WHITE PAPER NO. 20 – GREEN BAY MODELING
EVALUATION OF THE EFFECTS OF SEDIMENT PCB BED MAP REVISIONS ON GBTOXE MODEL RESULTS

Response to Comments on the

REMEDIAL INVESTIGATION FOR THE
LOWER FOX RIVER AND GREEN BAY, WISCONSIN,
FEASIBILITY STUDY FOR THE LOWER FOX RIVER AND GREEN BAY, WISCONSIN,
PROPOSED REMEDIAL ACTION PLAN FOR THE
LOWER FOX RIVER AND GREEN BAY, AND
RECORD OF DECISION FOR OPERABLE UNIT 1 AND OPERABLE UNIT 2

This Document has been Prepared by
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ABSTRACT

During the public comment period for the *Final Remedial Investigation for the Lower Fox River and Green Bay, Wisconsin* (RI) (RETEC, 2002a), the *Final Feasibility Study for the Lower Fox River and Green Bay, Wisconsin* (FS) (RETEC, 2002b) and the *Proposed Remedial Action Plan, Lower Fox River and Green Bay* (Proposed Plan) (WDNR and EPA, 2001), several commenters expressed concern about mass and volume estimates for total polychlorinated biphenyls (PCBs) in Operable Unit (OU) 5, Green Bay. The Agencies' original PCB mass estimates were based upon 100-year simulations using a model, GBTOXe (HydroQual, 2001). Since the original model evaluation, new data have been collected and original sediment bed maps revised. With these new data and bed map revisions, the GBTOXe 25-year model simulations were rerun, and results analyzed. These initial condition changes affected the simulations results as follows:

- Lowered the carbon-normalized PCB sediment mass estimates for all three layers (0 to 2, 2 to 4, and 4 to 10 centimeters [cm]) in zones 2, 3A, and 3B with the greatest difference occurring in Zone 2.
- Lowered the estimate for the 0- to 2-cm layer for Zone 4.
- Increased the carbon-normalized PCB sediment mass estimate for the 4- to 10-cm layer for Zone 4.
- Did not appreciably affect the predicted rate of change over time (both simulations show a decrease over time, slowly until year 10, with the rate slowing until year 20, and then with a level steady state).
- Lowered the water column dissolved PCB concentrations estimates appreciably in Zone 2, but less so in Zone 3A.
- While both water column concentration simulations showed a decrease over time, the rate of change differed overall.

Finally, recalibration of the GBTOXe model based on the alternative PCB mass estimates may reduce the differences between water column PCB concentrations computed in the two scenarios.

This white paper is submitted in response to comments as a component of the Responsiveness Summary for OUs 3, 4, and 5 and Responsiveness Summary for OUs 1 and 2 (released in January of 2003).

1 INTRODUCTION

In June 2001, HydroQual completed a series of 100-year simulations of PCB fate and transport in Green Bay as part of the Green Bay Remedial Investigation and Feasibility

Study (RI/FS) conducted by the Wisconsin Department of Natural Resources (WDNR). In that effort, bed maps of various sediment bed properties were developed as part of Task 2F (WDNR, 2000). Those bed maps were used to generate initial conditions for the GBTOXe model. Since the development of the Task 2F bed maps, decisions were made to exclude particular data previously included and additional sediment property data were obtained and incorporated by WDNR into revised bed maps yielding an alternative sediment PCB mass estimate. These alternative PCB bed maps are presented in *White Paper No. 19 – Estimates of PCB Mass, Sediment Volume, and Surface Sediment Concentrations in Operable Unit 5, Green Bay Using an Alternative Approach*. GBTOXe was used to assess the effect of this sediment PCB mass difference in Green Bay. A 25-year GBTOXe simulation has been performed with inputs derived from the revised bed maps, and the results of this simulation have been compared to the results of the original simulation, in which inputs were based on the previous bed maps. Discussions of the method of analysis and results follow.

2 METHODS

WDNR provided HydroQual with the revised bed maps for PCBs and dry bulk density (with concentrations expressed on a mass per volume basis). These bed maps were prepared for sediment depth intervals of 0 to 2, 2 to 4, 4 to 6, 6 to 10, and greater than 10 cm. The upper two (0 to 2, 2 to 4 cm) GBTOXe sediment layers correspond directly to bed map layers, however, GBTOXe sediment layer 3 (4 to 10 cm) encompasses the interval covered by two bed map layers. Therefore, ArcView spatial analyst was used to generate a 4- to 10-cm layer by taking the depth-weighted average of bed map layers 3 and 4 (4 to 6 cm and 6 to 10 cm, respectively). No modifications were performed on the dry bulk density bed maps because they were provided at depth-intervals corresponding to GBTOXe's sediment segment depths. Revised particulate detrital carbon (PDC) bed maps were generated as the product of the original total organic carbon (TOC) grids and revised dry bulk density grids. The sediment PCB mass inventory associated with the revised bed maps is 14,603 kilograms (kg) in contrast to 70,000 kg from the original bed maps.

