: In Figure 4.3-7, you use the sample standard deviation to represent the variability in measured PCB concentrations. Why didn't you use the 95% confidence limits (or ± 2 standard errors), since this better quantifies the measurement precision?

<u>EPA Response</u>: EPA agrees that use of two standard errors better describes measurement precision. The figure provided below displays mean concentrations plus or minus two standard errors, as recommended by the Reviewer. The qualitative conclusion from this analysis does not change from that based on the figure provided in the report using the standard deviation. Of the six comparisons (of species/age combinations), five result in means of field data within two standard errors of the FCM model simulation. Irrespective of the choice of metric for precision, the model objective was not to test a null hypothesis that the model simulations were strictly equal to the means of the data, but rather to ensure that the effect sizes of any differences were acceptably small. The figure confirms that this is the case.



Uncertainty (RSM Model): Can you define the variables used in Table 5.2-8?

<u>EPA Response:</u> Refer to attachment labeled UncertiantyVariable_Table.doc.

FCM Uncertainty: Would it be appropriate to include parameter correlations in the uncertainty analysis? In my own experience, this can significantly reduce the dispersion of the Monte Carlo output distributions, which you indicate is in some cases (e.g. largemouth bass) excessively large?

EPA Response: Parameter correlations were included in the FCM uncertainty analysis, but only for a subset of the parameters where a correlation was known to exist and could also be reliably quantified.

The distributions for the EFDC linkage (tPCB exposure) parameters in sediment and water column were correlated in the Uncertainty Analysis. Correlations were based on Spearman rank correlations calculated using the 52 EFDC uncertainty iterations. The strongest correlations were observed for upstream reaches (i.e., Reach 5A rank correlation of -0.601). Incorporation of the intercorrelations between simulated PCBs on surface sediment and suspended solids was warranted because it reflected the correlations in linkages provided by EFDC, which were appropriately carried through the linked uncertainty model.

The intercorrelations among organism feeding preferences were also included in the FCM uncertainty analysis by incorporating prey-switching behaviors, as described in the Model Calibration Report (Sections C.4.1.1 and C.4.2.1.2). When the amount of any dietary item was adjusted, other dietary items were also adjusted to retain the 100% total of all dietary contributions. The details of this analysis are provided on pages C.4-4 and C.4-5 of the Model Calibration Report (Appendix C).

Other intercorrelations among FCM uncertainty parameters were not specified in the Monte Carlo simulations because: (a) there is no known mechanism by which the parameters would be related (e.g., the PCB K_{OW} value does not affect organism bioenergetics), or (b) a mechanism may exist but could not be reliably quantified. For example, it is possible that invertebrate respiration rates may be related in a complex manner to invertebrate growth rates, since both are linked to whole organism bioenergetics; however, there are insufficient data to quantify this relationship.