To generate sediment concentrations for each GBTOXe sediment segment, the PCB, dry bulk density, and PDC bed maps were overlaid on the GBTOXe model grid. ArcView spatial analyst was then used to compute the spatial averages across the GBTOXe cell surface areas. The method for incorporating the alternative sediment PCB mass inventory into the GBTOXe modeling framework was the same as that performed for the RI/FS. The bottom sediment layer depth was adjusted such that the product of all sediment segment volumes and their corresponding PCB concentration (i.e., the initial condition concentrations extracted from the bed maps) summed to the total mass inventory of the bed maps. The bottom sediment layer depth that approximates the alternative mass inventory of 14,603 kg for the entire sediment bed was computed as 3 cm in contrast to 21 cm used for the original RI/FS. PCB loadings were based on the first 25 years of the no-action RI/FS projection run (i.e., no remedial action for either Green Bay or the Lower Fox River).

3 RESULTS

PCB results from both the original RI/FS and alternative mass 25-year scenarios were annually averaged and plotted for comparison. Figures 1 through 3 are comparisons of the annually averaged carbon-normalized PCB concentrations in sediment layers 0 to 2, 2 to 4, and 4 to 10 from both scenarios. These figures show that the carbon-normalized sediment PCB concentrations from the alternative mass scenario are lower in zones 2, 3A, and 3B in all three layers and the 0- to 2-cm layer of Zone 4. By contrast, the Zone 4 concentrations at 2 to 4 cm show no appreciable difference, and at the 4- to 10-cm depth interval, the alternative mass scenario concentrations are higher than concentrations from the original RI/FS scenario. With time, both scenarios show concentrations decreasing slowly until about year 10. After year 10, concentrations decrease more slowly than in the first 10 years and then tend to approach a level state.

Figure 4 presents a comparison of the annually averaged dissolved PCB concentrations from the original RI/FS and alternative mass scenarios for each GBFood zone. The dissolved PCB concentrations from both simulations tend to decrease slowly with time. The concentration profiles from the alternative mass scenario for zones 3A, 3B, and 4 are initially lower by 14 to 17 percent at year 1. With time, the differences increase to over 60 percent by the end of the simulation period, but at lower concentrations. The alternative mass scenario concentrations in Zone 2, however, are initially lower by 40 percent. In contrast to the other zones, the difference tends to remain relatively constant with time, increasing slowly to 60 percent by the end of the simulation period. As a consequence of the alternative sediment PCB mass estimate, concentrations in Zone 2 are more comparable to the concentrations in zones 3A, 3B, and 4 (from either scenario since the concentrations in these zones do not differ much), and yields a more homogeneous distribution of water column PCB concentrations throughout the Bay. The table below presents a summary of the percent reduction in water column dissolved PCB concentration by zone in response to the alternative mass estimate.

TABLE 1 PERCENT REDUCTION OF WATER COLUMN DISSOLVED PCB CONCENTRATIONS (VOLUME BASED) IN RESPONSE TO ALTERNATIVE SEDIMENT PCB MASS ESTIMATE

Zone	Year					
	1	5	10	15	20	25
Zone 2	44.2	56.8	62.3	68.6	68.4	68.9
Zone 3A	17.3	44.1	53.4	58.4	60.2	60.6
Zone 3B	13.4	43.0	53.7	58.9	60.9	61.2
Zone 4	13.7	29.0	33.7	35.2	35.5	33.8

4 DISCUSSION

While the sediment PCB concentrations of the alternative mass scenario tend to be lower in all zones, the greatest difference occurs in Zone 2. The differences in GBTOXe output for the two mass estimates show up to 60 percent for the sediment layers of Zone 2 and 20 to 30 percent for Zone 3A. By contrast, the initial differences shown for the sediment

layers of zones 3B and 4 range from 1 to 8 percent, with the exception of layer 4 to 10 cm of Zone 4 where the alternative mass scenario concentrations are consistently higher by 40 percent. Given the large surface area of Zone 4, this difference reflects a substantial increase in buried PCBs in the northern region of the Bay compared to the sediment PCB distribution in the original RI/FS. The differences associated with Zone 4 remain virtually unchanged over time because most of Zone 4 sediments are characterized as hardpan where there is little or no mass transfer between the water column and surface sediments, or between sediment layers.

A general conclusion from this effort is that the alternative mass estimate derived from the revised bed maps introduces new initial conditions, which appear to be substantially lower in Zone 2 (and to a lesser extent, Zone 3A). The lower initial condition in Zone 2 results in reduced Zone 2 concentrations relative to the original RI/FS scenario that are more consistent with those computed for zones 3A, 3B, and 4 over the course of the simulation period. While there are substantial differences between the concentrations computed in these two scenarios, it is noted that these are due only to the differences in sediment initial conditions based on the alternative PCB mass estimates. As discussed in *White Paper No. 19 – Estimates of PCB Mass, Sediment Volume, and Surface Sediment Concentrations in Operable Unit 5, Green Bay Using an Alternative Approach*, the alternate bed maps are considered to be a lower-bound estimate for PCB mass in Green Bay. By consequence, then, the results presented in this white paper may be interpreted as being a lower-bound transport estimate of PCBs.

It should be noted that the analysis did not include an effort to recalibrate GBTOXe based on the alternative PCB mass estimates. It is reasonable to assume that a recalibration of GBTOXe would reduce the differences between water column PCB concentrations computed in the two scenarios.

5 REFERENCES

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FIGURE 1 RI/FS NO-ACTION SCENARIO RESPONSE TO ALTERNATIVE SEDIMENT PCB MASS ESTIMATE, ANNUAL AVERAGED SEDIMENT PCBS 0–2 CM