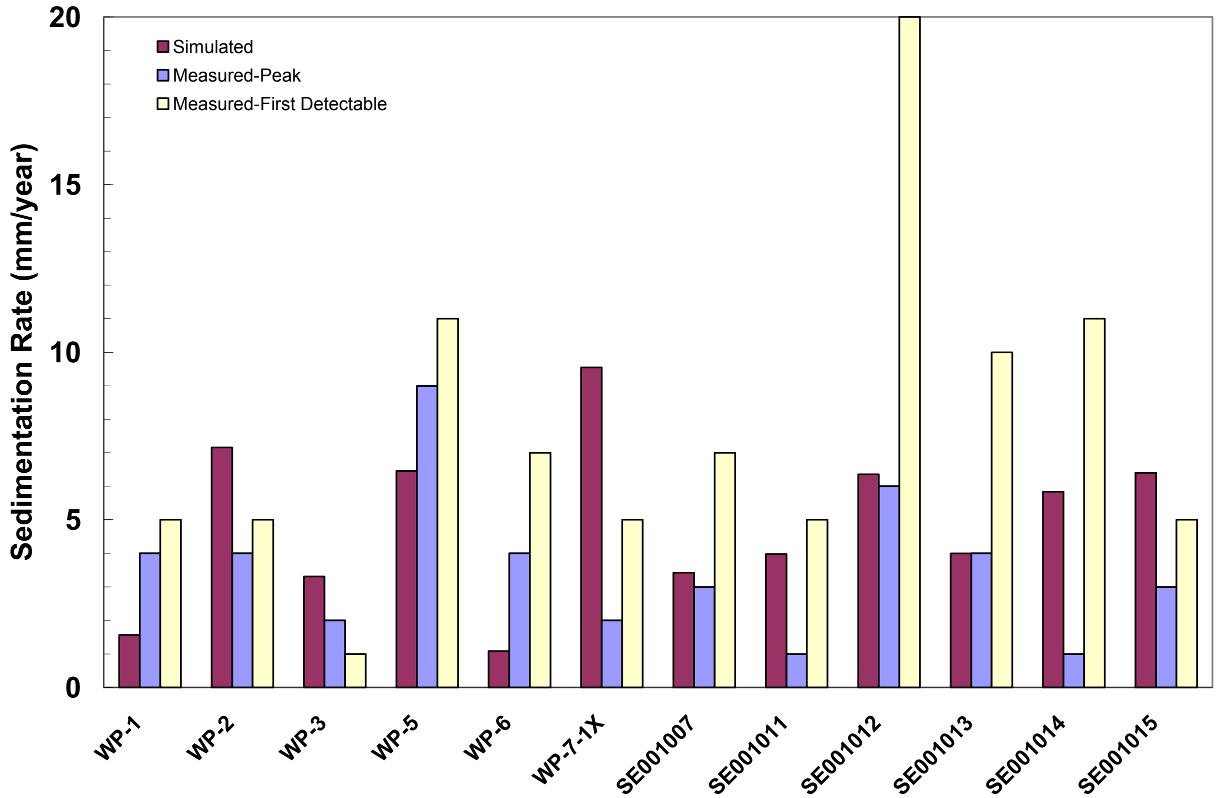
EPA did not characterize the dispersion of Monte Carlo output distributions as being "excessively large" for largemouth bass or any other species. On page 5-55, EPA referenced the wide ranges of empirical distribution functions observed. However, the discussion of these ranges was in the context of the very low probabilities of these events, in which numerous parameters were sampled in the extreme tails of the distribution. Because 5000 model iterations were performed, such extreme outcomes are bound to occur due to chance (i.e., the greater the number of random draws, the greater the likelihood of sampling simultaneous extreme values). These extreme results do not comprise a signification portion of the resulting probability density function. As shown in Table 5.2-14, the 10th and 90th percentiles of the output distribution are much closer together than the full range of values. For example, using the EDF and considering Woods Pond adult largemouth bass, the output range was 10 to 501 mg/kg tPCB ww, but the 10th and 90th percentiles were 34.6 and 162.9 mg/kg tPCB ww, respectively.

EFDC Validation: It was disappointing to see how little use was made of the bed elevation change data in the EFDC sediment transport validation (pages 6-52 thru 6-54). You offered the rationale that much of the observed net erosion or deposition was subgrid-scale phenomena. Unfortunately, this means that one of the most direct measurements of sediment transport dynamics cannot be used to test the model. Had you known of this outcome in advance, would you have made different decisions regarding model grid resolution?

EPA Response: No, the decision on the grid resolution (discussed in detail in the Calibration Report and Responsiveness Summary) was made with consideration of a number of factors, not just the resolution of the erosion and deposition observed in the river. In fact, is was well understood at the earliest stages of the modeling study that in many locations these processes occur at a spatial scale far smaller than that at which even the most simple model could reasonably be discretized, and also occur due to mechanistic reasons not incorporated in models (consider the effect of woody debris in Reaches 5A and 5B as an example of both). EPA believes that a grid with the resolution that could potentially capture some of the fine-scale variations in bed form is not necessary to achieve the overall goal of the modeling study which is to evaluate baseline conditions and potential remedial alternatives.