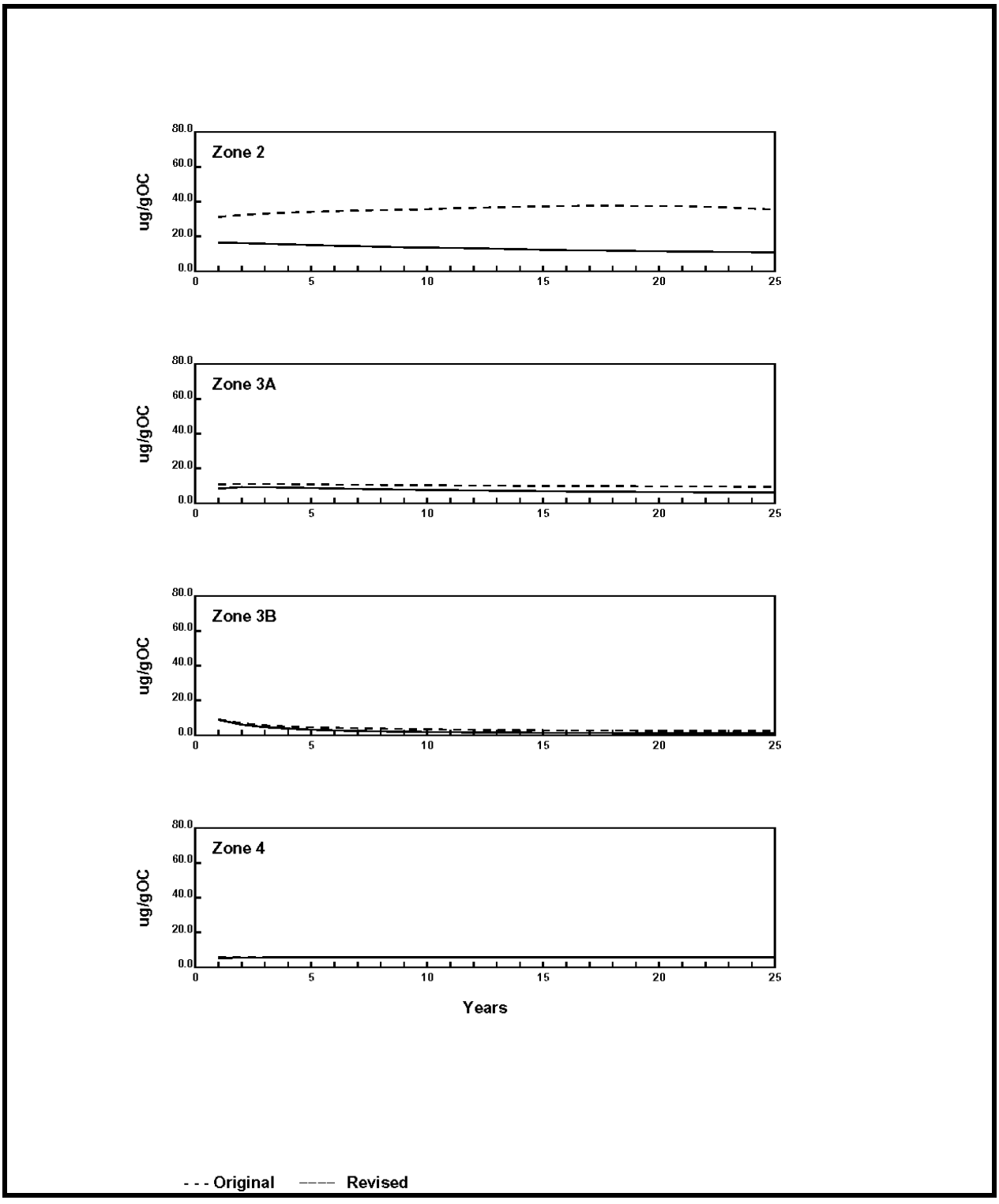

FIGURE 2 RI/FS NO-ACTION SCENARIO RESPONSE TO ALTERNATIVE SEDIMENT PCB MASS ESTIMATE, ANNUAL AVERAGED SEDIMENT PCBS 2–4 CM

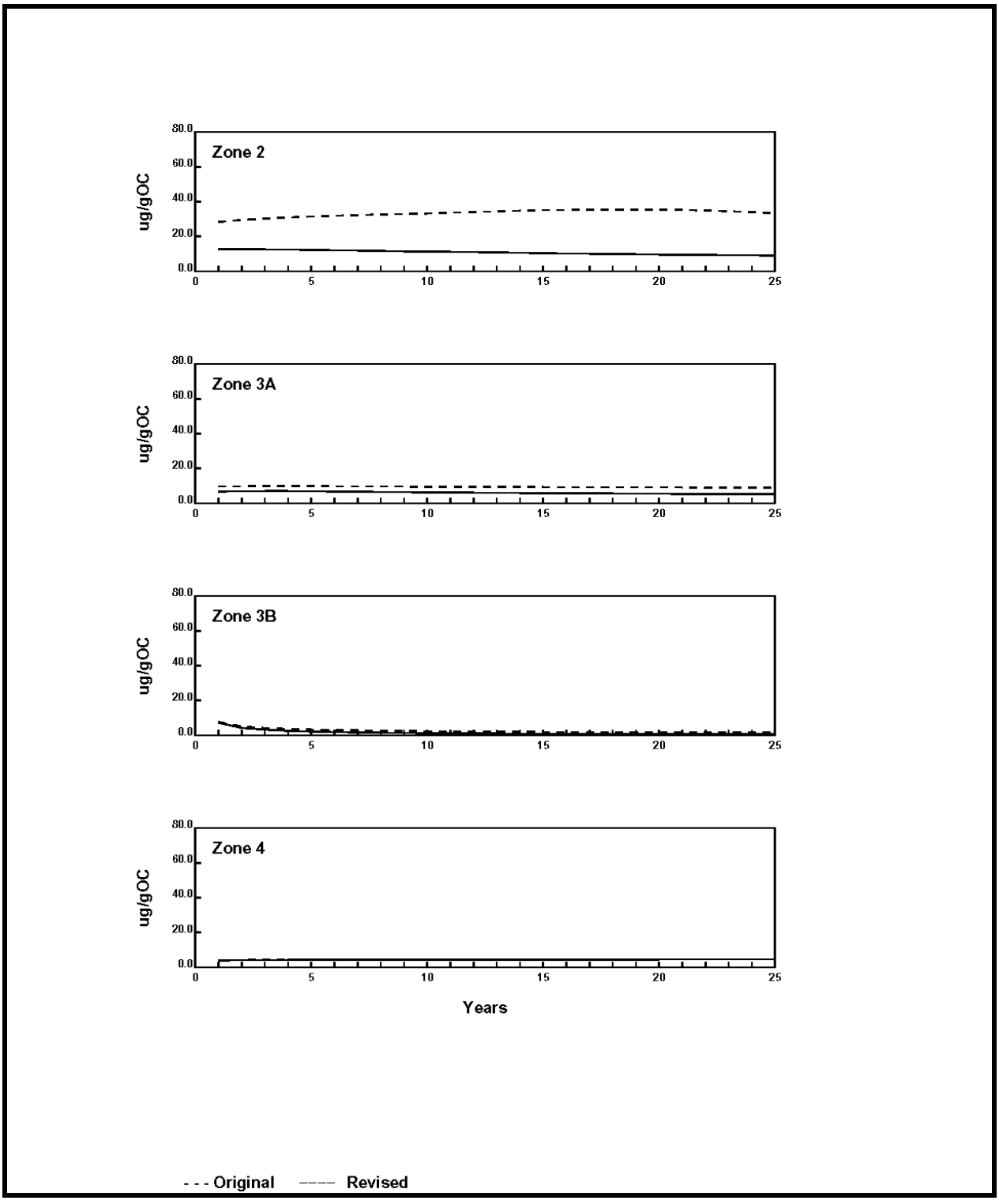

FIGURE 3 RI/FS NO-ACTION SCENARIO RESPONSE TO ALTERNATIVE SEDIMENT PCB MASS ESTIMATE, ANNUAL AVERAGED SEDIMENT PCBS 4–10 CM

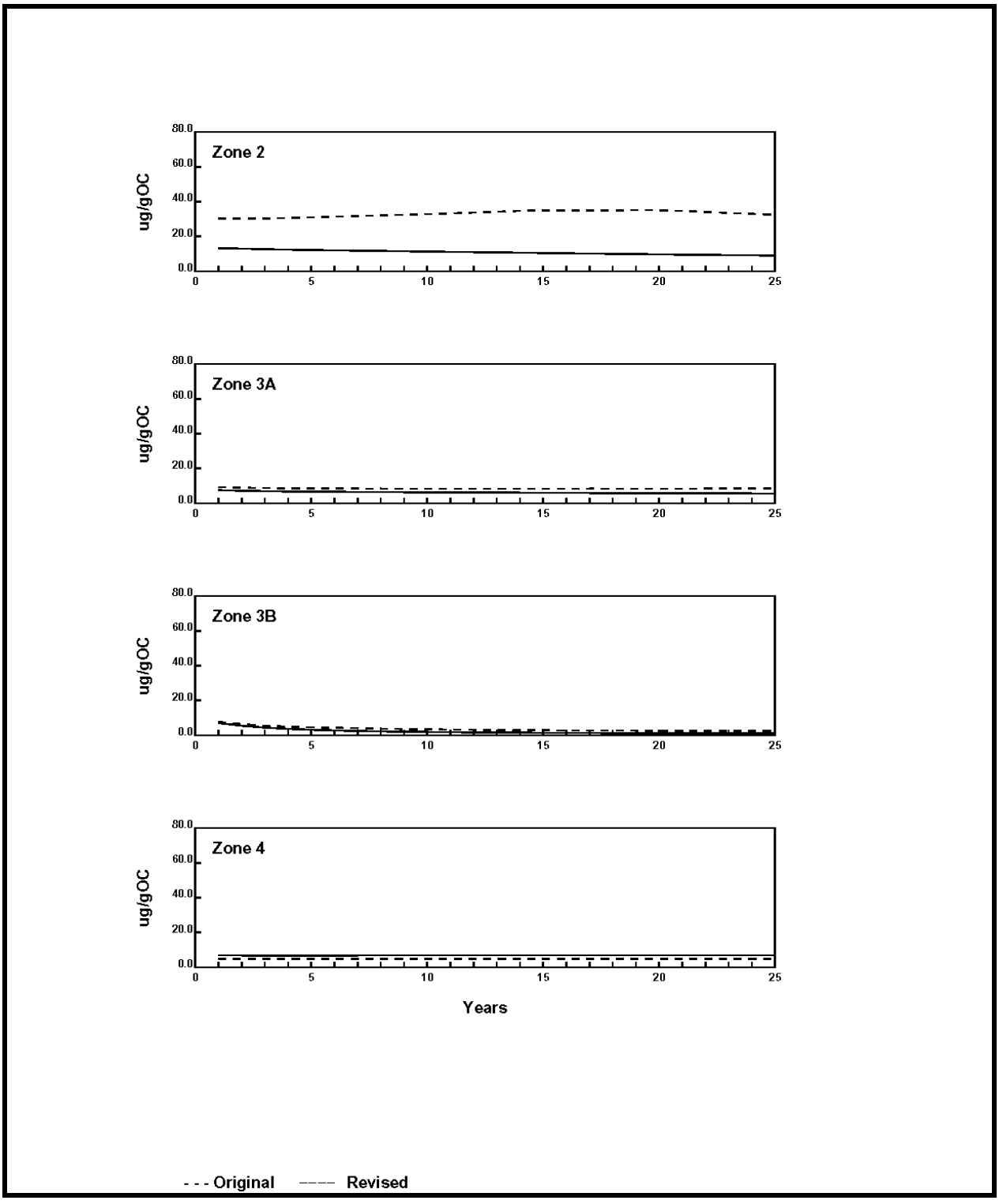

FIGURE 4 RI/FS NO-ACTION SCENARIO RESPONSE TO ALTERNATIVE SEDIMENT PCB MASS ESTIMATE, ANNUAL AVERAGED DISSOLVED PCBS IN WATER COLUMN