Woods Pond Sedimentation Rate Data vs. Predicted Accumulation: This comparison (page 6-54 and Figure 6.2-34) also seems to undervalue the data. There are many EFDC grid cells in Woods Pond, and a significant number of dated sediment cores. Yet, the only comparison being presented is in terms of pond-wide average sedimentation rate. Does Figure 6.2-34 show that EFDC does a good job of reproducing the pattern of sedimentation rates? What would an x-y plot of predicted vs. measured sedimentation rates at the coring locations look like? If EFDC is not doing a good job, why not? Is this another subgrid-scale phenomena?

EPA Response: Alternate comparisons of simulated and “measured” sedimentation rates are provided on the following figures.


20
15
10
5
0
Sedimentation Rate (mm/year)
Simulated
Measured-Peak
Measured-First Detectable
WP-1
WP-2
WP-3
WP-5
WP-6
WP-7-1X
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SE001011
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SE001013
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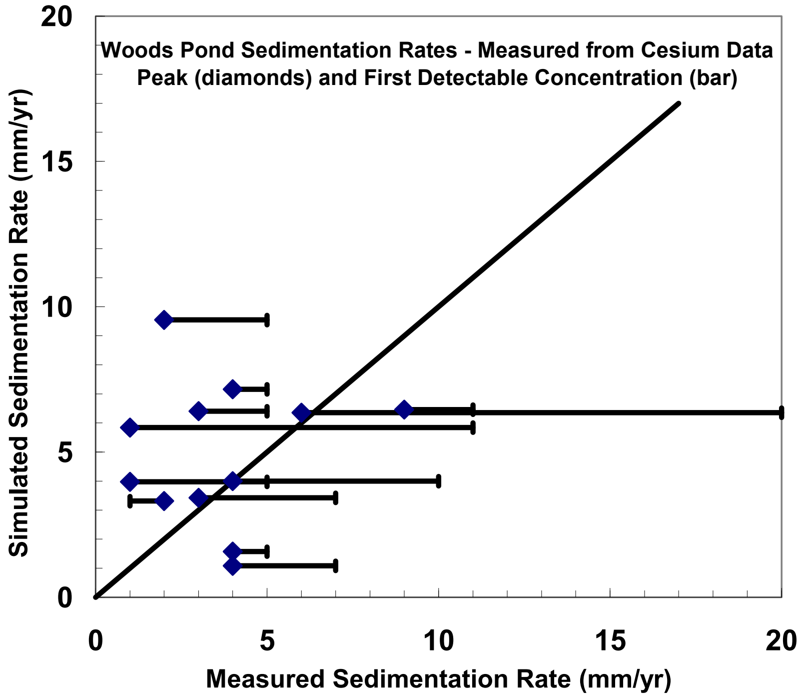
SE001015



Censoring of Low-Flow TSS and PCB Data:

Bounding Analysis (p. 6-87): I think this could be very helpful for our understanding of how the models link to one another, but some further information is needed. Please show the specific results of the bounding analysis that are summarized here, including the sensitivity of individual fish species to zeroing the water column PCB concentrations. Also, is this a result based upon modeling the entire validation period, or just a selected time interval?

EPA Response: More detailed results of this bounding analysis are presented below. Cyprinids, sunfish, and bass were the species most sensitive to the effects of low water column exposures. Bass tissue PCB concentrations in Woods Pond are reduced by 11% when the linkage data set is truncated at 0.06 µg/L. Bottom fish exhibited very low sensitivity to the statistical treatment of low tPCB concentrations observed during low flow conditions.

Overall (Averaged Across Species and Reach)

	All Reaches
Average Percent Difference	**-4.82%**

By Reach

	Reach 5A	Reach 5B	Reach 5C	Woods Pond
Average Percent Difference	**-6.61%**	**-1.10%**	**-6.50%**	**-5.07%**

By Species

	White Sucker	Bullhead	Cyprinids	Sunfish	Bass
Average Percent Difference	**-1.28%**	**-1.21%**	**-6.90%**	**-7.07%**	**-7.60%**

By Species and Reach

		White Sucker	Bullhead	Cyprinids	Sunfish	Bass
Average Percent Difference	Reach 5A	**-1.7%**	**-1.7%**	**-8.8%**	**-11.5%**	**-9.8%**
	Reach 5B	**-0.5%**	**-0.4%**	**-1.6%**	**-1.7%**	**-1.5%**
	Reach 5C	**-1.7%**	**-1.6%**	**-8.9%**	**-8.7%**	**-11.0%**
	Woods Pond	**-1.3%**	**-1.1%**	**-8.3%**	**-6.4%**	**-8.2%**

Regarding the mechanics of the bounding analysis calculations:

- To simulate exposure via surface sediment, FCM was run with sediment (and associated freely dissolved pore water) tPCB concentrations provided from the EFDC linked validation.

- To simulate exposures via the water column, the model was run with two different scenarios of POM (and freely dissolved in the water column) tPCB concentrations.

- The two scenarios run were "baseline" and "trimmed"; in the latter, water column exposures were set to zero for any concentrations below 0.06 µg/L tPCB in the water column. The trimmed analysis therefore represents an extreme bounding case that is likely to understate actual tPCB concentrations.

- The entire validation time period up to October 1, 1998 was simulated (i.e., model results were linked from the beginning of 1979 through October 1, 1998, when the percent difference statistics were calculated).

- Differences between trimmed and baseline results were evaluated on October 1, 1998, an important date for FCM as it is the most temporally representative date for our combined calibration and validation data set (in terms of representing potential seasonal bioaccumulation responses). The vast majority of samples were collected in late September or early October. Therefore, although the bounding analysis represents a selected time interval, it has broad relevance to the majority of the data evaluated during validation.

- Average percent difference between trimmed and baseline scenarios were calculated for all relevant species and age-classes and then summarized on a reach and species basis.

- Because the bounding analysis produced results that are lower than the baseline analysis, the percent difference calculated using the following equation resulted in negative numbers:

$$\frac{\left(Result_{Trimmed} - Result_{Baseline}\right)}{Result_{Baseline}}$$

John List Questions

Could we have Figure 2-2 with confidence limits imposed on the bar graphs?

<u>EPA Response</u>: The mean PCB loads presented on Figure 2-2 represent the results of data analyses (not EFDC model results), which involve estimation of flows, when PCB concentration data were available, and estimation of flows and PCB loads/concentrations during periods when neither flow nor PCB data were available. Therefore calculation of confidence limits for these mean loads is not a straightforward exercise. For each location, estimates of hourly flows were generated based on multiple non-linear regression analyses of hourly flow data from the USGS flow gage at Coltsville and intermittent location-specific flow data. The estimated time series of river flow for each location, therefore, includes a prediction uncertainty associated with the non-linear multiple regression flow analyses, which were performed separately for the steady, rising, and falling portions of the hydrograph.

Based on predictions of river flow at the time of PCB measurements and available PCB concentration data, "measured" PCB loads were calculated and multiple non-linear regression equations were developed to predict PCB loads separately for the steady, rising, and falling portions of the hydrograph. Predicted PCB loads, therefore, include some uncertainty associated with the flow estimation and the prediction uncertainty associated with the multiple non-linear regressions developed to estimate hourly PCB loads as a function of river flow conditions.
If the uncertainty associated with regression equations is not included, the confidence interval of the mean predicted loads would be quite small, because the means are based on over 130,000 hourly predictions during the 15-year period included in the analysis. It is assumed that the Reviewer is interested in the confidence interval that includes the uncertainty in the underlying

regression equations, which can not be calculated in a straightforward manner because of the use of one set of regression equations (for flows) to generate the load "data" used in the development of the next set of regression equation (for loads). Analytical variability of the PCB concentration data adds another level of uncertainty to the overall analysis.